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SMT MAGAZINE

FEBRUARY 2017

NEW TECHNOLOGIES

Introducing a New Micro eBook Series

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I-Connect007 is excited to announce the release of the first title in its ***Printed Circuit Designer's Guide to...***™ series, *The Printed Designer's Guide to…Design for Manufacturing (DFM).*

Written by David Marrakchi, a Senior Technical Engineer at Altium, this micro eBook provides designers of all experience levels all the DFM knowledge they need to produce a manufacturable and functional board.

This is a must-read for any board designer who wants to get a good board back, every time.

The Printed Designer's Guide to…Design for Manufacturing (DFM) provides an in-depth look at DFM: what DFM entails, why it's so critical today, and how to implement DFM best practices.

We welcome you to download this book free by visiting the book's website.

Look for these other exciting titles in our new micro eBook series to be released soon:

- ***The Printed Circuit Buyer's Guide to... Solderless Assemblies*** *by Joe Fjelstad*
- ***The Printed Circuit Buyer's Guide to... Flex Design*** by American Standard Circuits
- ***The EMS Buyer's Guide to… Procuring High Complexity Electronics*** by Zentech
- ***The Printed Circuit Buyer's Guide to... Simulation and Analysis*** by Mentor Graphics

We hope you enjoy *The Printed Designer's Guide to…Design for Manufacturing (DFM)!*

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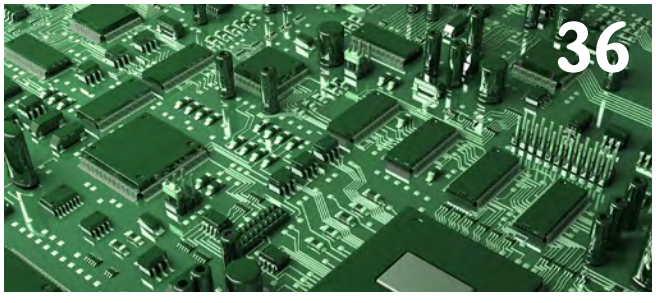

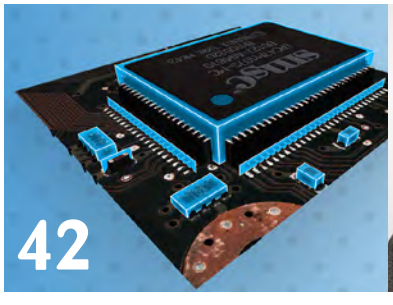

New Technologies

This issue of *SMT Magazine* highlights some of the latest technologies aimed at addressing the current manufacturing challenges in the electronics assembly industry.

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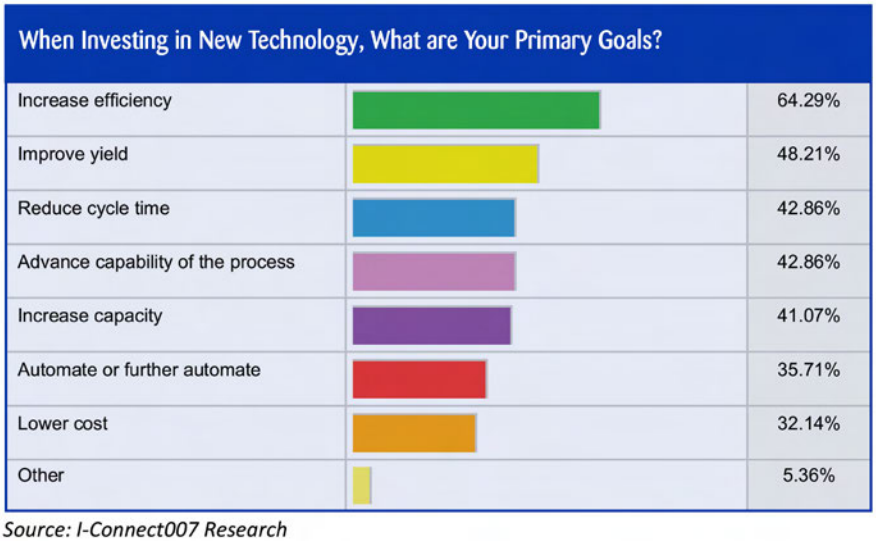
Survey Says: New Technology!

by Stephen Las Marias
I-CONNECT007

Rising manufacturing costs, OEM price pressures, shorter product lifecycles, fiercer competition, and continuously changing customer demand are the new normal that electronics manufacturers face in the current manufacturing landscape. There's also the continuing evolution in electronics design and increasing complexity, brought on by the expanding functionalities being packed in more and more compact systems and assemblies.

To become successful, these challenges require electronics assemblers to become more diligent in maintaining flexible production capabilities and advanced, if not leading edge, manufacturing systems and equipment. Manufacturing is undergoing what the industry considers as the fourth industrial revolution. With Industry 4.0, we are entering an era where we see new technologies and techniques transforming the look, systems and processes of what we consider as a modern factory. Automation, IoT, analytics, and robotics, to name a few, are among the advances and strategies that electronics assemblers must embrace to improve their manufacturing performance, lower labor costs and create smarter factories.



Source: I-Connect007 Research

Indeed, electronics manufacturers are beginning to consider investing in new systems to take their processes to the next level. In our recent survey on the topic of new technology, the top reasons cited by manufacturers to invest in new technologies are to increase efficiency, improve yield, reduce cycle time, and to advance capability of the process.

Adopting new technologies involves a heavy capital investment, but surprisingly, the majority of the respondents in our recent survey considered the capabilities of these systems as the most important factor when buying new equipment for their factories.

Respondents indicate they are more interested in quality, and whether the systems meet their needs, including one who commented, "I do not want to pay for features I do not need. Price is the second factor in determining what I buy."

Meanwhile, one survey question asked about technology at upcoming shows. Test and inspection equipment tops the list, followed by automation systems, and solder materials/equipment.

This month's issue of *SMT Magazine* highlights some of the latest technologies and trends that are impacting the electronics assembly industry.

In my interview with Metcal's Robert Rousch, we look at their patented hand-soldering technology, which they will unveil at this year's IPC APEX EXPO in San Diego, California.

Columnist Rich Heimsch explores the great promise of Industry 4.0 when it comes to productivity, and how it is changing the rules of the game for manufacturing.

In my interview with Tom Hunsinger of Alpha Assembly Solutions, he describes the lat-

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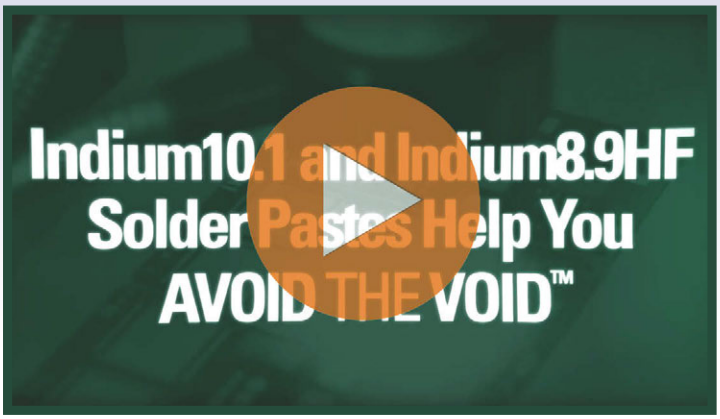

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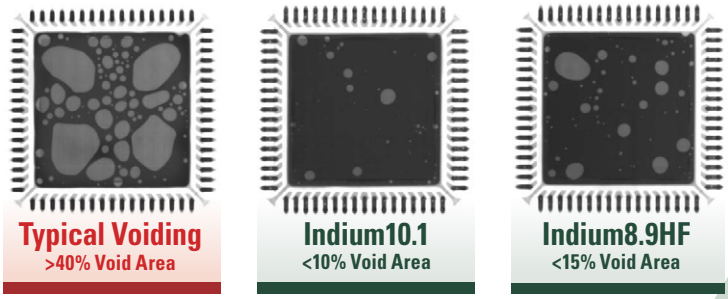

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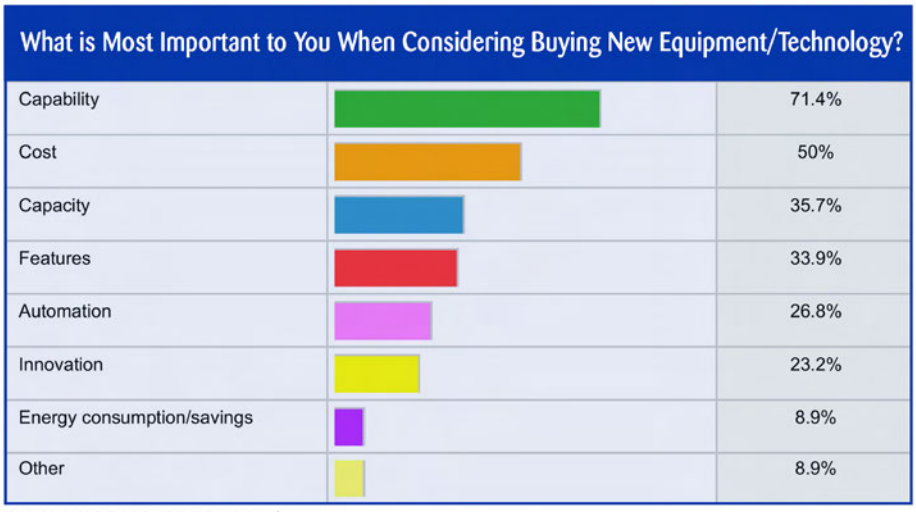

Source: I-Connect007 Research

est technologies to tackle solder voids in electronics assemblies.

Tom Borkes, in his feature contribution, explains his perspective on the general drivers of change in the electronics assembly industry—such as additive technologies, RF and power management, robotics, wearable electronics, and cloud-based computing and data security—and the specific new product and process types that are a result of those drivers.

I also interviewed Electrolube's Phil Kinner, who gives us the latest on conformal coating and resin solutions to address the thermal management issues in automotive electronics and LED applications.

Thom Hansen of EMS firm MC Assembly, outlines the factors driving the rapidly changing electronics assembly industry, and how technology developments have impacted the EMS industry in recent years and will likely continue shaping the industry in the future.

Finally, we have Goepel electronic's Thomas Wenzel who analyzes the latest trends and technology innovations happening in the test and inspection front.

Our lineup of general interest articles and columns is quite extensive this month. First, Michael Ford of Mentor Graphics explores IPC-1782, IPC's newly created standard and specification for traceability practices across all levels of electronics manufacturing, and specifically for electronics assembly.

Manncorp's Tom Beck offers how three OEMs are benefitting from their decision to bring their SMT assembly in-house.

Chintan Sutaria of CalcuQuote describes how the process approach applies specifically to the request for quote (RFQ) process in the EMS industry, and the impact of this strategy on a business overall.

In his column this month, Tom Borkes continues his discussion on organizational structure labor costs, and introduces an alternate organizational structure—one that permits a more efficient and cost effective way to manage electronic product assembly.

In my interview with VirTex CEO Brad Heath, he shares his insights on the challenges facing the EMS industry, and the latest technologies and trends that are providing significant impact in the EMS industry.

As you probably know, mid-month at IPC APEX EXPO, the whole electronics assembly industry supply chain will converge once again under one massive roof to showcase the latest innovations, systems and solutions aimed at taking manufacturing processes to the next level. Plenty of industry experts will be on hand discussing the latest technologies, trends and challenges we can expect to see this year.

As always, I-Connect007 will be present at the event to provide you, our readers and partners, in-depth and real-time information on the technology and business developments happening in our industry. And we want to talk to you! Drop us a note to set up an appointment, or just drop by our booth to say hello. I look forward to meeting you at IPC APEX EXPO 2017! **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.

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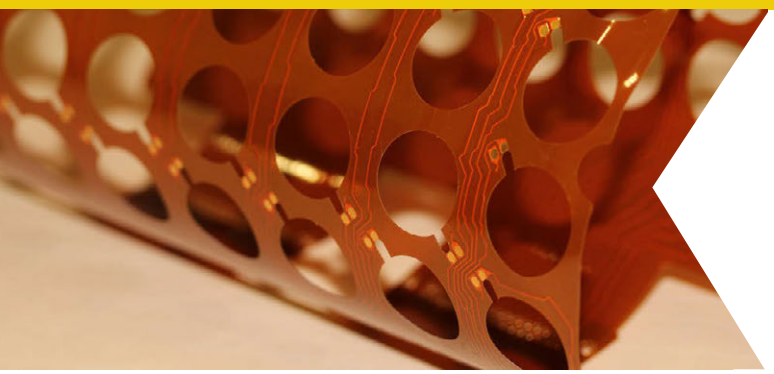

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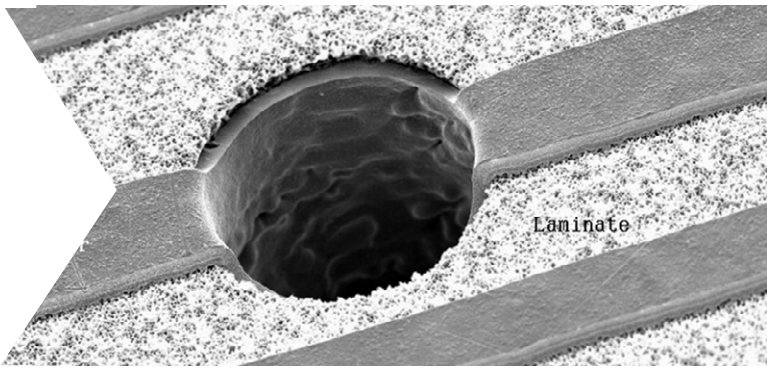

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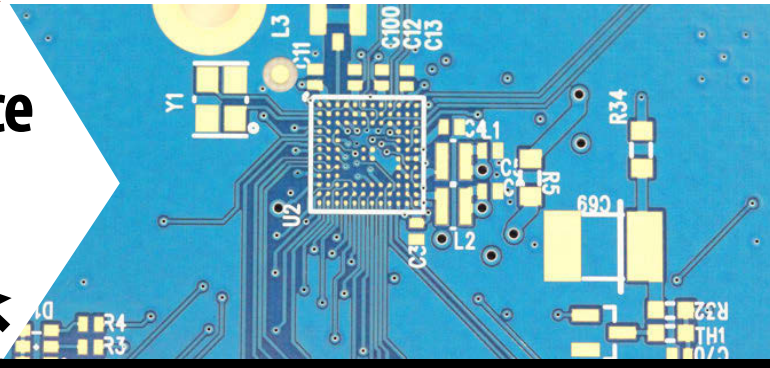

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In Pursuit of 4.0

by Rich Heimsch
SUPER DRY-TOTECH EU

Industry 4.0 changes the rules of the game for manufacturing. It holds great promise for significant increases in productivity by connecting machines with information technologies and the Internet.

Companies that use new technologies for Industry 4.0 are more competitive because they produce at lower costs and possess the flexibility to meet wide ranging and quickly changing customer requirements. Industry 4.0 is upon us, and those that are prepared to implement it now will actively shape and lead the change.

Mass customization is a marketing and manufacturing concept that merges the personalization and flexibility of custom-made with the low cost per unit for which mass production is known. The 4.0 environment advances this concept towards reality. With all useful information available at any time, in any location, it is possible to economically produce individualized products in very small batches. Companies that implement Industry 4.0 produce faster, with more flexibility, greater efficiency of material, and reduced complexity and downtime.

This greater efficiency of material often means robotically automated inventory logistics and tracking systems that virtually eliminate manual material handling, and are integrated with enterprise-wide MES and ERP systems. lt has some additional meaning and unique requirements in the production of printed circuit board assemblies (PCBA) and the management of the inventory involved there. These include not only maintaining the known whereabouts of tens of thousands of devices, but to also track the status of their exposure time to ambient atmosphere. Most individual devices assembled into a PCBA, including often the PCB substrate itself, are susceptible to moisture absorption and have various but specifically limited floor life available before they become a severe risk to elevated temperature processing, the method by which all of the PCBA interconnections are made. During reflow soldering, when temperatures as high as 260°C are applied, excessive moisture (i.e., > 0.1% water weight) that has permeated the components' hygroscopic encapsulation can escape in sudden bursts, crack-

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ing open the packaging and exposing the encapsulated die and its interconnections to permeating oxygen, typically resulting in field failures (often not end-of-line defects).

There are eight different levels of moisture sensitivity, expressed in hours of available floor life ranging from unlimited, to less than 24 hours. It is imperative that floor life exposure be known at all times, in order to prevent moisture induced damage. It is possible to "reset" device floor life by removing the moisture, but it must be done under carefully controlled conditions in order to retain its solder-ability and usefulness. For instance, oxidation and intermetallic growth are both detrimental to the interconnection process and both are induced by high-temperature baking to remove moisture.

The documented management of these issues is critical to avoiding field failures and product liability nightmares. This management is frequently accomplished with fully automated warehouse robotics, as introduced earlier, but also sealed within low humidity environments (<5%). As parts are moved to and from the assembly floor, real-time reporting of the whereabouts and condition (floor life exposure) of each device needs to be available, for optimum inventory utilization and moisture safety.

Not all manufacturing businesses feel that they can afford such large-scale automation, or have not yet or will not grow enough to warrant the associated investment. Their MSD management consists of one or many desiccant dry cabinets and heated floor life reset cabinets, which are manually loaded and unloaded.

Nonetheless, the key essence of the 4.0 solution is available to them. The same software that tracks and traces devices robotically moved on and off the assembly floor is available for less automated environments as well. Dry storage cabinets can be located at different points across a factory floor, or in different buildings across a manufacturing campus. At any location, operators are able to scan components and PCBs into and out of discrete safe storage cabinets, as well as floor life reset cabinets. The software automatically maintains accurate status of their location and floor life exposure and/or floor life reset status. These various locations can also include ambient atmosphere inventory warehouses storing unlimited floor life devices or components still in their MBBs.

Discrete dry cabinets can be networked together, with all operating parameters available for tracking in real time and tracing back in time. This information automation enables manufacturers of any size to comprehensively maintain control of all their component inventory, and particularly their moisture sensitive devices.

Whether integrated with existing ERP and MES systems or used in a standalone fashion, real time monitoring and traceability of moisture sensitive inventory helps manufacturers of any size on the path to achieving their 4.0 goals. **SMT**

Richard Heimsch is a director at Protean Inbound and for Super Dry-Totech EU in the Americas.

CES 2017: Disruptive Technologies

In his recent columns, Dan Feinberg wrote about the many new products showcased at CES 2017, including drones, autonomous cars, robots, IoT devices, and even smart trash cans. But what about truly disruptive technologies that will radically change the way things are made and used and the way we live? In this column, he discusses three of the most disruptive technologies that will change the way we design and make electronic (and other) devices, the way we commute and the way we are entertained as well as the way we travel. Over the next five to ten years these areas will undergo radical and disruptive change and that change will be happening rapidly.

To read Dan's article, please click here.

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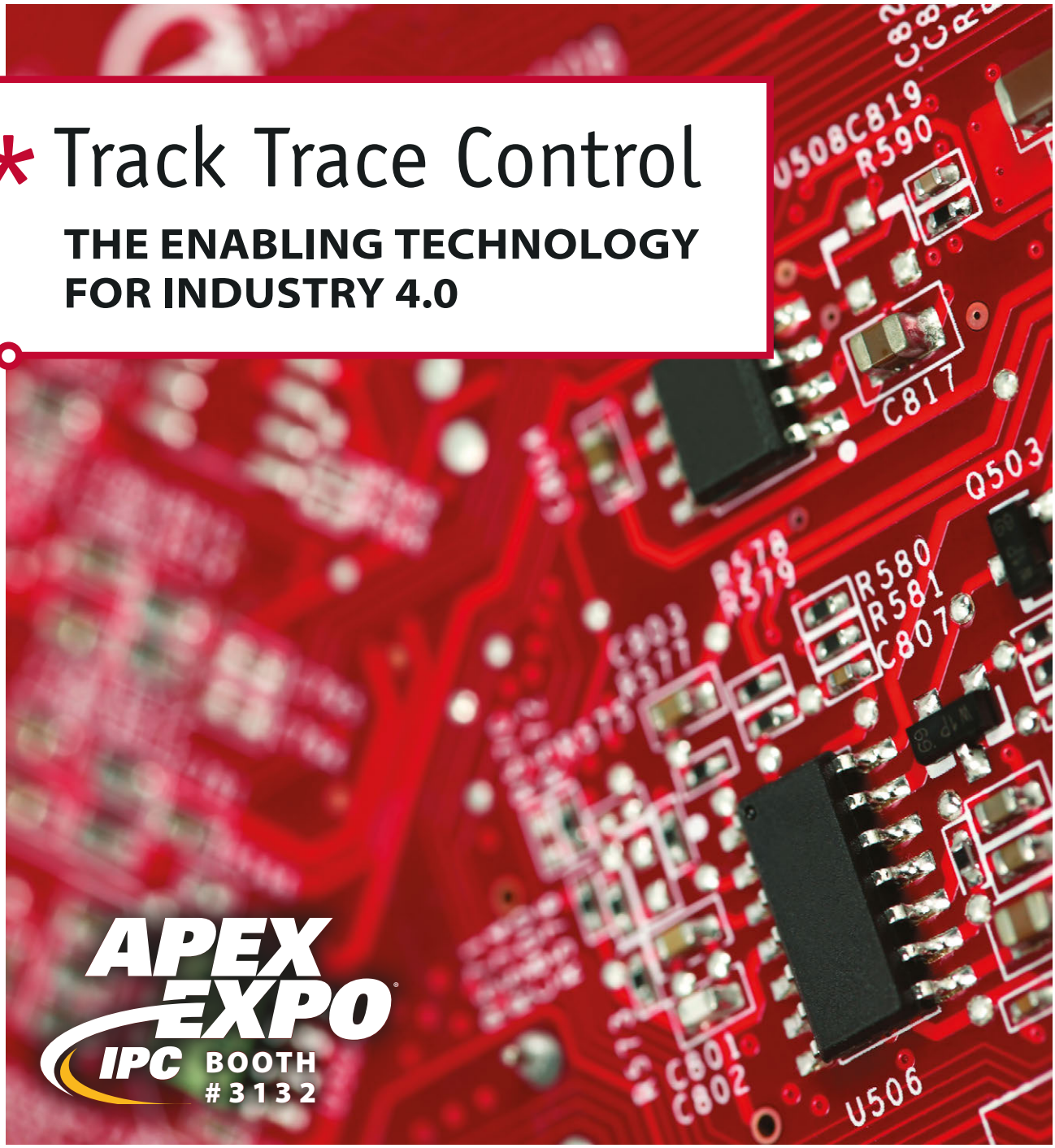

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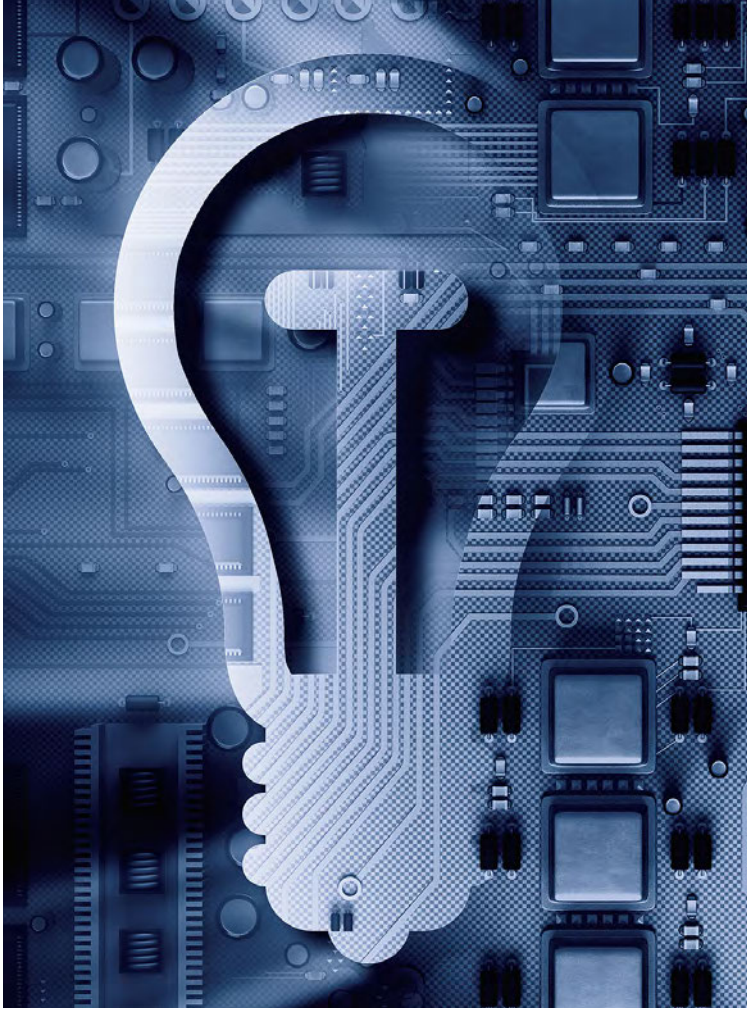
ALPHA on New Technologies to Tackle VOIDING



by Stephen Las Marias
I-CONNECT007

In an interview with *SMT Magazine,* Tom Hunsinger, vice president of marketing at Alpha Assembly Solutions, discusses how their company is addressing voiding—one of the greatest challenges in soldering.

Stephen Las Marias: ***From a soldering standpoint, what are the greatest challenges that your customers face?***

Tom Hunsinger: Voiding continues to be a critical issue for our customers in both BGA and in bottom terminated components, where you're using that termination as a heat sink, or LED packages where the device is being used to drain heat away from the LED. That becomes more challenging because the solder is being used as a thermal interface material and so the presence of voids means you are lowering your thermal conductivity.

Understanding what causes the void formation during the assembly process is paramount and usually is where customers need some assistance. Flux, for instance, plays a big role in controlling void creation particularly during the preheat phase of a reflow process so optimizing your profile can significantly reduce voiding. It is also important to use soldering materials that match the application, so at the onset of a project, we take the time to discuss the design parameters with the customer so that both parties have the right information to decide on which alloy is best.

Las Marias: ***How is Alpha helping customers address voiding?***

Hunsinger: In terms of voiding, Alpha is in the process of developing several products that will help prevent void formation. One is a solder paste material that was developed to meet the high reliability needs of both the automotive and lighting markets, while also delivering low levels of voiding. We also have a new solder preform coming soon that is designed specifically for large area power components that require consistent low-voiding solder joints from normal SMT processes.

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The new solder paste Alpha is developing has a modified flux chemistry that enables us to minimize the reactions between the flux and other materials in the solder and on the surface finishes to minimize the amount of voids forming in the first place. This will be particularly helpful to the automotive market because we've had several discussions with key customers during the year on the impact voiding has on reliability. The solder preforms in development contain an ultra-low voiding flux formulation that is deposited very accurately from preform to preform ensuring repeatable performance every time. They will be available in tape and reel for easy assembly in SMT reflow applications and, upon request, can contain various coating levels, customized shapes and thicknesses to address a specific application.

Tom Hunsinger

***Las Marias:** What market development trends are shaping product innovation strategies at Alpha?*

Hunsinger: We are seeing a great deal of material innovation for the flexible, formable and printed electronics sector and Alpha is developing a robust portfolio of new products and technologies to specifically meet the demanding performance and reliability requirements of flexible and printed electronic circuits. This is one of the fastest growing technologies in the world and is allowing electronics to be used in places it never has before, so we are quickly learning how to make materials that are adequate for this new environment. Our product development falls within two broad categories. First, with flexible PCBs which involves assembly of conventional components, such as ICs or processors, onto circuited flexible substrates. The second would be printed electronics/circuits on flexible polymer films in which the flexible circuits are additively printed on a polymer base film, typically through a continuous roll-to-roll process or through a high throughput sheet-to-sheet process which is then followed by other subsequent processes.

***Las Marias:** What other solder solutions should we expect from Alpha this year?*

Hunsinger: In addition to what was already mentioned, Alpha will be introducing a new solder paste, a cleanable, no-clean material with fine feature printing capabilities that is derived from the SAC family of alloys. We also have our latest VOC-free, halide-free flux coming out soon that is designed to meet current REACH and RoHS legislation. And we also have a few other preform technologies coming to market, one that is geared toward power module assembly and the other focused on bond line control to prevent die tilt and help fix your bond line thickness.

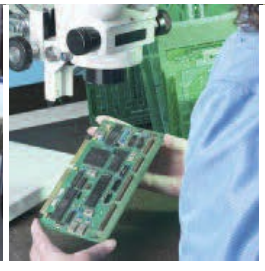
***Las Marias:** How does Alpha provide value to your customers?*

Hunsinger: One of Alpha's key differentiators is the strength of our technical service, both from an R&D standpoint where we are designing materials that meet today's challenges and future challenges as well, and from our customer technical support group in the field. This team is solely dedicated to working with customers to troubleshoot application problems, identifying key factors in their process and helping them select the right materials for their application. This is how we understand our customers' challenges, how we help resolve the challenges and ultimately, how we help them meet the challenges of their own customer base.

***Las Marias:** What is your outlook for the soldering market this year?*

Hunsinger: I think the outlook is promising for the solder market given the upward demand from EMS companies. We anticipate growth



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with the LED and automotive electronics industries, we see new opportunities to work with our customers in the consumer electronics space and the newer flexible, formable and printed electronics market that is taking off. I'd say 2017 has the potential to see the release of several solder material innovations. And, in addition to the work we are doing to develop new materials and assembly solutions, we are also continuing our work on improving the sustainability of materials used in electronics assembly through our metal reclaim programs and our participation in other industry led working groups.

***Las Marias:** Any final comments?*

Hunsinger: Alpha Assembly Solutions is committed to be the industry's preferred supplier of high performance materials and chemistry by delivering leading technology represented by our innovative products, processes and people.

***Las Marias:** Thank you, Tom.*

Hunsinger: Thank you. **SMT**

Help Wanted! Our 2017 Industry Hiring Survey

In January, we conducted an industry survey on plans for hiring during the year. Below is a summary of the results of that survey.

When we asked whether they are planning to hire additional people this year, more than half of the respondents answered yes while only about a third said no—which we take as an optimistic sign that our industry plans to expand in 2017.

It is interesting to note that the bulk of the planned new hires will be in technical and operations areas (line operators, process engineers and the like) with few in administration and management. As expected, a good number of sales and customer service personnel will also be added. We believe this points to a general flattening of internal structure and a real expansion in the industry.

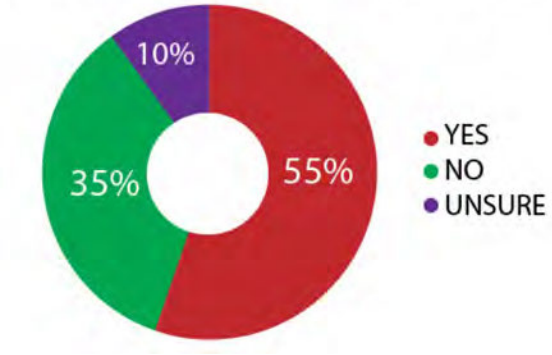
For our question on the greatest challenges when hiring, "finding qualified candidates" is the most overwhelming concern—93% of respondents cited this as a challenge.

Answers ranged from "no pool of experienced operators" to "finding seasoned engineers" to "finding the right people that fit." It certainly sounds like there is a real shortage of qualified people to help our industry expand.

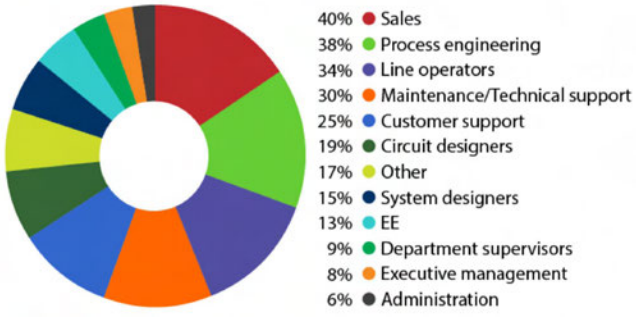
In our survey, the bulk of respondents were from North America and Europe—two regions where the electronics industry has suffered in past years. Couple that with the fact that most hiring will take place in the first half of the year and it appears there is a very positive outlook for anyone working in PCB fabrication with ample opportunity for experienced people. But expansion of companies and hence our industry could be hampered by a real shortage of those same people.

Read More About the Results of the Survey Here.

1. Do you plan to hire additional people this year?



2. What positions are you looking to fill?



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MilAero007 Highlights

Sparton and Ultra Electronics JV Inks $30.3M US Navy Sonobuoy Contract

Sparton Corp. and Ultra Electronics Holdings plc have been awarded subcontracts valued at $30.3 million to their ERAPSCO joint venture, for the manufacture of sonobuoys for the United States Navy.

Orbit International's Electronics Group Lands $1.23M U.S. Navy Contract

Orbit International Corp.'s Electronics Group has received an award from a U.S. Government Procurement Agency valued in excess of $1,230,000 for its MK 119 Gun Computer System Cabinet (GCSC).

Libra Industries Completes Advanced SPI Training with Omron

Libra Industries technologists Glenn Watson, quality manager, and Joel Wolnik, production manager, recently completed SPI training at Omron's Chicago facility.

Ellsworth Now Authorized Distributor of Henkel Products for Aerospace Industry

Ellsworth Adhesives has announced that it is now an authorized distributor of Henkel's surface treatments and structural adhesive products for the aerospace industry in Canada.

Aimtron Acquires PCBA Specialist Target

Aimtron Corp. recently acquired PCBA specialist and military equipment manufacturer Target Corp. (including its Cardion Electronics Division) for over $1 million in cash.

Computrol Installs Five New Intelligent Component Storage Systems

Computrol recently installed five Europlacer LZero3 Component Storage Systems at its Meridian facility. The Lzero3 networks with existing MRP/ERP systems and pick-and-place machines to efficiently pick and restock factory works orders.

Kimchuk Installs ACE Selective Soldering System in Connecticut Facility

ACE Production Technologies Inc. has announced that Kimchuk Inc. has invested in a KISS-103 selective soldering machine.

Colonial Assembly and Design Earns IPC J-STD-001 and IPC-A-610 QML

IPC's Validation Services Program has awarded an IPC J-STD-001 and IPC-A-610 Qualified Manufacturers Listing (QML), meeting Class 3 requirements, to Colonial Assembly and Design LLC, a wholly owned subsidiary of Zentech Manufacturing.

VirTex – 2016 Reflection; 2017 Outlook

For nearly 20 years, VirTex has experienced year-on-year growth. Even through turbulent times, the company has remained profitable and financially stable.

Lincoln International EMS Stock Index for Q4 2016 Outperforms S&P

Lincoln International's EMS Stock Index has outperformed the S&P in the fourth quarter of 2016.


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The Shape of Things to Come

by Tom Borkes
THE JEFFERSON PROJECT

Where is our industry going? The beginning of a new year provides a good opportunity to look into the crystal ball and foretell what we think will be. Using general cause and effect observations of the past, can we predict products and processes that will be developed in the near future?

In science, we call it extrapolation: establishing a relationship between variables that form data points (statistical inference) and using the relationship or function to predict an occurrence outside the known observation range.

In a sense, this is what Professor Marvel did in the Wizard of Oz when Dorothy asked him to tell her the future. He sees a young girl running away from home with a picture of an older woman (Auntie Em) in her basket and combines this with the danger of the forthcoming tornado and says, "I see a woman who is very worried about someone she loves very much." Professor Marvel infers a conclusion from a series of observations.

The Wizard of Oz, 1939.

We can create a predictive model with causes and effects based on independent and dependent variables. However, the model may have to be very complex and statistically based. Remember the butterfly effect, where a tiny action like a butterfly's fluttering wings in Singapore is attributed to causing a hurricane in Florida.

Starting with a set of initial conditions we apply the most likely changes to the independent variables (What we allegedly have control over, like climate change) and calculate the effect on the dependent variables—like the seas rising. Does the model converge or diverge? The dirty little secret is that when we know the conclusions we want, we can rig the model to predict the desirable results. How? We keep changing the model's relationships

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H.G. Wells, *Things to Come,* Janus Films.

to agree with the model's results (the actual observations), that in turn, become the new set of initial conditions. Creating a predictive model for weather systems produces similar problems—where small perturbations cause significant changes in results.

It is chaos theory that helps lead us to the conclusion that perhaps there is nothing absolutely improbable or absolutely probable (i.e., either a zero or a one). We sit in a conference room listening to the boss bloviate on how we must perform better as a company this year. At that moment, how many of us think about the fact that we can't predict absolutely where each gas molecule that makes up the air in the room will move in the next microsecond? There is a finite probability that after a while they will all move into a corner and you will suffocate—based on some of the bosses I have had, there are worse outcomes. However, it is a very, very small probability—but not zero!

In 1933, H.G. Wells wrote a story titled "The Shape of Things to Come." This work of science fiction tells the history of the world from 1933 to 2106. It is taken from the notes of a Dr. Philip Raven, who meticulously compiled his dreams of a future history book he was reading. It predicts World War II that officially started in 1939 with the invasion of Poland.

This account of a future history is one of many utopian and dystopian views of where we as a species are ultimately headed. In this case Wells foresees an optimistic ending.

However, our purpose here is not to predict human destiny, but simply to predict the shape of things to come in the high tech electronic product assembly business.

What are the general drivers of change in this business, and what specific new product and process types do we see that are a result of those drivers?

Change drivers:

1. Reduced product cost
2. New disruptive technologies and applications
3. Time to market

New products and processes associated with change drivers:

■ Additive technologies (3D printing, Occam, thick film polymer printing of components)

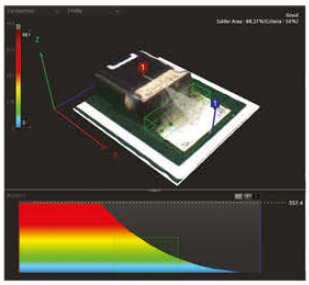
In the long run, assembling atoms is more cost effective than assembling and then removing and discarding atoms. In addition, cost is reduced when less material is used and the material that is used does not require post-fabrication assembly material and labor. Prototypes and preproduction product models will be expedited using 3D printing, overall time-to-market for new product introduction (NPI) will be reduced.

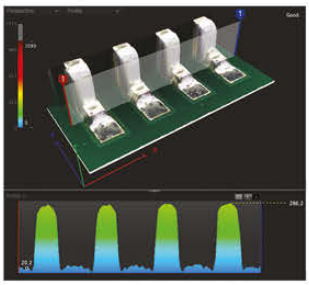
■ RF and Power Management

Telemetry and product portability will continue to extend their reach into new areas. This will require material and assembly processes with short electrical distances. Smaller products using smaller components (e.g., 03015 metric) and robust electrical designs that run on uberlow voltages will proliferate. High component densities will cause assembly technologies to continue to push automation to greater accuracy and precision. In addition, smaller circuit boards configured in larger panels along with direct chip attach will high process accuracy and precision. Traditional yield loss will not be tolerated. Assembly yield expectations will be in the 99.6%+ range, in general. To achieve these yields meta-process control will be required (i.e., automated self-correction of process to accommodate material and process variation). Nonvalue added activities such as ICT will gradually be removed from the assembly process to reduce labor cost.

MIRTEC

"ALTRON Inc. is a veteran owned service orientated, contract manufacturing company dedicated to providing high quality circuit board and mechanical box build assemblies including servicing and order fulfillment solutions for a wide variety of industries. ALTRON Inc. is certified to AS9100, ISO13485 and ISO9001. As part of our commitment to continuous quality improvement we recently acquired 6 new MIRTEC MV-7 OMNI 3D AOI systems. After evaluating several leading 3D AOI vendors, we selected MIRTEC as the best solution to meet our ongoing quality initiatives." - Al Phillips - Owner and CEO





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Robotics

The emphasis will be on assembly labor content reduction as upward pressure on labor rates will continue along with re-shoring initiatives. Robotics will play a key role in this effort. Back end box assembly will need to de designed for this automation. Skilled personnel will be required to develop and manage this assembly automation.

Wearable Electronics

Mr. Electron, meet Mr. Dacron. Weaving electronics in fabric is happening now and will continue to grow in application. However, wearable electronics means more than joining electronics to fabric. Medically, it means carrying the electronics that will continually measure blood glucose level and automatically deliver insulin without the need for human interaction. Drug delivery without human intervention is analogous to meta-process control (see above). In addition, using telemetry, your doctor can receive a constant flow of data reporting medical metrics and drugs delivered.

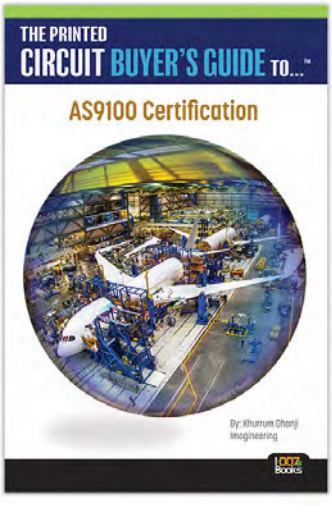
Cloud-based Computing and Data Security

Although not directly tied to hardware and assembly technology, these are areas that will have much attention paid to them. More and more data processing will be done in cloud servers, requiring less hardware and software to be owned by the individual user. Protection from hackers will be a major initiative for IT and data managers.

So, Toto, I've a feeling we're not in Kansas anymore. **SMT**

Tom Borkes is the founder of The Jefferson Project and the forthcoming Jefferson Institute of Technology. To reach Borkes, click here.

Emmy Ross Discusses the New I-Connect007 E-Book Series



One thing that is long overdue in our industry is a series of guidebooks focused on helping companies with all their needs, from qualifications like AS9100 and Mil-P-31032 to various technologies, heavy copper, rigid-flex and microvias. I-Connect007 is now providing our industry with an entire series of these guidebooks called "The Printed Circuit Buyers Guide to…", "The Printed Circuits Designers Guide to…", and several others. The aim is to educate the buyers to help them lower their costs, buy better boards, make better deals, and establish better processes.

The interesting thing about this new project is that the books will be authored by companies that are experts in their chosen topic. For example, a quality assurance company can write a book about electrical test, or a company that provides coatings can write a book about solder mask. Thus, this is a win not only for the readers but for the companies involved as well.

Emmy Ross, who recently joined the I-Connect007 team to head up this book division, discusses with Dan Beaulieu what these new guidebooks are and the benefits they will offer companies in our industry.

To read the interview click here.

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ELECTROLUBE Highlights Latest Technologies Targeted at Automotive, LED Applications

Thermal shock chamber

by Stephen Las Marias
I-CONNECT007

Electrolube's Phil Kinner, global head of the conformal coatings division, talks about the trends shaping the company's product innovation strategies, and their latest solutions and technologies to help address their customers' greatest challenges.

Stephen Las Marias: *From a conformal coating standpoint, what are the greatest challenges that your customers face?*

Phil Kinner: Many of our customers increasingly face challenges regarding environmental protection, with more and more applications taking electronics to places where they wouldn't previously have gone before. So we have seen a lot of opportunities for coatings and encapsulation resins to help protect customer devices from even the harshest of operating environments. These opportunities have largely arisen from automotive and LED customers who consistently face challenges with corrosion, condensation and high humidity. We've also seen an increase in customers enquiring about reducing tin whisker growth, eliminating VOCs, reducing conductor spacing and ultimately increasing productivity. Everything's got to be smaller, more tightly spaced, faster, more powerful and has to last longer. We are also frequently asked about coverage, if the coating doesn't cover, it can't protect and that is certainly an issue facing customers.

Las Marias: *How is Electrolube helping customers address their issues above?*

Kinner: Our strength lies in our ability to resolve problems and find suitable solutions for our customers. In the last year, we have made significant investment in the very latest testing equipment for our laboratories and a top of the range selective conformal coating system, which definitely gives us an edge over competitors when it comes to helping our customers. Our new thermal shock chamber is state-of-the-art and most chemical protection manufacturers don't have this kind of machine at their disposal, and need to first send their products off to a third party test house before they understand the capabilities of their products. If we have a specific technical enquiry from a

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Phil Kinner

customer who wants to know whether or not something will meet a specific number of cycles, or a specific range, then we can run it for them. For instance, we had an enquiry where the customer was looking at a -40°C to 160°C temperature range for a product and had three weeks to make a decision and we managed to turn the testing around in just two weeks giving the customer a whole week to evaluate the data. The new system is also becoming increasingly beneficial for automotive customers, especially as they transition from solvent-based materials to VOC-free alternatives. Given that most of the products that we're developing are VOC-free, and thermal shock is one of the main challenges to this technology, it naturally makes sense to invest in the equipment not only for customers, but for our own product development, to help us reduce the time to market of reliable, high-performance materials. Testing our products before they go to market is everything, and ultimately positions us well as a reliable and complete solutions provider across all areas of the production process.

Las Marias: *What are some of the latest technologies released by Electrolube over the past year that are helping customers address their specific problems?*

Kinner: Traditionally, we have our resin business and we have our coating business. What we've done is merge the two divisions together to make a hybrid product called 2K, so it has the protection of an encapsulation resin with the ease of application and reduced weight demands of a conformal coating. It's a pretty revolutionary product—it's green, solvent-free, easy to apply, cures quickly and gives superior protection to any other coatings that are available on the market right now. The product helps customers save time, reduce cost and improve productivity. It's a thicker material that enables better edge coverage without compromising on thermal shock or other performance parameters. It helps increase productivity by reducing material usage, cost and cycle time and improves process optimization and reliability. 2K features all the advantages of the coating and all the advantages of encapsulation resins combined into one package, which really solves both environmental performance and process issues that relate to all of these issues. The 2K two part conformal coating range currently consists of three products; 2K100, 2K300 and 2K500, and we are in the process of developing new products to extend the series.

We have also developed an ultra-thin coating called FPC, which also helps boost productivity. FPC is a specialist fluorinated polymer coating that repels hydrocarbon and silicone oils, synthetic fluids and aqueous solutions due to its very low surface energy. It performs extremely well, offering excellent protection for printed circuit boards and electronics in exposed environments. Once dried, FPC has a low film strength and is easily removed, allowing assemblies to be coated without masking. It's also very easy to apply and has an exceptionally fast-touch dry time.

Our new selective conformal coating system, equipped with both film coat and spray valves, is an advanced conveyorized platform providing the highest quality and productivity for automated coating processes. A wide range of con-

formal coating process parameters can be monitored for both statistical process control and traceability purposes. Many of our customers now prefer to use selective coating methods in order to minimize their materials and process costs, and to meet specific design issues. We are very keen to ensure that our latest products are fully optimized in terms of viscosity, chemical composition and associated work time, as appropriate for selective coating. Having such advanced production grade equipment in a laboratory setting will help us further strengthen our capacity to replicate customer issues and develop materials for optimum performance in selective coating equipment, which in turn will also help us provide the very best support and guidance on product and process selection. We are also using the new equipment for customers engaging in product trials. Our customers are given independent access to Electrolube's facilities, bringing their samples to the laboratory to evaluate the performance of new products, application techniques or processes. In this way, later disruptions to production from unsuitable product or process selection can be avoided.

***Las Marias:** What makes these products unique in the market?*

Kinner: The 2K series of conformal coatings is particularly revolutionary and unique as it offers the distinctive protection of an encapsulation resin with the ease of application and reduced weight demands of a conformal coating. There is no other solvent-free, high-performance, thick-film, 2K coating material on the market like it. Our FPC fluorinated polymer coating is unique in terms of its lower insertion force required to remove coating during connector mating, hence providing a more reliable connection. It also received UL94V-0 recognition and has a UV trace to aid inspection.

***Las Marias:** What market development trends and which end-applications are shaping product innovation strategies at Electrolube?*

Kinner: The automotive market is currently a major driver of product development, particularly in conformal coatings and encapsulants for electronics in hostile environments, and there are 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 also been a catalyst for accelerating our development of new thermal transfer materials and UV stable coatings for this market. The protection provided by conformal coatings allows for higher power and closer track spacing, in turn enabling designers to meet the demands of miniaturization and reliability.

***Las Marias:** What new technologies should we expect from Electrolube this year?*

Kinner: We will be introducing new encapsulation resins, thermal management materials and conformal coating systems, particularly with emphasis on extending the 2K series.

***Las Marias:** Overall, how does Electrolube provide value to your customers?*

Kinner: Electrolube is among the world's foremost experts in the formulation and application of conformal coatings designed to meet international approvals, including European and American military specifications). Fundamentally, we are solutions providers, we like challenges and solving problems. There are a number of key factors that pass on value to our customers. We are present in 55 countries and offer a truly integrated, global offering with our extensive distributors and our own in-house manufacturing plants based in the UK, India and China. This enables us to provide solutions to customers quickly and effectively anywhere in the world. We also have an extensive product portfolio that includes thermal management materials, conformal coatings, encapsulation resins, electronic cleaning solutions and gener-

al maintenance products. This enables our customers to find solutions in one place rather than having to source several suppliers for their material needs. We also offer a wide range of packaging to better suit customer needs. Our customers also benefit from unlimited access to our technical support experts, who are available to help and advise customers on solutions for their applications, processes and suitable products. We are a collaborative organization who work with industry and customers to develop solutions, and our relentless attention to quality, R&D and innovation is a driving force with our customers to transform their products into secure, reliable devices that deliver a high-performance experience in turn for their customers.

Las Marias: *What is your outlook for your industry this year?*

Kinner: We are very positive about the year ahead, with pioneering new products to launch and increasing our market share in automotive electronics, particularly in line with smart technology and 'green' thinking. We consistently innovate and work in a cycle of research, development and new product introductions in line with changing market requirements. We are always working with the latest technology, anticipating future needs of the market and will be introducing advanced new resin, thermal management and conformal coating technologies this year. We will continue to break new ground in the automotive and LED markets, where growth has been extraordinary for Electrolube.

Las Marias: *Thank you, Phil.*

Kinner: Thank you. SMT

Millennials in Manufacturing: Tom Scales—Manufacturing from an IT Perspective

The next millennial to be featured in the Millennials in Manufacturing column is IT Manager Tom Scales. Tom has been with Saline Lectronics for about two and a half years, and he describes the daily challenges as the most rewarding part of the job:

"As a contract manufacturer, there are always unique problems given the diverse range of products that we make. This affects me directly in IT, supporting changes to an ever-growing set of complex systems integrations and data analysis requirements."

Getting to grips with a manufacturing mindset when it comes to IT support has been a big challenge, especially in relation to cost mitigation.

"Providing the best service my department can, but at a low a cost as possible. That has been a balancing act because the solution that fits us best as a company isn't always the cheapest option. Working on making a business case and proving ROI based on figures as well as technical reasons is very different when you are trying to sell the idea to people who are not experts in your field and do not see the immediate benefit."

One of the other major challenges Tom experienced has been moving from a communications field to a manufacturing support field. Becoming familiarized with the proprietary hardware and software that the company runs, as well as the overall manufacturing process was challenging.

Tom also talked about loyalty, work ethics, motivation, and leadership, as well as what he thinks the manufacturing industry should be doing when it comes to attracting more millennials to join this field.

To read the full article, click here.

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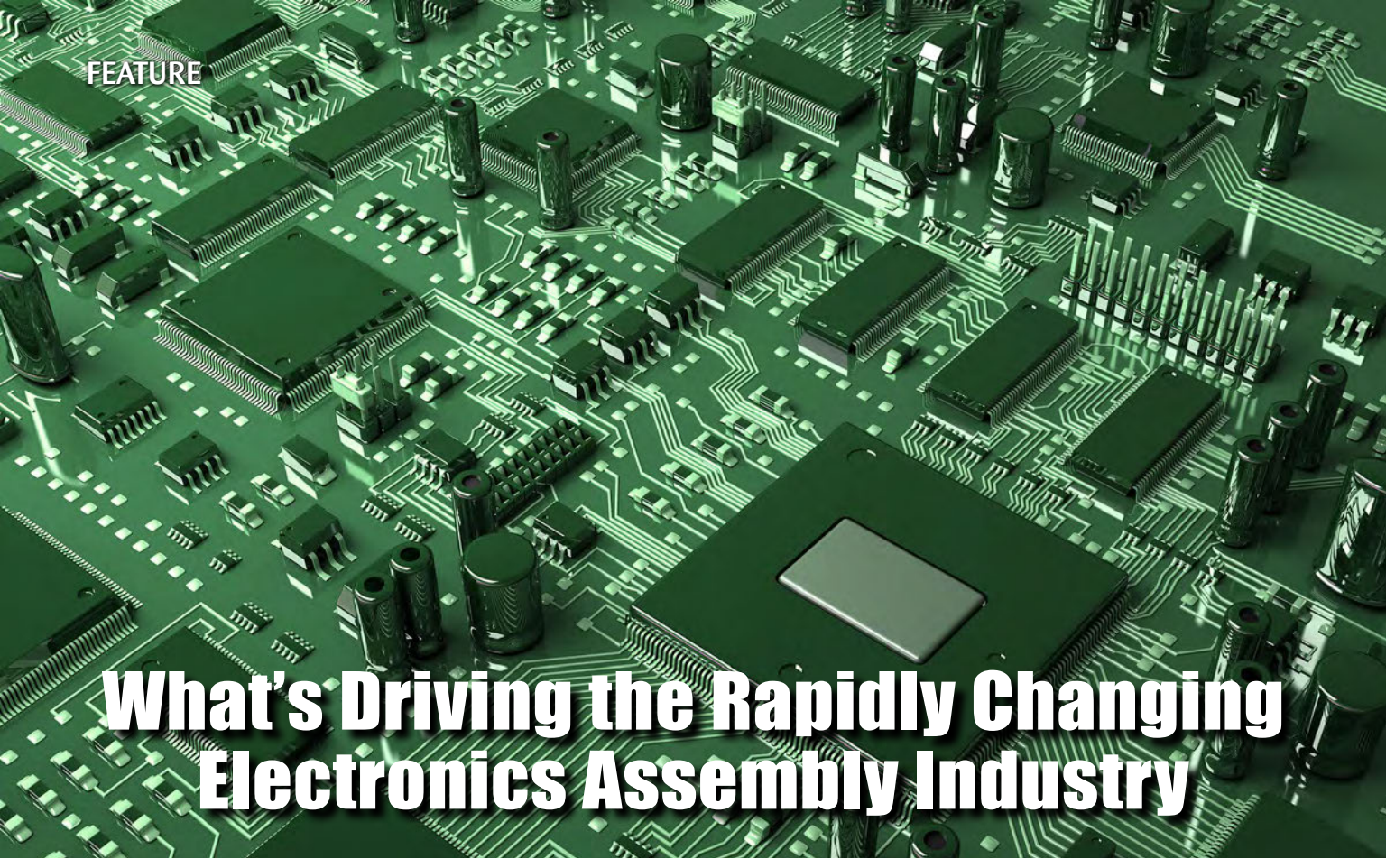

What's Driving the Rapidly Changing Electronics Assembly Industry

by Thom Hansen
MC ASSEMBLY

Since the EMS landscape has become so competitive, staying on top of new advances in technology and being able to rapidly adapt to changing customer needs, market demands, trends and technological advances is critical. The following are some examples of how electronics assembly technology developments have impacted the EMS industry in recent years and will likely continue shaping the industry in the future.

Layers of Verification

Today, recent advances in testing and inspection technology enable a robust quality review process with layers of verification, providing a much more reliable product to customers.

It starts in the very beginning with scanning in bar codes rather than typing in numbers and eliminating the opportunity for human error. This process offers efficiencies and at the same time provides a layer of verification.

The layered testing process continues with automated SMT set up verification and solder paste inspection. Then, an automated optical inspection (AOI), X-ray and visual inspection is used to assure the product meets customer requirements. ICT, flying probe and ESS tests add to the reliability of the products being built. Many EMS's also continually invest in their employees by training them in Lean manufacturing techniques, SPC, regulatory requirements, along with certifications to standards like IPC workmanship, J-STD, etc.

One of the newest technology advances on the market in the last year was an automated router for printed circuit boards. The automated router allows the ability to de-panel boards without stressing the components on the board from a manual de-penalization process.

The other new technology that is popular includes automated conformal coating equipment to eliminate hand spraying and manual masking process. Additionally, 3D AOI technology provides a much better understanding of the quality of product being produced.

New equipment that is currently in development is designed to give faster results and include more capabilities, streamlining and improving on current technology and processes. Any new technology that EMS providers are looking at investing in should add to product reliability or provide flexibility to customers.

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Paperless Work Shops

Many modern EMS shop floor systems are now paperless, where all the work instructions and routing steps are online. Most are forced routing processes, where you have to scan the product in and out of the work cells. It's also how quality and test data is collected with pull down menus and all the reference designations of components, that feeds all the real-time data being provided to the work cells and customers.

The Demand for Smaller Technology

One recent trend, especially in the defense industry, is a focus on man-portable electronics. Everything is shrinking, which affects the size of products and the footprint available to place the components in, so any new technology investments going forward must be geared towards smaller technology, with reliability in mind.

> "Since everything is getting smaller, we're having to place .01005 components on some products now."

Since everything is getting smaller, we're having to place .01005 components on some products now. Technology like wearable electronics, vision goggles, and wearable medical devices, among others, are driving smaller and smaller platforms, which means electronics manufacturing services have to be more diligent, with profiling of thermal properties of the product recipes and equipment that can handle and verify the smaller scale components.

Using smaller components has really driven the industry to be more focused on the upfront quality of the paste, the placement accuracy, and the verification of those components.

Real Time Results

Customers now want to be more involved in monitoring the process and are demanding more feedback and analysis. They want to be able to see real-time results as the product is going through the process.

Customers also want to see real-time feedback on yields and test data, so they can see how their products are performing in reference to the specifications. Customers are paying much more attention to analysis in engineering towards process capabilities and where their products fall in line with those process capabilities.

To meet this demand, most EMS companies are now providing customers with capabilities of their test systems talking back to them directly or indirectly or being able to provide outlets to them through their test systems and online shop floor systems. Reports can be set up to pull yields off the floor and send them via e-mail directly to customers, which gives them all the pareto analysis of their products, the yields, any defective components, and the EMS partner's actions taken to correct any problems. In contrast, the old way of doing things included monthly or weekly data reports that summarized the EMS firm's observations.

Customers enjoy that kind of open communication. They gain confidence in knowing that if a problem arises, they will be notified. It's another way to provide transparency to customers.

Adaptability to Change

Rapid adaptability to new technology and capability is a must in today's EMS environment. The days of hundreds of mom and pop EMS companies are gone. Now, most EMS providers are top rated and competing aggressively for customers. So getting the new technology and becoming knowledgeable of that technology is a must. Being able to continually improve processes to be more efficient and show customers the added value you can provide through quick turnover capabilities and flexibility is the only way to survive. **SMT**

Thom Hansen is the director of operations at MC Assembly—Boston.

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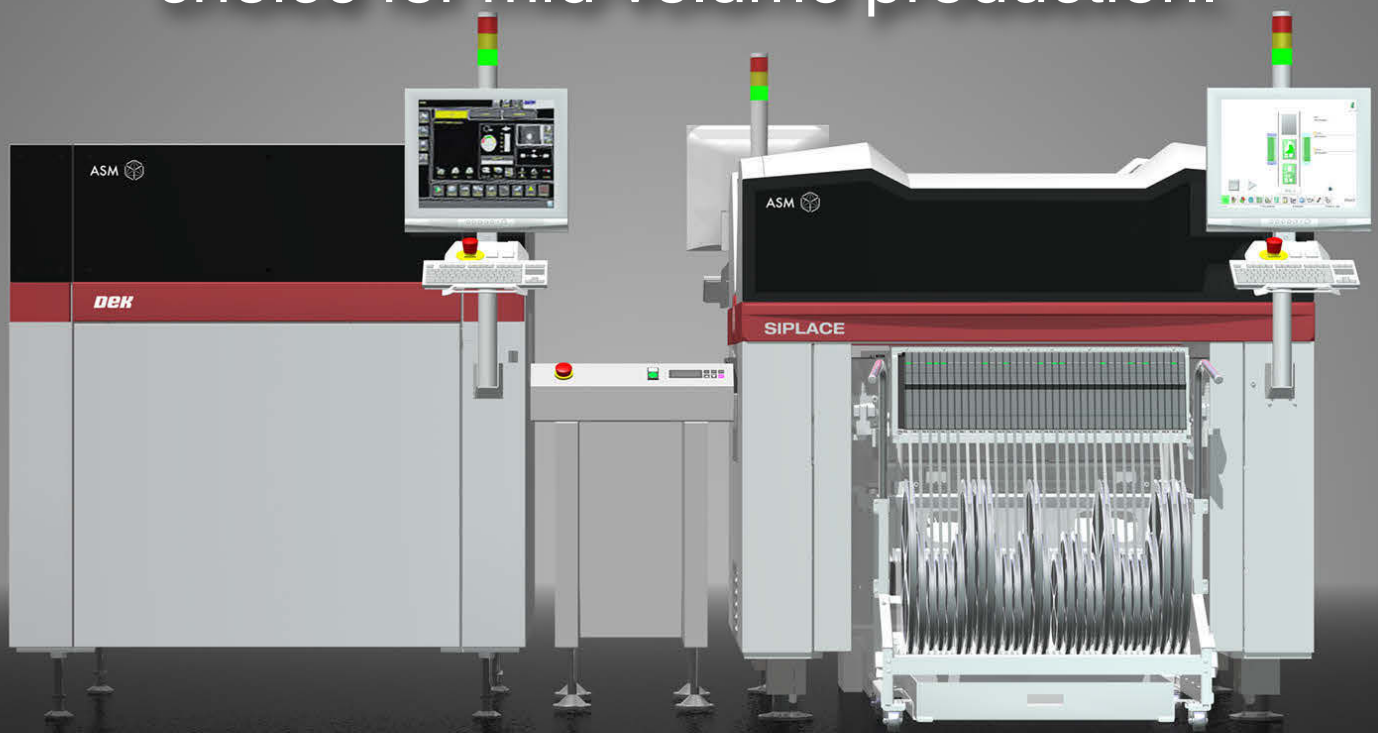

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Supply Lines Highlights

Meeting Current and Future Requirements of the Automotive Industry

Phil Kinner, technical director of Electrolube's Coatings Division, speaks with I-Connect007's Pete Starkey about the role of conformal coatings in various applications of the automotive industry.

Nordson Acquires ACE Production Technologies

Nordson Corp. has acquired assets of ACE Production Technologies Inc., a designer and manufacturer of selective soldering systems used in a variety of automotive and industrial electronics assembly applications.

New Representative for Rehm Thermal Systems

Rehm Thermal Systems has further expanded its international sales structure with the appointment of Exmore as its representative for Belgium, the Netherlands and Luxemburg.

Cogiscan Hires New Applications Engineer in India

Cogiscan Inc. has appointed Yogesha S.K. as an applications engineer in India.

Indium Corporation VP of Technology Elevated to IEEE Fellow

Indium Corporation's Dr. Ning-Cheng Lee, Vice President of Technology, has been bestowed the prestigious title of Fellow of the Institute of Electrical & Electronics Engineers (IEEE) for his leadership in surface mount technology and interconnect materials.

AIM'S Timothy O'Neill Obtains IPC-A-610 Certification

AIM Solder is pleased to announce that Timothy O'Neill, technical marketing manager, successfully completed the Application Specialist course of study on IPC-A-610, Acceptability of Electronic Assemblies, and is now recognized as a Certified IPC Specialist.

Speedprint Appoints Mark Brawley as President

Mark Brawley has been promoted to president of Speedprint Technologies, with responsibility for all aspects of the Speedprint business globally.

KIC Celebrates 40th Anniversary

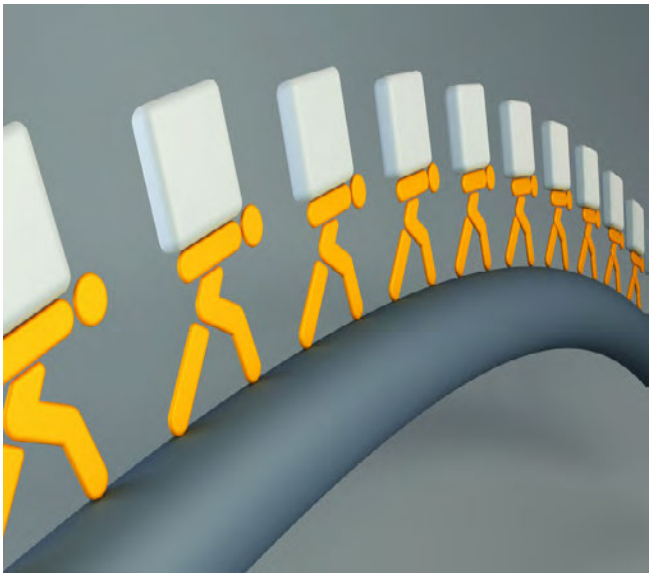
KIC is celebrating its 40th anniversary in the thermal processing business and helping manufacturers improve quality while reducing costs.

Aqueous Technologies Marks 25th Anniversary

Aqueous Technologies, a manufacturer of automated circuit assembly cleaning equipment, cleanliness testing systems, and stencil cleaning machines, is celebrating its 25th year in business.

Nordson to Retain ACE Manufacturing, Service and Support in Spokane

ACE Production Technologies Inc. will operate as a new line of business within Nordson's Advanced Technology Systems segment. The engineering and manufacturing operations together with the customer support function of ACE will remain in Spokane Valley, Washington and will report to Peter Bierhuis, Vice President – Nordson Advanced Technology, Process Systems.



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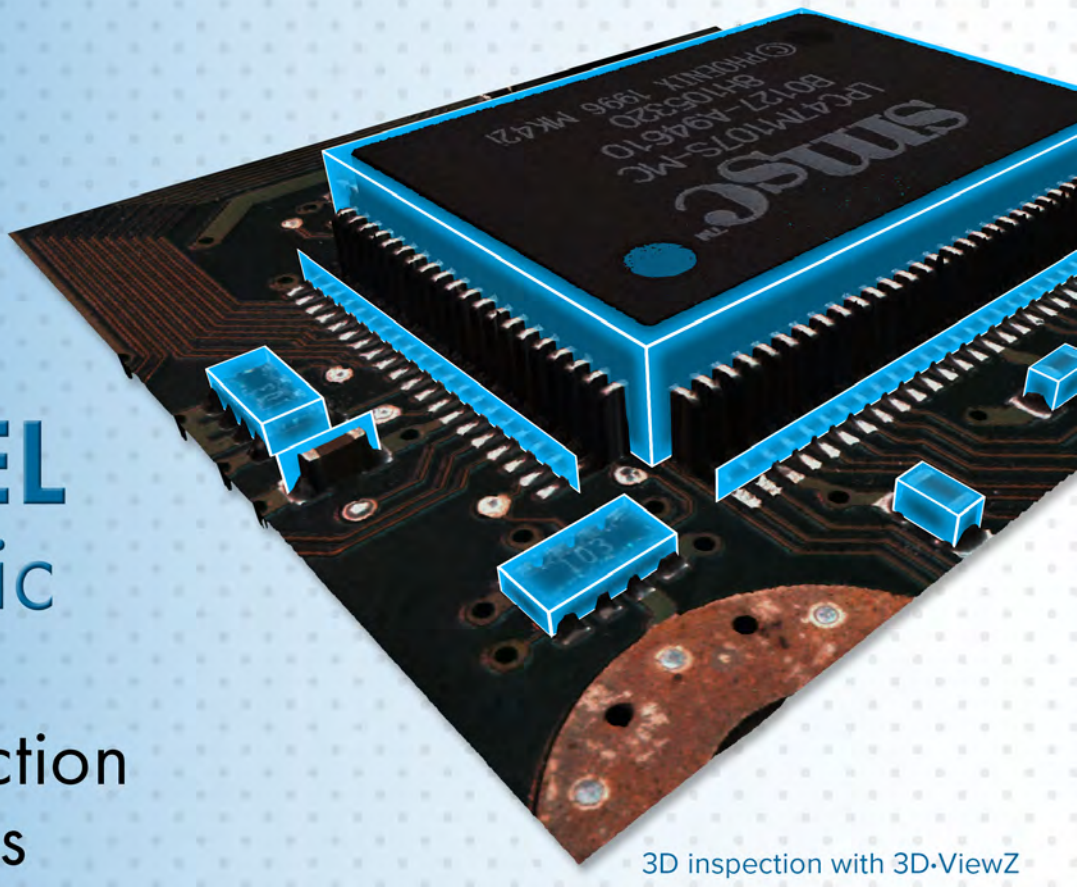

3D inspection with 3D·ViewZ

by Stephen Las Marias
I-CONNECT007

Thomas Wenzel, managing director of the Embedded JTAG Solutions Business Development at GOEPEL electronic, talks about the latest technology innovations happening in the test and inspection segment, and the market trends shaping them.

Stephen Las Marias: ***What are the greatest challenges that your customers face when it comes to test and inspection?***

Thomas Wenzel: Each new generation of products increases the problem of physical test access. This has led in recent years to a strong demand for embedded validation, test, debug and programming solutions, but also for new methods of inspection.

Thomas Wenzel

Contract manufacturers often have to cope with high requirements from their customers, and linked data management over several systems for more efficient production, which is an aspect driven by the Industry 4.0 trend.

Las Marias: ***How is GOEPEL addressing such issues?***

Wenzel: In the field of automated inspection—AOI, AXI, SPI—3D is the keyword in the recent times. While three-dimensional inspection of the solder paste volume is a standard, the market shows an increasing demand for 3D AOI systems. Nevertheless, a combination of 2D and 3D together with angled-view seems to be the most versatile solution.

For electrical test, there is a continuous trend towards integrating more and more test and programming functions directly into the target and to use these embedded technologies during the entire product lifecycle.

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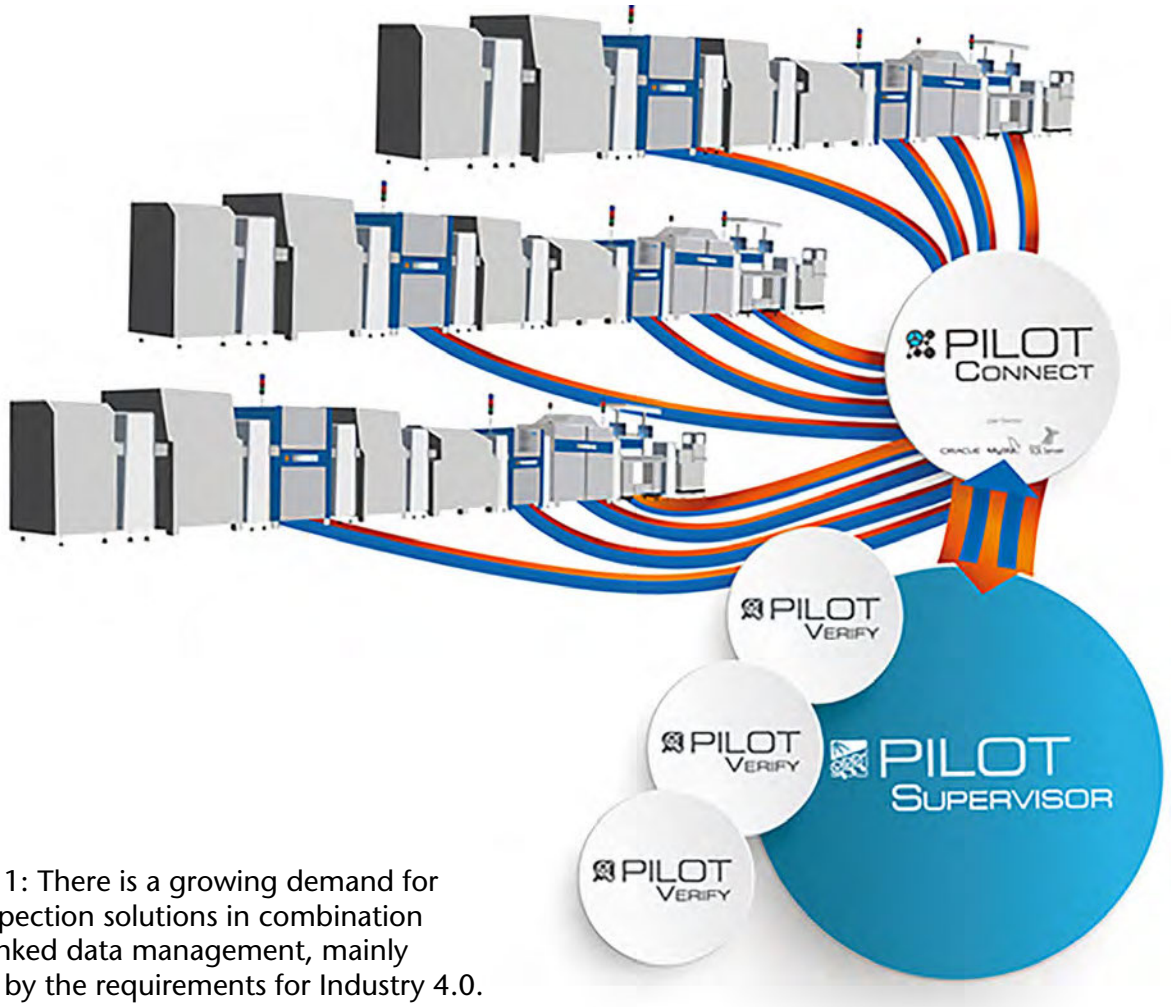

Figure 1: There is a growing demand for 3D inspection solutions in combination with linked data management, mainly driven by the requirements for Industry 4.0.

With PILOT Supervisor, a central verification of inspection results from different AOI/AXI/SPI systems and production lines is possible—even from third-party manufacturers, which is a further step towards Industry 4.0.

Using our new SCANFLEX II architecture, it is possible to combine all the innovative embedded system access procedures, including mixed signal tests on one hardware platform to solve the problem of lower physical test access without a compromise on test coverage.

***Las Marias:** On average, how long does it usually take to create a new test/inspection equipment?*

Wenzel: GOEPEL's development philosophy is based on modular designs. This enables a high degree of flexibility to adapt a solution on new requirements or to improve certain performance criteria. In this respect, we are talking about typical development times in the range between three to six months. The development cycle for a complete new equipment generation need in average of one to two years, depending on the product application. Our ISO 9001-certified development flow helps us to cope with the challenge to synchronize the many different design disciplines covering optics, mechanics, electronics, software and haptics. Concurrent engineering is another very important part of this strategy.

***Las Marias:** What market development trends are shaping product innovation strategies at GOEPEL?*

Wenzel: On the one hand, there are many challenging product developments from our customers that we need to support with our so-

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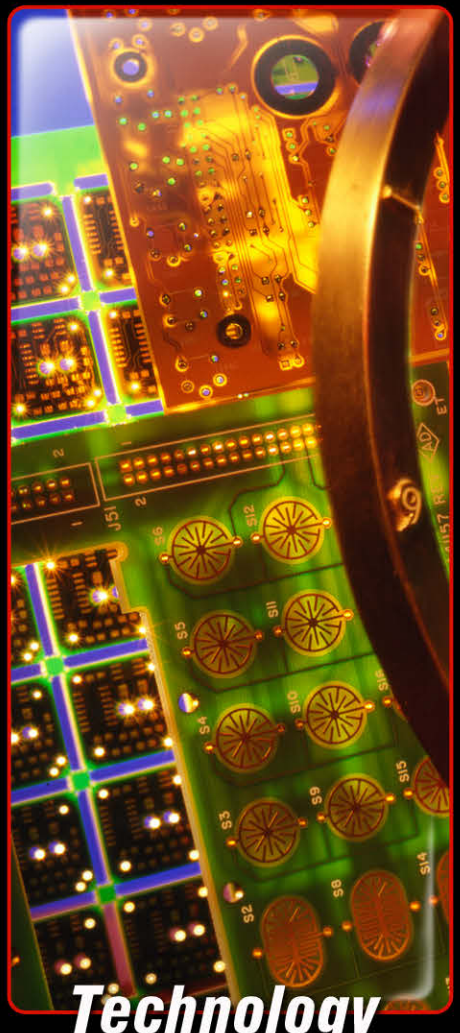

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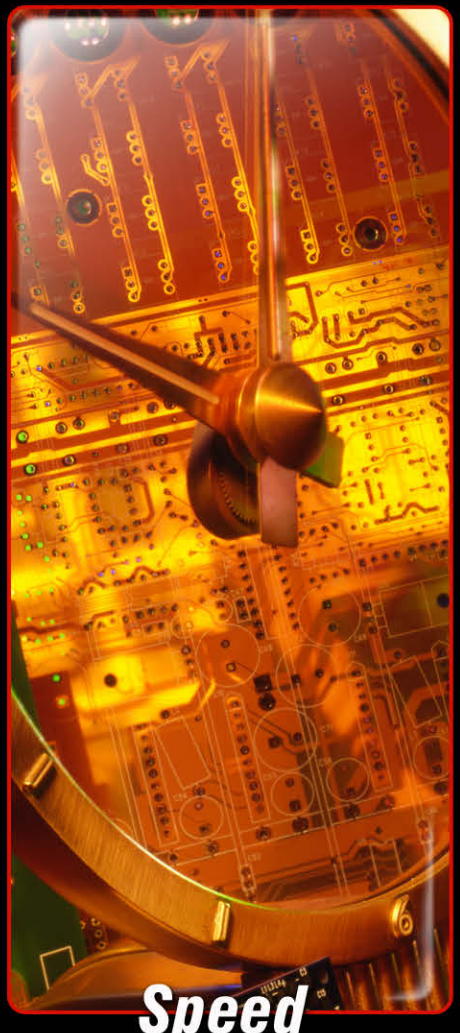

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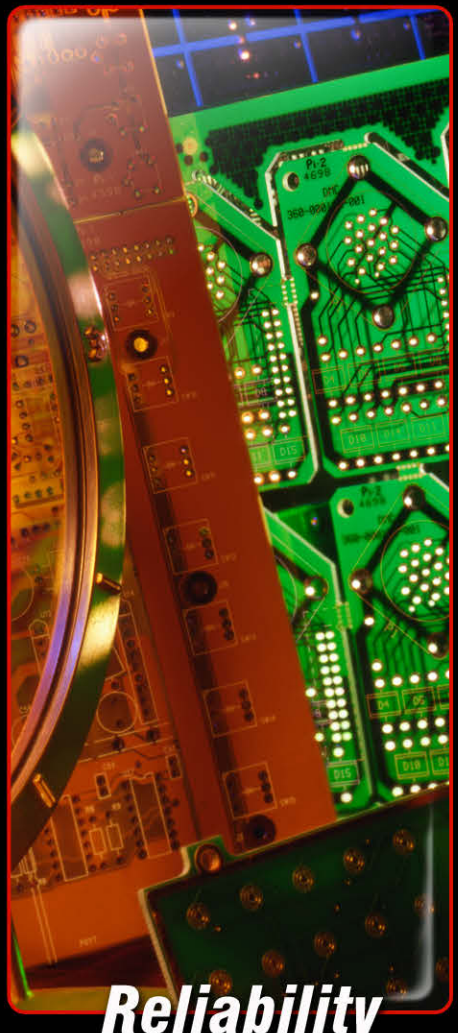

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Figure 2: GOEPEL will launch multiple new products for test and programming based on the new SCANFLEX II technology.

lutions. Market trends include IoT, 5G, smart devices, and advanced driver assistance systems (ADAS) in the automotive industry, just to name a few. Delivering to our customers exactly the equipment they need to stay competitive is our first priority.

On the other hand, we are implementing newest technologies like cloud services, software defined instrumentation, mixed signal tester on chip (ToC), all programmable SoC solutions, and adapted optics in our products to stay ahead in the frame of Industry 4.0.

***Las Marias:** What new technologies should we expect from GOEPEL this year?*

Wenzel: In the domain of the embedded solutions, GOEPEL will launch multiple new products for test and programming based on the new SCANFLEX II technology. New software features in the JTAG/Boundary Scan platform SYSTEM CASCON and many new test and programming IP for software based instrumentation will complement the product portfolio further. Especially the test of high speed I/O is here in the scope. In the field of inspection solutions, we will focus in increasing the speed of our 3D inspection systems to provide the fastest systems with the highest test depth in the market.

***Las Marias:** How does GOEPEL provide value to customers?*

Wenzel: GOEPEL delivers a wide range of complementary products for optical inspection, X-ray inspection, solder paste inspection, industrial test, embedded test and programming, and automotive test. Thus, it is possible to offer tailored solutions up to turn-key systems that exactly fit the needs of the customers. In addition, through our embedded solutions, we can help customers shrink their designs and improve the test coverage, compared to traditional invasive access techniques. Last but not least, our inspection systems help customers improve the throughput and optimize the process quality with their linked data management.

***Las Marias:** What is your outlook for the test and inspection equipment market this year?*

Wenzel: We see a growing demand for 3D inspection solutions in combination with linked data management, mainly driven by the requirements for Industry 4.0. Here, we expect significant growth. Due to the continuous erosion of the physical access, we also expect our embedded test and programming solutions further growing, especially for high speed I/O test and embedded functional test. Our automotive test solutions are well equipped for the expected market growth in the domains of advanced network testers, bus controllers, run-in testers, seat testers, motor testers and many others. **SMT**

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The New IPC Standard for Traceability Makes Compliance and Reporting Easier

by Michael Ford
MENTOR GRAPHICS CORP.

IPC has created a new standard and specification for traceability practices across all levels of electronics manufacturing, and specifically for electronics assembly. The IPC-1782 standard defines four levels for material and process traceability[1]. With this new standard, companies that are practicing basic levels of traceability can evolve to higher levels (Table 1). Implementing this standard means that companies will be able to clearly define the expectations of what is required for compliance and conformance to customer needs.

Traceability is often a key component of quality standards across the electronics industry. But it has been approached from various points of view, and it can be defined as any combination of material traceability, product tracking, and process recording. And even within material traceability, views can differ on what should be recorded, how detailed it is, and how accurate it needs to be. Materials traceability could mean tracking specific materials to a work order, to a specifically identified PCB within a work order, or even to a specific component placement on that PCB. It may include all types of materials or perhaps only high-value, safety-critical parts or serialized parts. It may include or exclude parts replaced at repair stations or where an alternative or substitute part has been used, and it can include many more examples where a choice in the depth and breadth of recording is needed.

Accuracy is another area of contention. Process operational efficiency may conflict with the accuracy with which the traceability data is collected, as for example trays are re-filled without positive poka-yoke confirmation of verification. These are just some typical variations in the level and degree of material traceability. For product tracking and process data recording, an immense number of other similar decisions have to be made.

Individual companies typically have created their own set of high-level rules for traceability data that should be collected as part of their conformance requirements. The problem with all of these different specifications, often made without an in-depth understanding of the processes involved, was that exactly what data should be recorded, from where, and how it was supposed to relate to the product and process was left undefined. This has resulted in the collection of traceability data that is unreliable, incomplete, and/or irrelevant.

Negotiations around traceability requirements between the product owner and manufacturing have become increasingly difficult be-

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	Level 1: Basic	Level 2: Standard	Level 3: Advanced	Level 4: Comprehensive
Material Traceability	**M1:** Part number listed to work order	**M2:** Unique material ID listed to work order	**M3:** Unique material ID listed to PCB assembly	**M4:** Unique material ID listed to reference designator
Process Traceability	**P1:** List significant process exceptions to work order	**P2:** List critical process characteristics and exceptions to serialized PCB assembly	**P3:** List all key process characteristics and exceptions to serialized PCB assembly	**P4:** Capture all available metrics to serialized PCB assembly
Data Integrity (in the range of)	3 Sigma	4 Sigma	6 Sigma	9 Sigma
Data Collection/ Storage Automation	90% Manual	70% Automation	>90% Automation	Fully automated
Reporting Lead Time	48 hours	24 hours	1 shift	Available at completion of the process
Data Retention Time	Life of product plus 1 year	Life of product plus 3 years	Life of product plus 5 years	Life of product plus 7 years

Table 1: IPC-1782 summary of traceability levels.

cause neither speaks the same language, and they have common no point of view. Spectacular and public cases of product recalls have been the result, even while electronic systems are becoming more of a critical part of our everyday lives, and counterfeiters are having a significant effect on product quality and brand trust.

Compliance to internal or external standards helps assure manufacturers that work is only placed into manufacturing centers which demonstrate the appropriate compliance certificates or approvals. Today, compliance requirements extend to all quality sensitive markets for electronic goods such as military, medical, automotive, aerospace, telecommunications, and industrial controls. Even lower-priced consumer goods, such as handsets, toys, and games, require safety and environmental compliance. Manufacturers who are not able to demonstrate this compliance simply do not win business in these markets. These trends are driving manufacturers to implement higher levels of traceability for a wider range of industry segments.

The IPC-1782 Critical Components Traceability Task Group was created to address these issues. This committee has completed the first all-encompassing traceability standard for electronics, which is designed to be applicable to every product, in every company. Traceability is seen by many as a burden to the manufacturing process, and no one wants to have to comply or conform to yet another process or standard in the office or factory. The IPC-1782 committee members who all contributed so much to the creation of the traceability standard agreed that traceability ought to be implemented based on the merit that it brings to the manufacturing operation, rather than through some compliance mandate.

The nature of electronics assembly is hierarchical. A finished product, represented by an assembly cell, is typically made up of raw materials plus subassemblies. Each of the subassemblies is, in turn, a finished product of another

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assembly process also made up of raw materials and potentially other subassemblies. Thus, the IPC-1782 task group thought that the structure of traceability data should align with this physical reality. Figure 1 is a simple illustration of this structure.

The assembly cell, here identified as "724435," contains data about the work order and process sequence, BOM, the process traceability data, which is a record of events and transactions that have taken place during the assembly process, and the materials traceability data which contains information about specific raw materials, as well as other "roots" of information about each subassembly.

A raw material is defined as any component that does not have a traceability record. Because this is a modular approach, the traceability detail of subassemblies can be combined easily at a later date, either when the subassembly is used, or even later, as long as the unique ID of the subassembly is recorded. The subassembly data can later be imported or simply referred to when stored in a connected system.

Then, specific cells of information that contain different attributes are defined for each of the materials and processes. The IPC-1782 standard lists the requirements for data capture for each of these cells, relevant to the specific level of traceability chosen: M1 through M4, and P1 through P4.

In the case of process traceability, common elements of traceability data apply to all processes and then additional requirements are dependent on the specific process type. For example, common elements are process name or ID, time in and out of each PCB, etc. Specific data by machine type would include the list of materials consumed for an SMT process as well as details of machine errors during the operation, whereas a test process would include a pass and fail result, as well as process measurement data.

For all the materials identified as being used at each process, the associated material traceability data cells are referenced. Information in these cells can include unique material IDs (as well as unique carrier IDs), supplier, date code, etc. The method of linking material traceability data through the use of unique IDs and the cellular structure of the data means that, at higher levels of traceability, data does not need to be repeated within the data structure. Any specif-

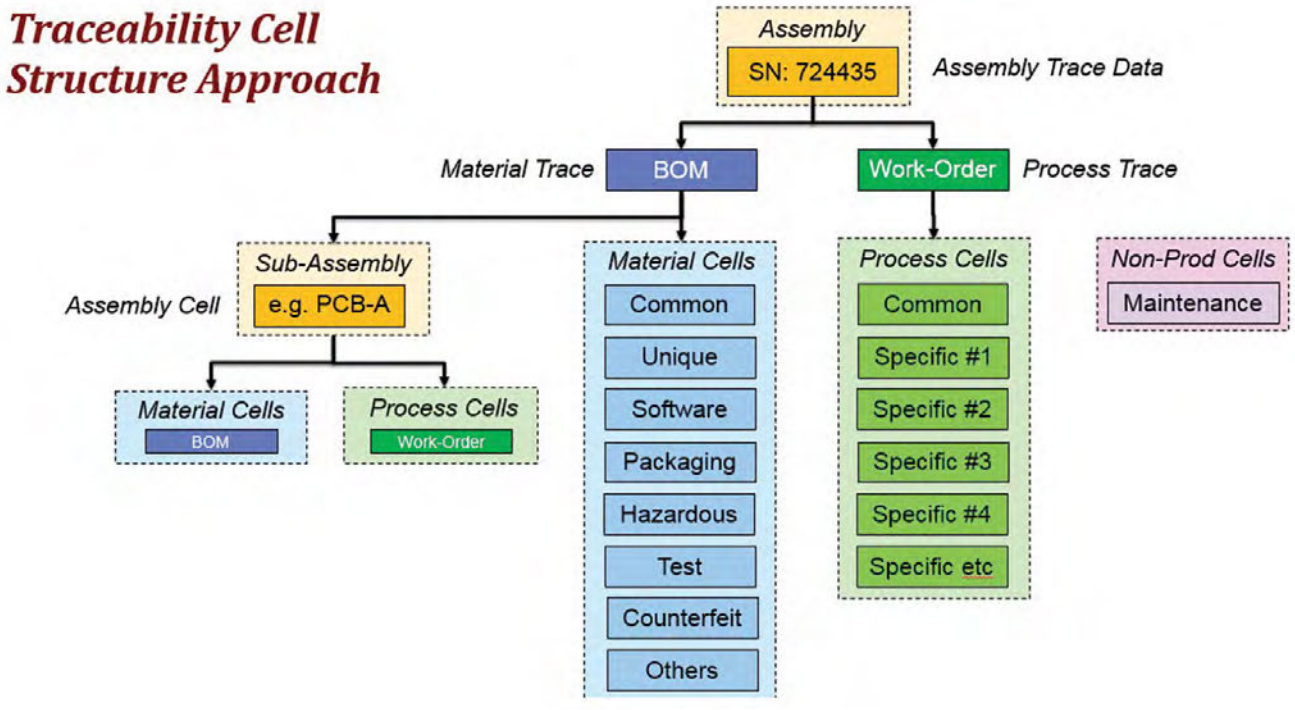

Figure 1: The hierarchical data structure approach adopted by the IPC-1782 standard.

ic material, identified by an ID with associated traceability data is needed only once and may be referred to from many reference designator positions on many different assemblies, and even across many different products. This helps to reduce the storage requirement for the data by a significant amount by eliminating needless duplicate data.

In addition to product specific records, the traceability structure also includes data relating to equipment maintenance, kept separate from the assembly tree structure, because it need not be related to any specific product but is time-based data which may occur while a product is being made or between products.

How to Implement IPC-1782

The IPC-1782 standard is designed to be as simple as possible to implement. It's not just a simple linear list of requirements, and understanding the hierarchical nature of the data, the content of different cells with different levels of detail, is necessary.

For getting started, first use the risk assessment methodology and IPC classifications to determine the target levels for traceability. Level 1 traceability for either process or materials is the minimum level that would be expected for any manufacturer of good standing. Level 4 would be appropriate only for the highest demands in the industry, especially with regard to process data. EMS companies may find that different levels of traceability may be required for different lines of products or for different customers.

The next step in the adoption process is to compare the calculated requirement with what is currently in place. This can be represented by existing quality or management control systems or negotiations with customers or product owners. Most of the data required for traceability likely exists within the operation, and a communication method needs to be established so that the data can be brought together in the form outlined by the IPC-1782 standard. Avoiding manual data collection will decrease the cost of traceability implementation and also increase the accuracy and timeliness of the data collected.

Most automated machines in the market that have been around for many years have some sort of data availability, which may require machine-vendor software support. Data may also be collected from transactional systems such as planning, material control, and including verification operations, etc. All of these sources of data can be combined more easily through the adoption of a single format, such as the Open Manufacturing Language (OML)[2], available today, which already supports IPC-1782 requirements. A single common language ensures a minimum of integration effort into databases, such as cloud systems and smart computerizations related to Industry 4.0 and smart factories.

Next, negotiation of contracts and agreements between manufacturing and product owners can be done with more simple definitions of expectations. Some education about the implementation of the standard, including how data is collected, may be required in the earliest stages. Traceability, related to materials and process, may initially start at a lower level until the inter-process communication infrastructure can be established and reliable in practical operation. The levels may then be increased over time, as more value from the traceability data is sought and related costs of data acquisition diminish.

A traceability system continuously contributes to the bottom line in the areas of insurance, conformance, and quality performance for the whole PCB assembly operation, and the new IPC-1732 standard, makes dealing with these issues a whole lot less painful. SMT

References

1. The IPC-1782 Standard for Manufacturing and Supply Chain Traceability of Electronic Products can be previewed, purchased, and downloaded by clicking here.

2. The OML Community website is at www.omlcommunity.com.

Michael Ford is senior marketing development manager with Mentor Graphics Corporation Valor division. To read past columns, or to contact the author, click here.

A New Organizational Model Using Logic, Cost Effectiveness and Customer Service, Part 3

by Tom Borkes
THE JEFFERSON PROJECT

Many of us look to the new U.S. federal administration sworn in on January 20 with a high level of economic curiosity. How will the new President's economic policies affect the high-tech electronic product assembly industry? Will the policies result in more jobs in our industry going to sources with low labor rates, or will they result in a renaissance of manufacturing and assembly activity here in the States and other high-labor-rate regions of the world?

As President-Elect, Trump said: "Companies are not going to leave the United States anymore without consequences."[1]

Does that mean that U.S. companies choosing to manufacture outside the U.S. will be penalized with an import tax (tariff) on their products when they are imported to the States for sale? That is the threat.

This is the sort of protectionist policy Brazil has had in place for decades. Products that are assembled outside Brazil and imported into Brazil are taxed. The increased price of the product is passed along to the Brazilian consumer. So, if you want to competitively sell your products into this large market (about 210 million people), you really need to assemble it there.

Historically, the evidence suggests when the government tinkers with the private business sector it never ends well. And, "ends" is the operative word.

We live in a throw away world. Whether it is a diabolical crime or a Super Bowl victory the impact of a news story doesn't last very long in the collective consciousness.

Politicians are aware of the public's fleeting appetite. They will often promote a policy that sounds good in the moment and plays to the emotional mood of the people for the potential popularity or vote count it brings—establishing a straw man on which to blame the plight of the

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people. This promotion is often done without regard to the long term damaging effect of the policy. This is the definition of a demagogue.

Having the government pick business winners and losers, even with the noblest intentions (e.g., leveling the playing field) may seem like the right thing to do, but eventually leads to making a bad situation worse, not to mention creating an environment rife with the potential for corruption.

Brazil and Venezuela are contemporary examples of these government-centric, collectivist private business policies.

To view the opposite end of the free market spectrum, look at Hong Kong when it was under British rule: total free trade. It was a bastion of economic activity. It is interesting to note that in 1997 when Hong Kong was returned to the control of the People's Republic of China, the free trade policy was maintained. So, where business in mainland China is regulated under a system of government controlled State capitalism, the Chinese government has refused (at least for now) to kill the Hong Kong golden goose cash machine. In addition, their business, or profit tax rate is 16%. In the United States, it is 35%.

To Tariff, or not to Tariff, That is the Question

Milton Friedman, a father of economic freedom, described a government imposing a punitive tariff this way: Imagine you are in a canoe on a lake with a rival. An argument ensues leading to your opponent shooting a hole in his side of the canoe. You decide to get even by shooting a hole in your side. The result in the long run is that both parties lose.

The point is, many think of government protectionism as a way for a country to create and maintain jobs and promote economic prosperity. This is predicated on the assumption that it is better for a country to export rather than import goods. We speak of a favorable balance of trade, as one where a country exports more than it imports. Or, use the pejorative term trade deficit to describe a country that imports more goods than it exports. This is a hotly debated question and beyond the scope of this column except to say the following: Timing must be considered. If there develops a scarcity of jobs in an industry because companies who design products have outsourced the manufacturing of those products to areas with low labor rates, consider this: What will accompany the exodus of manufacturing jobs is a reduction in the disposable income of those consumers.

So, it's fair to question to ask what good is it for a country to corner jobs in a particular industry if, in the long term, they destroy the buying power of the markets they want to sell the products into depressing that industry's economy?

In the long run, the effect in the manufacturing country will be upward pressure on labor rates, causing an increase in product prices making other manufacturing sources compete more favorably. In the consuming country, prices for the imported product will rise, both from the manufacturing country's increasing labor costs resulting in them raising their prices and the government imposing tariffs. The consumer eventually loses.

A Milton Friedman disciple would maintain that importing products made by others is actually a badge of economic success for a country, not a symbol of economic failure.

Why? Because it is a country's consumer who rules and makes the rules based on immutable economic law. This happens automatically without any conscious action. Adam Smith (the Scottish economist and contemporary of Thomas Jefferson) called it the "invisible hand."

Product prices are set, demand is created and industries are ultimately successful not because of government—*the government hand*—but by the natural laws of economics, or the invisible hand.

So, what is the general guideline for global business success? Find products, services and industries you can compete in successfully: on the merits of your product designs and/or value of your manufacturing services—not by hiding under your government's protectionist shield.

Back to Brazil: In Florida, as a prime tourist destination, we have a huge population of Brazilian visitors each year. As popular as the theme parks are there is another destination many will add to their holiday itineraries—the Apple Store. Why? Apple smart phones cost

50% less in Orlando than in Sao Paulo.

So there it is: If you buy the premise, then the way to win is to sell better products at lower prices—not whine about the protectionist policies of the competition.

What these *Jumping Off the Bandwagon* columns have attempted to do is provide a roadmap toward that end. Assuming the company's controllable component of product cost is labor, the columns have analyzed the corridors of labor looking for advantages and edges to realize the cost reduction part of this goal.

The other part of the product cost pie is material and shouldn't be ignored out of hand. However, at this point, it is beyond the scope of our discussion[2].

In summary, the following has been concluded:

1. Automation is the counterweight to low labor rates. High labor rate environments can compete by reducing labor content through automation.[3]

2. In this automated environment, the workforce needs to be transformed from many low paid direct personnel to a few high paid engineers with the ability to develop and maintain the automated processes.[4]

3. This new workforce must be cross-disciplined with each member having multiple skill sets and the versatility to multitask and wear whatever hat is necessary at a particular point in time. They will be focused on the products they are assembling, not the departments from whence they once resided.

4. What must accompany this workforce transformation is a transformation in the company's organizational model. The reduction in labor content must be accompanied by a corresponding reduction in indirect and overhead cost since there is less direct labor to absorb these costs[5].

5. This new organizational model is a structural disruption from the traditional hierarchical form of power pyramid (Figures 1 and 2).

6. What is needed for the new workforce requirements and new organizational structure is a new approach to education[6].

Doing Things the Way We Always Have Done Them

As discussed in last month's column, it seems we have hierarchical, pyramid shaped organizational structures because they are rooted in the past, not because they are necessarily best (Figures 1 and 2). They certainly cost more than alternatives.[4]

As mentioned last month, over the centuries academia has been able to adjust their educational offering to our changing understand-

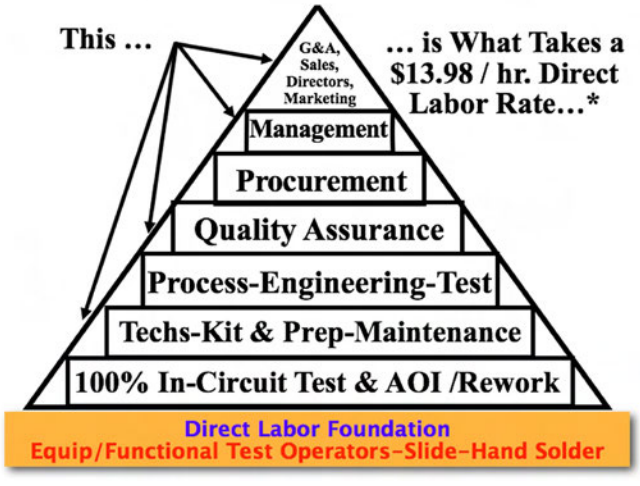

Figure 1: Direct and indirect labor cost contributors in a hierarchical pyramid organizational structure.

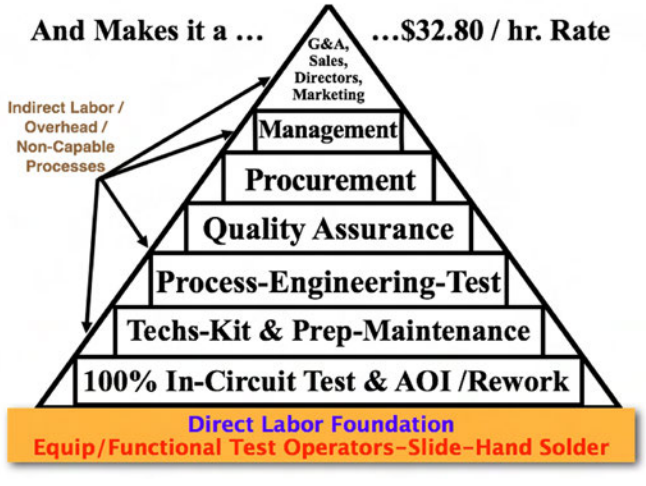

Figure 2: The effect of loading indirect labor cost on the direct labor rate.

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ing of the general laws of science. What they haven't done very well is adjust to the constantly changing practical application of these laws in product production—what we call industrial engineering.

Professors try to interpret the real world's needs and adjust, but those without practical experience continue to fail in the learning for earning part.[6] They are always playing catch up.

Noble Intentions, Failed Results

Sometimes we may have noble strategic objectives, but fail to develop or carry out a tactical plan to meet those objectives—the words are easy. Academia always has good intentions for industry, but seldom achieve good results. An academic institution has an objective of giving their students a firm understanding of the classical subjects. Part of the tactical plan that schools use to achieve this objective in technical subjects is to confront students with closed-form problems. Students that can demonstrate success in solving these problems are thought to have grasped an understanding of the underlying subject matter.

In the real world, critical thinking is an invaluable tool to solve the open-form problems that, more often than not, we are confronted with. Even with the best intentions, the academic classroom is a difficult environment to teach this important judgment tool.

The real world has had to comply with academia, rather than demand that academia meet their needs for qualified graduates. Lofty thinking and the ability to solve non-linear differential equations, while important, are not critical to success on the production floor.

How are We Going to Pay These People?

In previous columns, we introduced a fictional electronic product assembly company, Chips and Dips Inc. or what we affectionately call C&D.[7]

Two of the organizational charts for C&D at the top of the hierarchical pyramid are found in Figures 3 and 4. There are about 20 more. All of these departments, sections and groups are managed and nested into those above them until we reach the top level organizational chart (Figure 3), where they ultimately reside in one of six directorates, hence, the term hierarchical:

1. Operations
2. Engineering
3. Business Development
4. Finance
5. Quality
6. Human Resources

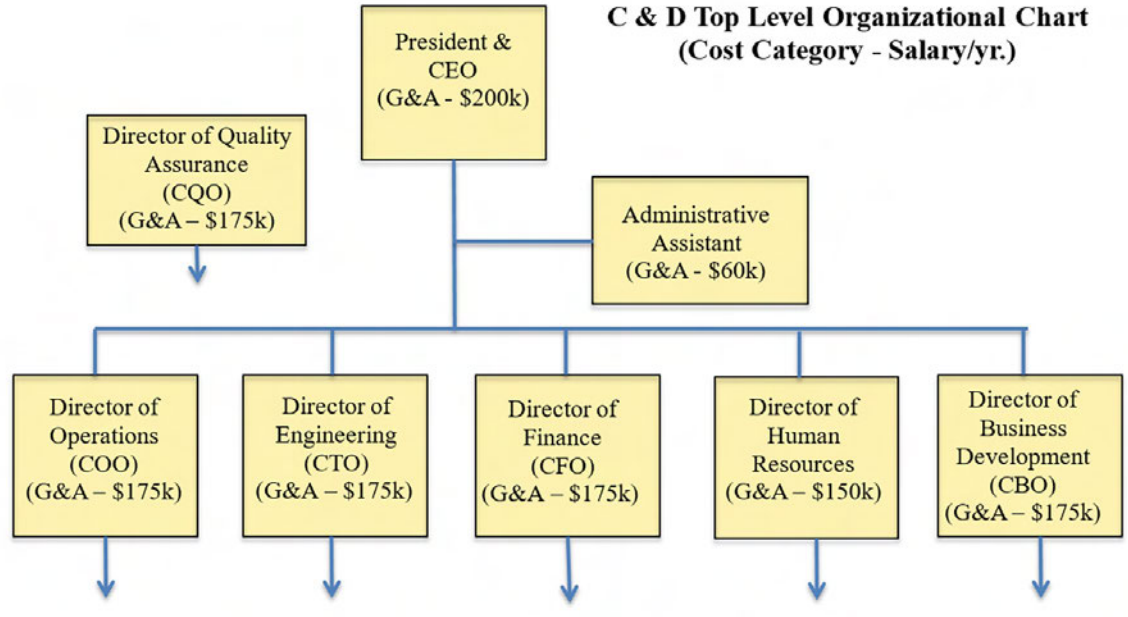
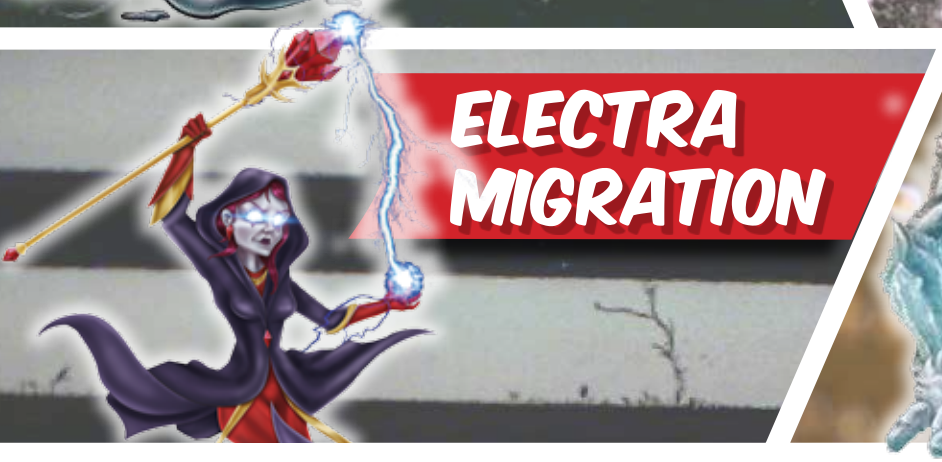


Figure 3: C & D top level organizational chart.

Are these villains wreaking havoc on your processes?



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Adding the total cost of this top level chart alone results in $1.285 million in salaries (this does not include the cost of each employees benefits, at an average of 40% of salaries, or $514,000) and incentives. This adds up to a general & administrative cost of about $1.8 million, plus indirect cost that MUST be absorbed by the direct labor rate when we quote a job—say, to build electronic home alarm security systems for an original product developer (OPD).

Add to this the indirect labor expended by the operations directorate (Figure 4), about $2 million more. This causes us to load the average direct labor rate (the average salary with benefits) of machine operators, hand assemblers, test personnel, hand soldering, etc., typically hourly employees used for the direct assembly of the product with about $3.8 million. But that's just part of the indirect cost iceberg—there are five more directorates!

All the department managers and some entire departments in the other five directorates are indirect labor sources as well, and must be absorbed by selling direct labor. This brief discussion makes it clear why the volume of direct labor that we sell is critical.

As striking as these indirect costs are, the organization's departments also create natural silos. This results in an employee's sense of working for operations or engineering or quality assurance first, not C&D!

Unless we have very strong leadership and managers who put the welfare of the company ahead of their own departments, decisions are often made in the best interest of a department, not C&D.

And let the warfare begin as the hunt for the root cause of a bad company result is fought on an organizational battlefield that pits department against department, using weapons of

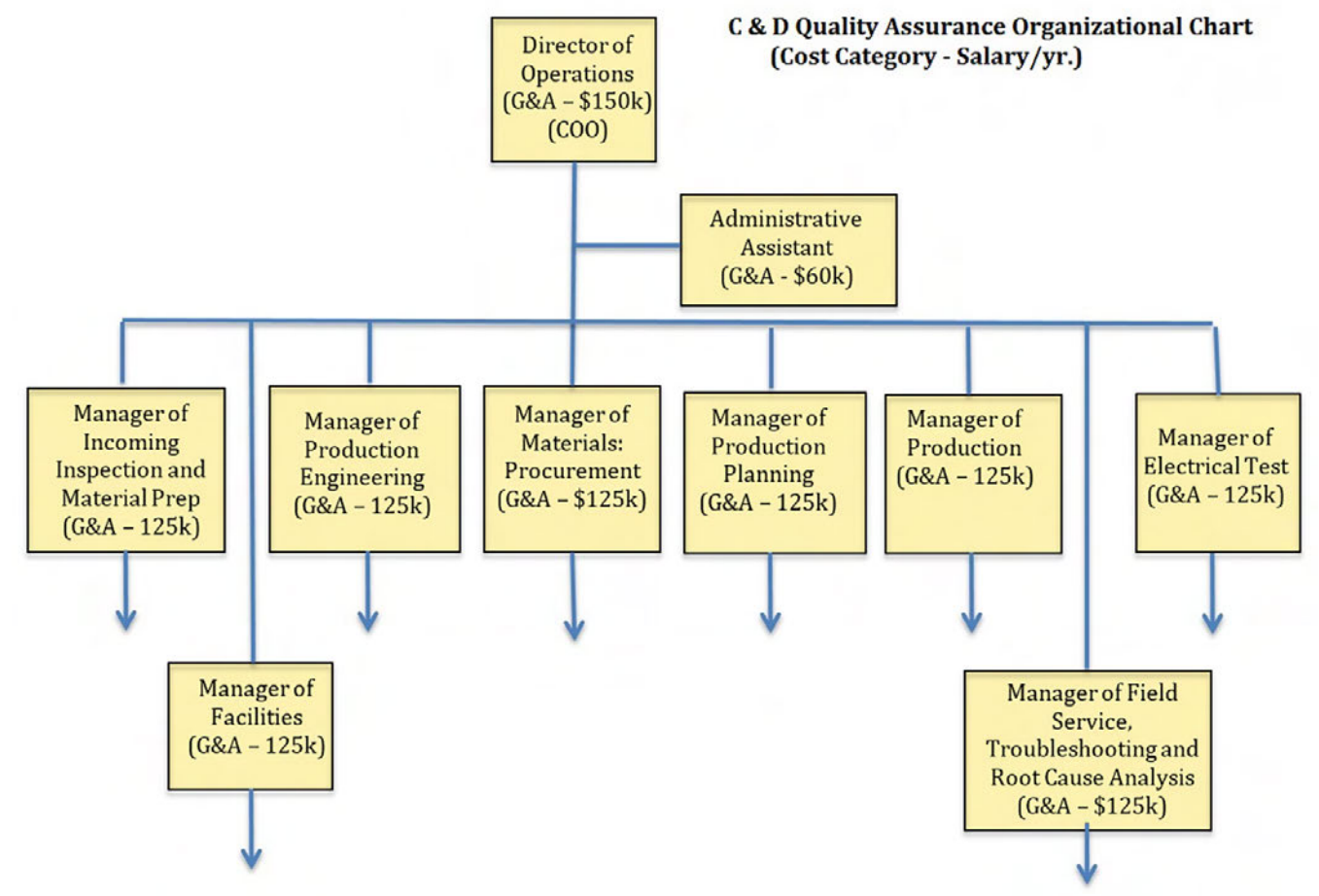
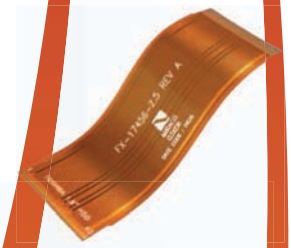


Figure 4: C & D quality assurance organizational chart.

Engineering And Providing Balanced Interconnect Solutions



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denial, blame and finger pointing. I've seen it many times; maybe you have as well. It's not a pretty picture.

The tentacles that tie the employees together across departments in the power pyramid are projects and/or new products. Good company leadership is essential to have personnel who reside in their department silos and are matrixed into a project team, work solely for the benefit of the project.

The lesson here is that an organization should try to maximize direct labor and minimize indirect labor to the extent possible.

Toward that end, a hierarchical, power-pyramid organizational structure biases labor in the opposite way, creating fractionalization built upon job specialization. This model in effect creates many towns, each town requiring a mayor and town council. But, where towns can operate in a quasi-autonomous fashion within a county, most departments in a product production company are intimately connected and each one's performance is dependent on their neighbors.

Isn't it amazing that we hire people to create and shorten an assembly process that reduces direct labor, but often don't give the indirect labor, labor paid for by direct personnel, the same scrutiny and academic treatment—maybe that's because many in these management ranks are academics.

New Model Considerations

I hope you recognize by now that it's a bit ironic that indirect costs are only paid for with direct labor. If we reduce direct labor content through automation, we can support less indirect labor.

Maybe even more than a bit ironic and more of a way of protecting indirect labor, was keeping direct labor. So, box build assembly and other labor-intensive processes were valuable. This worked, whether conscious or subconscious, until production companies in high labor rate markets were thrust into a global manufacturing marketplace. Alarmingly low labor offshore rates being available caused enormous pressure to reduce labor cost. Most companies took the easy route as they knee-jerked their production to the low labor rate sources.

Next month, we'll wrap up our discussion on organizational structure by presenting a radical alternative to the traditional hierarchical, pyramid-shaped one—one that greatly reduces the amount of indirect and overhead labor that needs to be absorbed by direct labor—one that ultimately permits a more efficient and cost effective way to manage electronic product assembly.

Hey, what do YOU say? I'd like to hear your thoughts and experiences. **SMT**

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Tom Borkes is the founder of The Jefferson Project and the forthcoming Jefferson Institute of Technology. To read past columns or to contact Tom, click here.

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Aviation Industry to go Faster with Real-time Data Analytics

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Worldwide semiconductor capital spending is projected to increase 2.9% in 2017, to $69.9 billion, according to Gartner, Inc. This is down from 5.1% growth in 2016.

Proof of Concepts Dominate IOT in Malaysia

Across 160 organizations surveyed in Malaysia, 50% are looking to deploy production IOT solutions in the next 12 months, while 15% are already in deployment to support their Digital Transformation (DX) agenda.

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Share of In-Cell Solutions in Smartphone Display Market to Reach 29.6% in 2017

The latest research on touch display solutions by WitsView, a division of TrendForce, finds that the share of in-cell products in the global smartphone display market will expand to 29.6% by the end of 2017.

Wearables Continue to See Strong Demand Across the Middle East & Africa

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Myanmar Smartphone Shipments Up to 26% YoY

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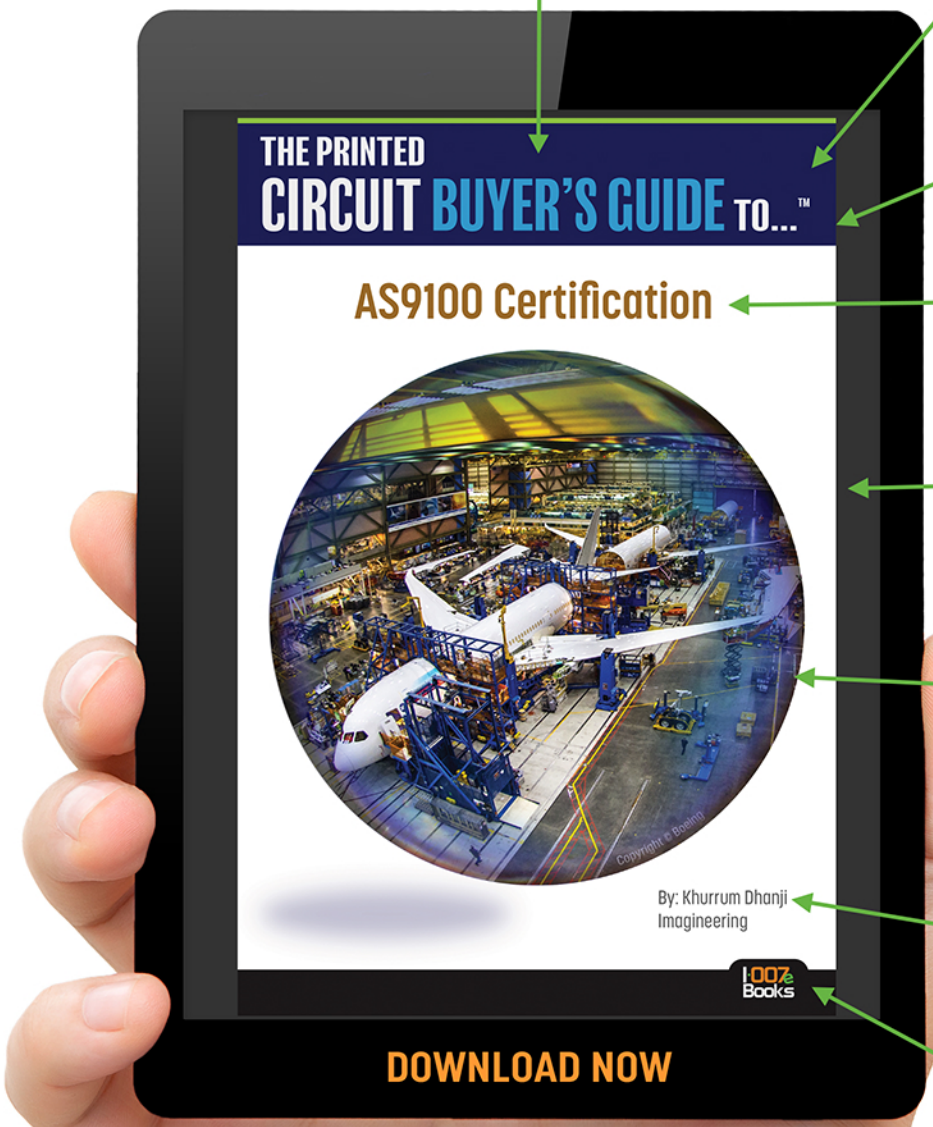

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BRINGING SMT ASSEMBLY IN-HOUSE

Case Studies of the Effects on Lead Time, Inventory, Quality, and Overall Cost

by Tom Beck
MANNCORP

A growing number of low- to medium-volume manufacturers of specialized electronic products are reaping the rewards of bringing their SMT assembly in-house. How have some of these companies justified the cost of their endeavors? In this article, three OEM companies share their experiences.

Campbell Company, of Boise, Idaho, is a manufacturer of pedestrian safety systems that has been subcontracting PCB assembly for nearly two decades. In just the last two years, the company has invested in its own equipment and brought the production of all but a few of its 27 different, mixed-technology PCB designs in-house.

"We've always had very good relationships with our subcontractors," said Phil Tate, Campbell president and CEO. "They all did a very good job for us. There were occasional problems, as one might expect, but we always worked through them. Our decision to bring our production inside was not a reflection on them. We just came to the realization that it was the only way we could meet our goals for inventory reduction and process control."

Recently acquired by Molex LLC, Sensorcon of Williamsville, New York, manufactures poisonous gas detectors for industrial applications. Founder and President Mark Wagner subcontracted Sensorcon's PCB assembly for only 18 months before deciding that in-house production capability would best serve their needs. "The need to accelerate development, take control of quality, guarantee product availability and, above all, reduce overall cost, were all key factors in our bringing production in house," said Wagner.

Sensorcon purchased its first SMT production line in July of 2013 and just recently installed a second line to keep up with the company's steady growth. "The new line will be

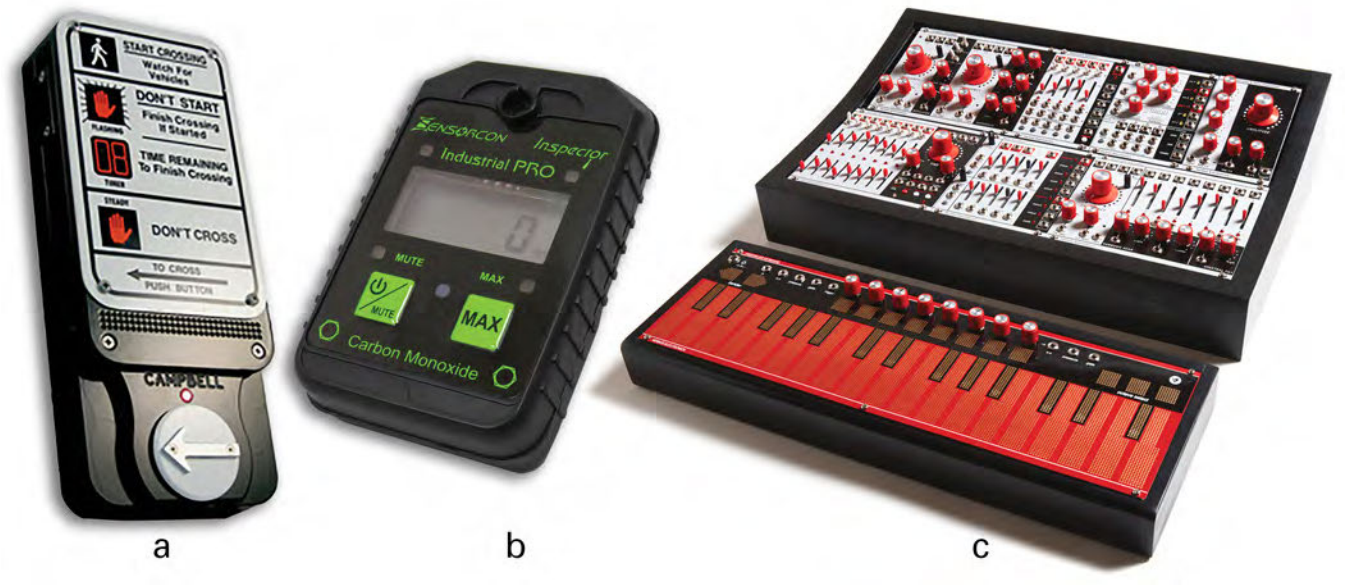

Figure 1a: Campbell Company's pedestrian safety systems are used worldwide. b: Sensorcon's high quality environmental sensor products meet the most demanding needs. c: Verbos Electronics' synthesizer modules are well known throughout the electronic music industry.

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dedicated to regular production, freeing up our original line for new product development and prototyping," Wagner added.

While sheer desperation may have been the motivating force that drove Mark Verbos to start building boards for his synthesizer modules, the electronic music pioneer and founder of Verbos Electronics found himself in a similar situation. After receiving funding for the development and production of a new product line, followed by a very successful launch at an industry trade show, his company was sitting on an abundance of orders that appeared impossible to fill based on his sources of supply at the time. Fearing the cancellation of orders due to an inability to deliver, Verbos immediately started looking for other subcontracting services. "But the story was always the same; either too expensive or too slow. That's when I knew I had to start thinking about getting the equipment to build the product in-house."

Interestingly, other than working with EMS subcontractors, none of these three companies had any previous hands-on experience in SMT manufacturing. And, although the circumstances that led each of them to acquire and implement their own SMT assembly lines may be different, they were all seeking better control over some phase of their manufacturing process. Be it product development, quality assurance, inventory management, lead time, or product cost, increased control is the common impetus for these companies, and many others like them, to bring production in-house.

So how does a company determine the true cost of obtaining this level of control? How much does it cost to set up and maintain an SMT assembly line? What is the payback period for such an investment? An examination of some of the benefits of in-house production will show how these three companies have gauged their results.

Product Lead Times

In the fall of 2013, Verbos placed an initial order with a subcontract assembler for 1,000 pieces of his company's synthesizer modules. "We started taking our first deliveries in January of 2014, but deliveries were very slow and sporadic," Verbos explained. "Our boards are rather

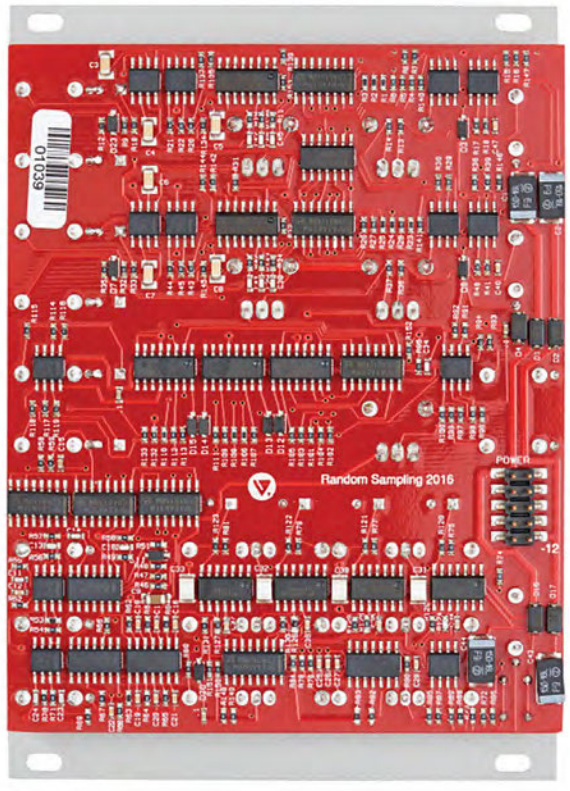

Figure 2: Verbos' random sampling synthesizer module is just one of his company's 12 exclusive designs which can have as many as 400 SMDs in a 2.5" x 4" area.

complex, some products having up to 400 components. Testing and final assembly still had to be completed in-house, and as we started to receive additional orders, we quickly knew we were going to have serious trouble meeting deliveries." After struggling through the summer of 2014, Verbos purchased a turnkey assembly line from Manncorp at the end of August, took delivery and received training in October, and in six weeks had shipped all his remaining backorders.

Of course, Verbos' experience with slow deliveries cannot be considered an indictment of all EMS subcontractors, but when weighing costs and selecting a new supplier, there is always the question as to whether they can deliver.

"Working with a good vendor, lead times were typically eight to 12 weeks," Campbell's Tate explained, "and that's with everything going right! From time to time, deliveries could

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extend out to 16 weeks." Now that he has the capability in house, Tate can turn those same boards around in one to two weeks. "I can have Gerber drawings in a day or two, and bare PCBs in about three days," he says. "I generally try to avoid having to do that but, in an emergency, a few weeks is all we need to flip a board."

For Wagner, the year and a half he spent using subcontract assembly services for Sensorcon's product was all the time it took for him to know that it was neither economical nor feasible. "New product development is such an important part of our long-term business strategy that subcontracting our prototype assembly, and even our initial production runs, just slowed us down to a point that it made little sense. And, despite their best intentions, we found that our subcontractors would sometimes make mistakes that not only cost us lots of money, but also wasted precious and unrecoverable time."

Inventory Control and Cash Flow

Quicker turnaround times lead to better control of inventory levels and reduced strain on cash flow. Prior to bringing their production in-house, Campbell Company's electronics inventory was heavily skewed toward a high percentage (almost 90%) of completed electronic assemblies that had been outsourced at a cost that included the subcontractors' labor. The remaining inventory (about 10%) consisted of

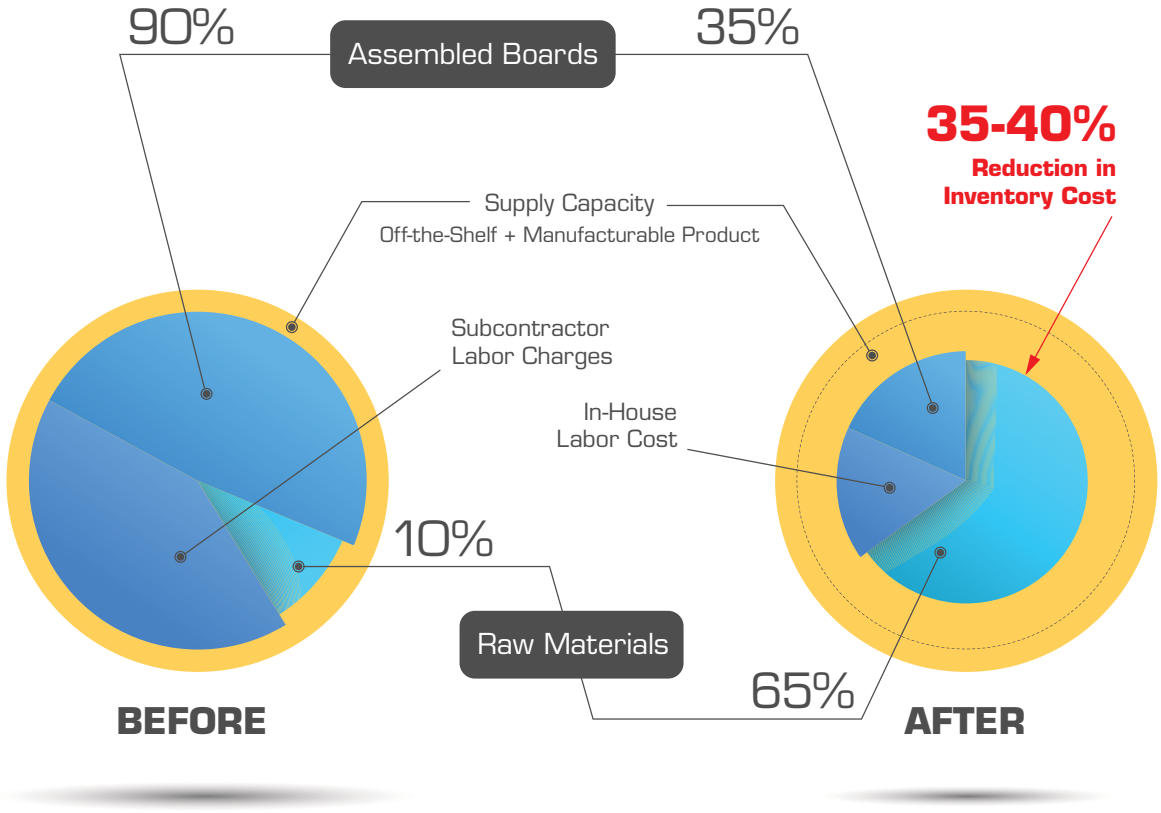

Figure 3: Campbell Company's electronics inventory before and after bringing their SMT assembly in-house. The blue areas, which represent inventory cost, are enclosed by a yellow area representing total supply capacity (off-the-shelf + manufacturable product). For equivalent levels of supply capacity, the ratio of assembled boards to raw materials went from 90/10 before to 35/65 after, resulting in a 35–40% reduction in the total cost of their electronics inventory. Also of note is that subcontracted boards in inventory tied up a significant amount of cash that paid for the subcontractors' labor and overhead. The ability to produce smaller batches more quickly in-house (and presumably at lower cost) significantly reduces the burden on cash flow.

the raw materials (bare PCBs and components) that the company purchased at the best possible prices and supplied to the subcontractors in kits to help reduce costs. "Now, it's almost the opposite," Tate explained. "Completed product now accounts for only about 30–40% of our inventory and we build it at a much lower cost than what we were paying our subcontractors. Also, we are now very vertically integrated. We can be building PCB assemblies at the same time we are building the mechanical parts. This allows us to build smaller lots (and by small, we're talking quantities of 1500–2000 pieces at a time) of various products each month to keep inventories low, while still meeting demand and keeping up with sales volume."

Less than a year and a half after bringing their production in-house, Campbell Company has reduced the cost of their total electronics inventory (finished PCB assemblies + components and bare PCBs) by a considerable 35–40%.

According to Suzanna Sims, Campbell's controller, in-house SMT production has been invaluable to the company's Lean manufacturing initiatives and a boon to cash flow. "To meet price points, we used to have to place blanket orders for 25,000 pieces of one board that would tie up $150K-$175K in one shot," said Sims. "We'd make our best estimates to coordinate delivery schedules based on sales forecasts, but we'd often end up paying for product that would sit in inventory a little longer than planned."

Large cash outlays for subcontract services were also a burden for Verbos Electronics. "It's a tremendous relief to not have to pay for product that has to be built in batches larger than orders demand. Setup charges from subcontractors necessitate a certain minimum volume; otherwise the cost per assembly becomes quite prohibitive," said Verbos.

Quality Control

For companies with no previous experience in SMT manufacturing, the thought of bringing production in-house and being able to maintain product quality can be somewhat daunting. "When we finally made the decision to take the plunge," said Campbell's Production Supervisor, Clark Hill, "we were all kind of asking ourselves, 'Are we really going to be able to do this?'"

Campbell's state-of-the-art pedestrian safety systems, which allow traffic agency technicians to control their equipment via remote web-based management, currently meet IPC-A-610, Class 2, specifications. State and federal regulations, which already require performance testing at extreme temperatures ranging from -70°F to +150°F, are soon expected to demand Class 3 compliance, due to the mission critical nature of the equipment in a full range of environs worldwide. Campbell is an ISO 9001:2008 certified company that undergoes semi-annual auditing and stringent inspection of their SMT assembly processes and quality control methods.

"To be honest, the whole process of bringing our production in-house was much, much easier than I anticipated," said Hill, "and the learning curve was way shorter than I expected. We had some through-hole experience, but 80–90% of our crew were very green when it came to SMT." Hill credits industry associations like IPC for the standards and education they provide but is also quick to point out that, "the initial training and continued support provided by our equipment supplier has been invaluable. Any time we have a problem or question, technical help is always available."

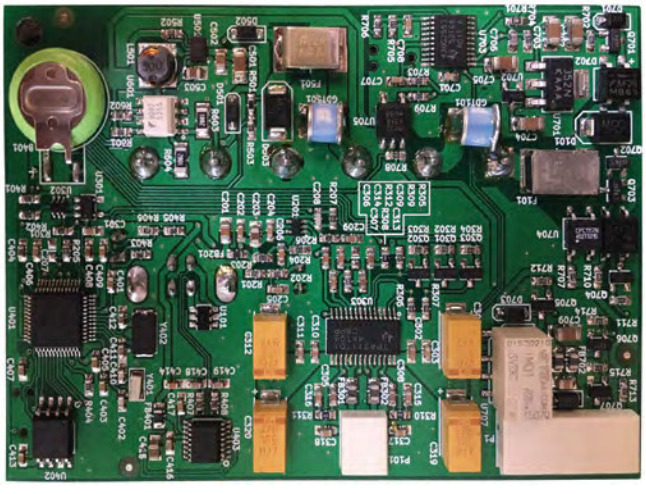

Figure 4: The high-mix board for Campbell Company's Advisor Guide Accessible Pedestrian Station contains approximately 160 different components and is just one of 25 unique designs they now assemble in-house.

Per Tate, there's no comparison between in-house production and subcontract assembly services when it comes to quality control. While subcontract assemblers may be extremely knowledgeable in SMT equipment, processes, and best-practice quality procedures, they're not intimately familiar with the nuances of any given product's design. This makes it much less likely that they will detect problems as quickly or as easily as the developer of the product. "Now, when we encounter problems, we can identify the root causes almost immediately and take whatever corrective action is necessary," said Tate. "Troubleshooting is always much more difficult in a subcontracting situation. Our products also require a lot of in-process testing at various stages of assembly and it's nice to be able to monitor that activity very closely, especially today, as important as SPC reporting and traceability have become."

Figure 5: With the addition of their second Manncorp SMT line, Sensorcon's 3000 CPH MC-400 pick and place will now be used for new product development. Its feeders are interchangeable with their new MC-385.

Calculating Actual Cost

Thus far, all the aforementioned advantages of in-house SMT assembly (shorter lead times, reduced inventory, improved cash flow, and better product quality) provide significant cost savings and commercial benefits. Because return-on-investment and payback calculations all take generated savings into account, these factors must be included. But let's put these factors aside for a moment and look strictly at cost. How does one go about establishing the actual cost of building one's own boards? How long of a payback period is to be expected for the purchase of the necessary equipment?

The cost categories associated with manufacturing a product can be broken down into direct materials cost, direct labor cost, and manufacturing overhead, which, among many other things, includes the cost of the equipment depreciated over time, utilities, maintenance, and training, to name a few. Overhead also includes a variety of other indirect product costs of greater and lesser significance, further complicating the calculation. As a result, one company may estimate its manufacturing costs quite differently from another.

While the services of an EMS subcontractor would seem to make it much easier to control and quantify the direct labor cost of a PCB assembly (cost of completed assembly less raw materials cost), without having to be concerned with manufacturing overhead, there are other indirect costs incurred when using these services. The amount of time and effort that goes into coordinating production and delivery schedules with a subcontract assembler can be significant. Costs for bare PCBs, components, and completed assemblies are a function of order quantities and, as mentioned above, balancing inventory levels for each of these, based on sales forecasts and actual product demand, can be extremely challenging.

"When we were first starting out, some of our vendors supplied turnkey product," said Wagner, meaning that the subcontractor supplied the boards, components, production, and anything else needed to deliver a complete PCB assembly. "Of course, you pay a premium for that, so as a next step toward reducing costs, we tried a pre-kitting service offered by one of our component suppliers. Despite some initial savings," Wagner explained, "an excess of raw materials seemed to accumulate after each job, telling us this system was inefficient and wasting money. Typically, the problems centered around tape-and-reel component packaging and minimum order quantities, so we finally

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decided we'd be better off doing our own component purchasing and pre-kitting."

As Sensorcon incurred the full cost of managing its raw materials inventory, Wagner continued to seek other suppliers that might be able to build his boards for less than the $12–$18 per board he was used to paying for each of his various products. "I visited several subcontractors and I often noticed there'd be lots of highly automated equipment that was frequently sitting idle," Wagner recalls, "yet there were always lots of hand-assembly operations being performed at manual workstations. This made me realize that, when dealing with many of these subcontractors, I wasn't just paying for direct labor; I was helping to pay their overhead for under-utilized equipment."

Wagner soon concluded that he should acquire his own equipment to build Sensorcon's products in-house and purchased a small turnkey assembly system (manual stencil printer, 3000 CPH pick and place system, and batch reflow oven) from Manncorp. "I realized that, in our case, speed wasn't an issue" he said, "and I wouldn't be justifying the equipment based on how fast I could assemble boards. We would still be limited by our manual operations, which include test and final assembly, but at least now we'd be paying for our own equipment and not somebody else's."

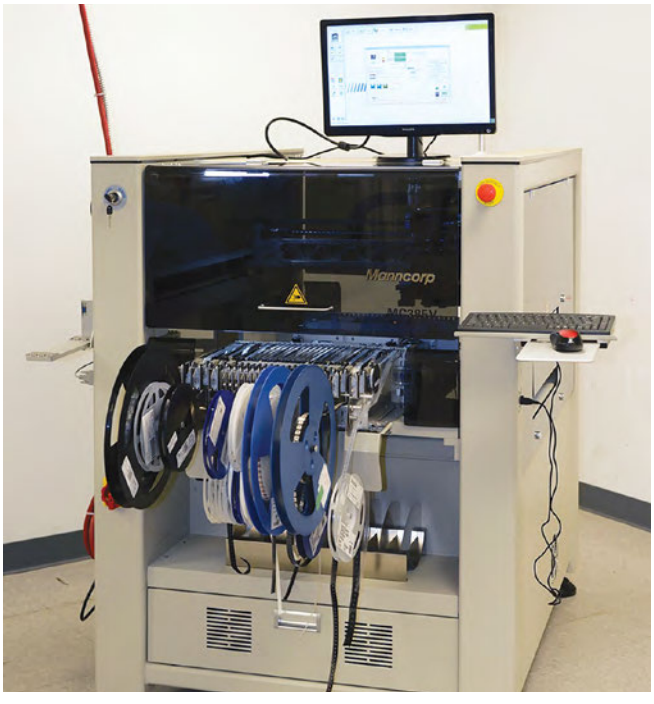

Figure 6: Sensorcon's new production line includes the 2-head MC-385 pick and place system, the same model Verbos uses to build his synthesizer modules. At 8000 CPH and $65K it ranks as one of Manncorp's most popular systems.

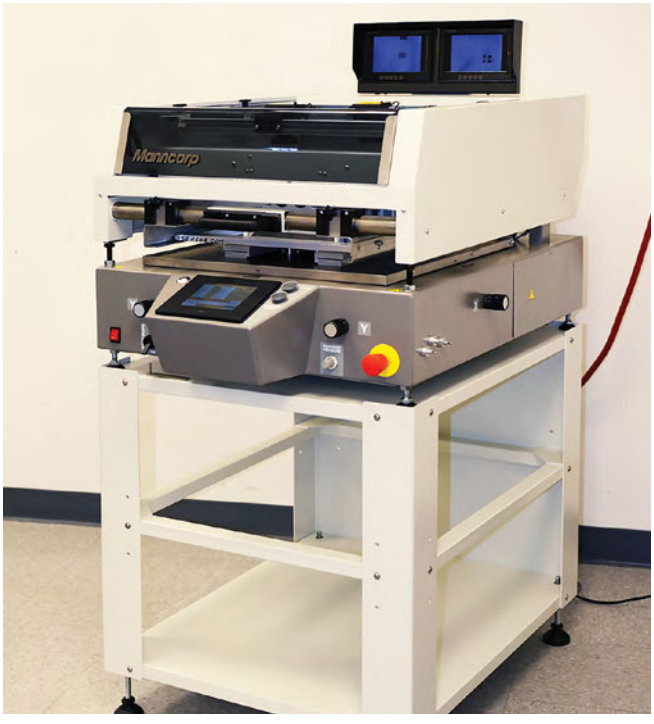

Figure 7: For increased printing accuracy and easier stencil to board alignment, Sensorcon chose Manncorp's PB2300 vision-assisted semi-automatic stencil printer. Like their original pick and place machine, their manual stencil printer will now be dedicated to prototyping and new product development.

Typically, Sensorcon builds its three main products in batches of just 200 pieces at a time, maintaining desired inventory levels using a just-in-time, Kanban production strategy. "Although we may have a little more money tied up in inventory, this takes a lot of the pressure off and allows us to maintain a steady supply of product," Wagner points out. "I felt that the PCB assembly could very easily be integrated into our existing production at minimal additional cost, because staff can perform many of their regular tasks while the SMT equipment is running." As it turns out, Wagner's predictions

have indeed come true, and the incorporation of SMT into their in-house capabilities has been so seamless that he believes he has reduced his direct labor cost to about $2 or $3 per assembly. Of course, this figure doesn't include any manufacturing overhead but, compared to what he had been paying, his savings are considerable.

Verbos saw himself in an almost identical situation with the subcontract assembly of the boards for his synthesizer modules. "For the prices I was paying just for labor (anywhere from $30 to $50 per board) and knowing exactly what my raw materials costs were, not to mention the slow lead times I was experiencing, I was totally convinced that I could easily justify the purchase of assembly equipment and pay for it in a very short period of time."

Like Wagner at Sensorcon, Verbos purchased an SMT assembly line from Manncorp (manual stencil printer, 8000 CPH pick and place system, and batch reflow oven). "Everyone was telling me I was crazy," he recalls. "They told me the only way I'd be able to make the equipment pay for itself was to take on additional work to keep the equipment running 24/7." But like Wagner, Verbos didn't see it that way and, in his opinion, he has proven himself right. "We've saved so much in production costs, I believe our equipment paid for itself in the first six months. Why should I care if the equipment occasionally sits idle until we're ready for a production run? It would be nice if the equipment were running all the time because that would only mean that we're selling more. But right now, our priority is being able to fill orders and meet deliveries, and we're doing that, even if our manufacturing cost isn't the absolute lowest it could possibly be. What used to take six to eight months from a subcontractor can now be produced in-house in six to eight weeks."

To meet throughput requirements, Campbell Company purchased a fully-automated SMT line (high-precision inline stencil printer, 10,500 CPH pick and place system, and a five-zone convection reflow oven) for just under $250,000. Due to their decades of experience in dealing with EMS subcontractors, their objectives from the start were less about reducing production costs than they were about reducing inventory and improving lead times. While

Figure 8: Campbell Company's fully automated SMT assembly line includes Manncorp's high-precision AP430 inline stencil printer, the three-head MC-389 pick and place system, and a CR-5000 convection reflow oven. With a full complement of component feeders and connecting conveyors, the line bore a price tag of nearly $250K, yet Campbell management believes it paid for itself in 12–18 months.

Tate, Sims, and Hill all agree that their equipment probably paid for itself in the first 12-18 months, they are almost indifferent about payback. Their enthusiasm is evident, however, in their willingness to talk about the significant impact that in-house SMT assembly has had on their entire operation. "We're doing some incredible things here," said Tate. "Bringing our PCB assembly in-house was a very good decision."

The Bottom Line

SMT equipment, by its very nature, is inherently fast. After all, in addition to smaller, standardized package sizes and higher-density circuits, ease of automation and higher speed assembly have always been trademarks of the technology. But the fact of the matter is that, outside of Asia, the vast majority of SMT assembly equipment throughout the world is underutilized. In general, SMT is so cost-effective that when manufacturers first start to consider purchasing their own equipment, placement speeds typically throw them off track. For example, a

Figure 9: Due to space limitations, a 90° turning conveyor is positioned between Campbell Company's three-head MC-389 pick and place machine and their five-zone CR5000 convection reflow oven. Single-sourcing a complete turnkey SMT production line provides such benefits as seamless equipment integration, special package pricing, coordinated delivery, installation and training, and extended warranties.

small company looking at a 5,000 CPH pick and place system to assemble a board with 200 components may immediately think, "25 boards per hour, 200 per 8-hour shift, 1000 assemblies per week. First of all, we don't sell anywhere near that many, and besides that, our testing and final assembly couldn't possibly keep pace. That machine is way out of our league and will be sitting idle half the time." The point is that this thinking doesn't really apply outside the world of very high volume SMT. For low- to medium-volume manufacturing of specialized products, it's probably OK if in-house SMT equipment isn't running at its fullest capacity 100% of the time.

If you look at an SMT equipment purchase from a total cost savings standpoint, instead of trying to base its justification on equipment utilization, it's a whole different story. As these three examples show, a more holistic approach is necessary. This is precisely the reason that "payback period" is of so little significance to Campbell, Sensorcon, and Verbos Electronics that none of the three have ever taken the time to go back and calculate it with any high degree of precision. Whether it was six months, 12 months, or 18 months doesn't really matter—they know it was quick—and, they know that the benefits to their business operations and the overall cost savings, have been so substantial that they almost don't care.

On this basis, one could even argue that the cost of equipment is so comparatively small, companies should make absolutely certain they don't underspend when it comes to installing their first SMT assembly line. Nothing can be more frustrating than trying to produce a high-quality product with equipment that isn't up to the task. This being said, there's certainly no need to overspend either. The key is to purchase the best equipment to get the job done right, while keeping an eye toward future needs and upgradeability.

Of course, trying to predict the future is perhaps the greatest challenge of all. Companies go to great lengths to keep abreast of changing technology and industry trends that can affect their businesses. But even the most optimistic among them will admit that it's virtually impossible to foresee the role that world events, macroeconomics, and other things beyond their control might play in the years ahead. Nonetheless, it now appears that a new, business-friendly administration is intent on setting policy that will benefit American manufacturers. **SMT**

Tom Beck is the director of marketing at Manncorp.

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Taking the "Process Approach" to RFQs in Electronics Contract Manufacturing

by Chintan Sutaria
CALCUQUOTE

The ISO 9001:2015 standard can be applied to any organization, any management system and any process. While it is generic in its application, the specific implementation can be the difference between lagging (inefficient, inconsistent) and leading (efficient, consistent) results.

The purpose of this article is to review how the process approach applies specifically to the request for quote (RFQ) process in the electronics manufacturing services (EMS) industry. For this, we will use the process approach framework of PDCA: plan, do, check and act.

Plan

In order to effectively improve any process, the first step needs to involve proper planning. This means setting objectives to meet business needs and defining the scope of the process it addresses.

For the purpose of RFQs in EMS, common objectives are:

1. RFQ turn time: Measure how efficient the process is and how effectively the organization is able to handle fluctuations in demand
2. Win ratio: Measure whether the output of the process is meeting customer or market needs
3. Estimated cost variance: Measure whether the output of the RFQ process is accurate
4. Margin: Measure whether the quoted price reflects a sustainable margin for the business to continue operating competitively

The process scope for RFQs begins when a customer submits an RFQ to their contact at the EMS company (perhaps a salesperson, program manager or other contact). It includes calculating the price to submit to the customer including materials, labor, overhead, risk and margin. And finally, it includes the conversion of the final quote into a purchase order and/or collection of feedback from customer regarding the quote.

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Do

Depending on the size of the organization and number of steps involved in your RFQ process, quoting might involve multiple people across several departments, or it could be vertically integrated into a single individual that plays multiple roles.

In either case, it is important to establish work instructions, templates, and tools to perform the RFQ function adequately. Here are some things you may wish to implement:

1. Detailed procedures for quoting to streamline training of new team members
2. Risk assessment template with questions to evaluate all relevant criteria
3. Documentation standards which can be shared with the person who is requesting the quote (including BOM formatting guidelines, Gerber file format, assembly drawing requirements, etc.)
4. Margin matrix: Turn qualitative inputs into a quantitative target margin range
5. Labor calculation template with researched and agreed-upon standard times and labor rates for activities
6. Glossary of common terms and phrases such as turn time, excess material, preferred supplier, available to ship
7. Bill of material (BOM) costing template to record quoted quantity requirements, required overages, and identification of materials at risk
8. Quote template communicating to end-customer price and turn-time commitments along with terms and conditions
9. Standardized RFQ template to capture relevant information from customer, including quantity, turn time, special build requirements, IPC standard, accompanying communications

Check

Once an RFQ process has been scoped and implemented, it is important to continue monitoring the effectiveness of the process. Reviewing process performance should be built into the process definition and not treated as an ad-hoc activity. Here are a few ways you can do that:

1. Schedule periodic reviews to go over key metrics, manage exceptions and load-balance resources and respond to changing forecast of RFQ activity
2. Create alerts or escalations to notify the appropriate stakeholders the status of key metrics and challenges
3. Benchmark against goals and historical performance to understand the progress of your process
4. Regularly solicit input from key stakeholders on opportunities for improvement

Act

Based on metrics, exceptions and escalations, it may be necessary to make modifications to the process. A few things to consider when making updates to a process:

1. Record the changes in all accompanying documentation, including training materials and forms
2. Be especially diligent in monitoring performance metrics after a process change to identify whether the change positively impacts business requirements
3. Ensure that the process change and the reason behind the process change are communicated to all stakeholders

Setting standards and implementing systematic processes can save companies time, provide consistency, and establish metrics to measure your continuous improvement. By expanding your implementation of the new ISO 9001 standard into the RFQ process, you'll save time and win more of the right business. **SMT**

Chintan Sutaria is founder and president of CalcuQuote, a RFQ management system for EMS companies. A lifelong veteran of electronics contract manufacturing, he has experience in PCB assembly, ERP implementation, and supply chain management.

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VirTex Discusses EMS Challenges, New Technologies and Trends

by Stephen Las Marias
I-CONNECT007

I recently interviewed Brad Heath, CEO and owner of EMS firm VirTex, about his company's activities, how they stay ahead of their competition and the new technologies and trends that are having a significant impact in the electronics assembly industry. We also discussed some of the greatest challenges their customers are facing and how VirTex is helping to address them.

Stephen Las Marias: *Brad, please provide some background about VirTex, for those who may not be familiar with the company.*

Brad Heath: VirTex is an EMS company that focuses on providing most of the same capabilities that Tier 1 companies can provide, but with greater levels of flexibility, primarily in the industrial, military and aerospace, medical, telecom, and automotive markets.

We provide different location options depending on the type of work our customer needs. We have a facility in Austin, Texas, at our company headquarters, which focuses heavily on industrial, medical and system build; we have a facility in Menomonee Falls, Wisconsin (just outside Milwaukee) that focuses on the military/aerospace and automotive markets; and then we have our facility in Juarez, Mexico, for customers needing high flexibility in a low-cost region.

Las Marias: *Geographically speaking, where are your customers based?*

Heath: Our customers are primarily regional and typically an hour-and-a-half to two-hour plane ride from a given facility, which makes it easier for them to travel and do business with a personal touch. It allows for ease of contact and to be in the same time zones as our customers.

Las Marias: *How has the EMS industry changed over the past two decades?*

Heath: The biggest change has been the level of services provided. With EMS firms, it's evolved from what I would call board stuffers—20 plus years ago—to full-service supply chain, logistics, fulfillment and new product introduction

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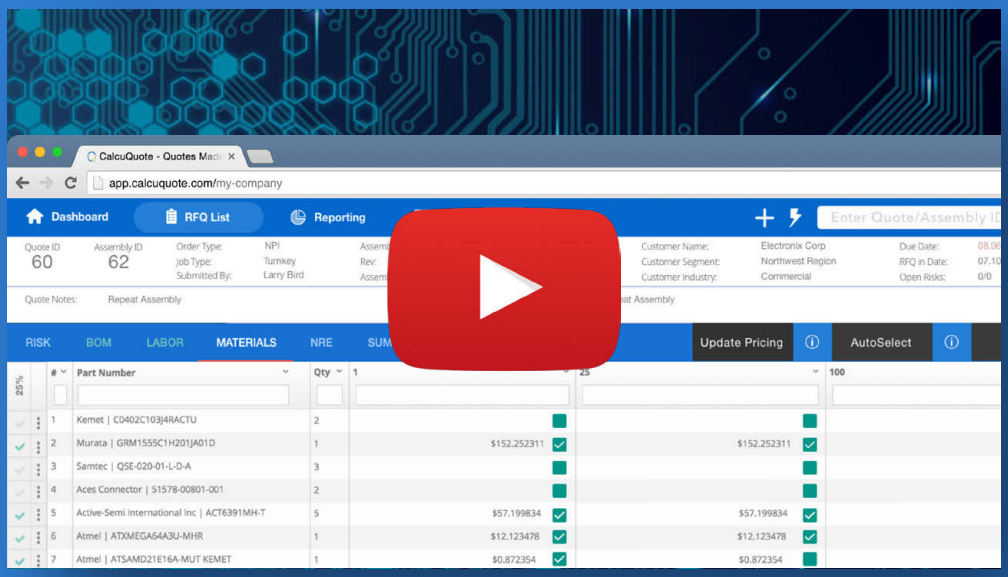

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Brad Heath

***Las Marias:** What are the challenges that you have experienced, and how were you able to navigate your business to be where you are today?*

Heath: There have been many challenges in almost 20 years, including several downcycles in the economy. But we focused heavily on diversity in our customer base which limits our ability to be impacted by that. But of course, in 2009, it didn't really matter what industry you were in, everything fell off the cliff; you had banking constraints and an inability to get capital. Despite all those challenges, we stayed on top, but we did that by doubling down on servicing the customers and having good relationships locally with bankers, with lending providers and PE firms who funded the growth coming out of the downturn. Many competitors cut back heavily, but we invested in the people and technology to take us to the next level. We knew we couldn't service our customer base without a solid support structure.

***Las Marias:** In 2014, VirTex acquired MTI Electronics. How has its acquisition benefitted the company three years on?*

Heath: It has really heavily benefitted both companies. It gave us a second source location for disaster recovery in the event of a natural or other catastrophe, which is something that sophisticated customers want; it gave us extreme strengths in the supply chain capabilities that MTI had, as well as some of the operational efficiencies. Some of the software and analytics that we developed in Austin, we've been able to deploy into the Wisconsin facility. So, it's really allowed us to look at all the things we did in both sites and offer additional services to customers that we weren't offering in that facility before. It gave us a broader capability, as well as a higher service level.

***Las Marias:** In November 2016, VirTex announced a new logo/visual brand identity—which underscored the alignment of VirTex and MTI under a new VirTex brand. Please tell us more about this.*

Heath: We are moving into additional services and additional things that we feel are very cutting edge, compared to our competition, so we wanted our brand to reflect that. We also wanted to unify the VirTex brand across our three facilities which, up to that point, had been operating under their original logos and names. Capitalizing on their brand equity, we brought them into the VirTex visual identity family, which internally and externally reflects the fact that we all have common processes, goals and strategies. We feel the new brand reflects, not just the strength of the VirTex brand, but maintains the strength and history of the MTI and AVJ brands as well.

***Las Marias:** Currently, what markets are the major drivers for growth for VirTex?*

Heath: We are seeing a lot of opportunities in clean energy; we are seeing a lot of them in medical—especially alternative methods of healthcare, to allow treatment to be performed better and more cost effectively—so additional new technologies and new technology developments in the equipment space for medical. Certainly, there's a big bump in the amount of electronics going into any vehicle these days, so automotive electronics is growing —both the standard products going into Tier 1s as well as the aftermarket—is strong. Another big driver that is starting to roll out is the IoT, and connected devices, where pretty much, over the next few years, everything will be connected to everything and everyone else.

***Las Marias:** What are the greatest challenges that your customers are facing?*

Heath: The biggest challenge for our customers is a combination of talent acquisition and shorter technology timeframes. The length of time to build cutting edge products is going to become shorter and shorter, so they really have to try to stay ahead of the thought, process and technology curve, in terms of their product development—the design cycles, the product cycles, from a lifetime standpoint, are significantly shorter than they were five to 10 years ago.

***Las Marias:** Talent acquisition is also a major problem?*

Heath: Yes, they must get the best and the brightest to develop those products. They need people who can come up with the new ideas and can think creatively to develop products, not just do things like the next generation of products that they already have. People are looking for new ways to break their new markets within the same companies.

***Las Marias:** Where does VirTex come in to help customers address their challenges?*

Heath: We've created strong partnerships, both with leading-edge design firms and top vertical manufacturers. We've also partnered with community colleges and universities, to find the next generation of talent, creating apprenticeships and internship programs, to bring those people in and get them familiar with what we are doing.

It's hard to have all of the engineering talent under one roof. You need people who understand wireless, you need people who know power supply design, and so on. Those are typically different design disciplines and typically not in the same design houses. We've partnered with those who we feel are the best in the localities where we serve, to be able to recommend them and connect them with customers and provide solutions and the talent that they need.

***Las Marias:** What capabilities does VirTex bring to the table to help customers address their manufacturing challenges?*

Heath: We have software that is world-class in the supply chain—we've received awards in that arena—some of the business analytics and quality analytics, we've developed a lot of custom software and custom security to safeguard the

Among the key factors to consider when selecting an EMS partner are cultural fit and flexibility. You really need a strong, customer-focused team where, if a customer calls with a new product or demands changes, the EMS can pull together with the customer and realign the supply chain and manufacturing resources to meet the challenge.

customers' IP. We've bolted additional software that we've written internally, to be able to handle higher levels of flexibility and higher levels of automation than a supplier of our tier would typically be able to provide.

***Las Marias:** What are the latest technologies, or upcoming technologies, that you think will significantly impact the electronics assembly industry?*

Heath: The top things that we are focusing on are the IoT and connected devices. Connecting everything throughout the factory is a big focus and how they connect at the factory floor edge. There are a multitude of new connected devices that are coming out with small form factors and new technologies are going to be required for devices that connect wearables and appliances; there's a variety of things people are going to do about that. And another large technology driver will be the new technologies to develop the clean energy space.

***Las Marias:** While automation makes sense in electronics assembly, do you think we shall be seeing a fully automated assembly line soon, or will it still be islands of automated systems within a factory?*

Heath: It will depend on the application. There's certainly some applications that currently are in a lights-out factory and fully automated; but there are several cases where, particularly in the high-mix, low-volume space, the flexibility needed doesn't lend itself to 100% automation.

***Las Marias:** With the trend towards IoT and Industry 4.0, having a strong analytics capability is a big factor in winning customers.*

Heath: Absolutely. I believe that if you are not heavily involved in Industry 4.0 or Manufacturing 4.0 over the next three to five years, you will be left in the cold. The same as for those people who were late in their shift to RoHS, or the shift towards elimination of CFCs. You have to go ahead and be able to supply that information to customers because they will be counting on it.

***Las Marias:** I believe what Industry 4.0 is also bringing to the table is an end-to-end visibility in your production line—and one of the biggest factors there is the traceability of your products.*

Heath: It can go there, and it can also go even further than that into the field. You can go ahead and get proactive and predictive with the data; there are several large-scale customers who are collecting intelligent devices failure rate data with respect to vehicles, where they are sending that data back for advanced warranty replacement. As soon as you start collecting data about a device, you can start doing predictive analytics as well, not just reactive analytics. That's the other place where much of Industry 4.0 is heading and it is the next logical step. The same thing holds true for the factory floor. We need to get moving toward the point in time when the equipment in the line is telling us before it's having problems and going down, rather than after.

***Las Marias:** What are the important factors to consider for a customer, or an OEM, when selecting an EMS partner?*

Heath: The biggest piece, far above everything else, is cultural fit and flexibility. Everybody has a lot of the same quality systems, we have more than most of our peers have. We have AS9100, FDA 21 CFR820, and we have several facilities with ISO 13485; it's not just ISO 9001. But in the high-mix, low-volume space, you really need a team to be able to work together; a strong, customer-focused team where, if a customer calls with a new product or demands changes, the EMS can pull together with the customer and realign the supply chain and manufacturing resources to meet the challenge.

***Las Marias:** What is your outlook for 2017?*

Heath: We're really looking at another year of double-digit growth. We are consistently outperforming our peers and right now, from what we're seeing in the order backlogs and bookings going into this year, we are going to do the same in 2017.

***Las Marias:** Thank you, Brad.*

Heath: Thank you, Stephen. **SMT**

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Recent Highlights from SMT007

1 RoHS and PoPs Chemicals Found in Nearly 40% of Electronics in Sweden

Sweden's Chemical Agency (Kemi) found banned chemicals in nearly 40 percent of audited low-cost electrical and electronic products. The audits revealed that the discount electronics category has a "high rate of noncompliance" with Swedish and European Union RoHS and Persistent Organic Pollutants (PoPs) requirements.

2 Millennials in Manufacturing: Andrea Tarhanich – What's Driving Millennials to Thrive—and Stay—in Manufacturing

For our ongoing series on Millennials in Manufacturing, we next feature Andrea Tarhanich, a millennial who has been with Saline Lectronics for more than four years. In this article, Andrea talks about loyalty and work ethics, leadership, and effective strategies to attract millennials to the manufacturing world.

3 Millennials in Manufacturing: Kyle Robertson – A Rewarding Career

We next feature SMT Technician Kyle Robertson. He discusses how working for Saline Lectronics has provided him the opportunity to learn new things related to the electronics industry every day and to witness the latest, most exciting technologies being developed.

4 How to Create the Perfect SMT Reflow Oven Profile

While EMS providers will have their own preference when it comes to machine type and brand, broadly speaking, the process steps they go through to produce PCBAs are the same. However, one step that can make all of the difference when it comes to quality and consistency is reflow. This article details how EMS companies can go about creating the perfect SMT reflow oven profile.

5 ZTEST Electronics Acquires Stake in Conversance

EMS firm ZTEST Electronics Inc. has acquired a 15.05% equity interest in Conversance Inc., a private Waterloo-based technology company.

6 Cirtek Joins Facebook's Telecom Infra Project

Cirtek Holdings Philippine Corp. has joined Facebook's Telecom Infra Project (TIP), a global initiative to develop technologies that will enable affordable telecommunications equipment and rapid deployment of such.

7 STI Electronics to Receive Best Paper Award for BTC/QFN Test Board Design Research

STI Electronics Inc. has been selected to receive the "Best of Conference" award for a paper presented during SMTA International in September.

8 Cirtronics Announces Advanced Integrated Documentation Upgrade

Cirtronics Corp. has upgrade its Factory Logix ERP software to provide a faster and more adaptable on-boarding process to its customers.

9 European EMS Industry Poised for Growth

After declining in 2014, the European electronics manufacturing services (EMS) industry is forecast to reach €27.4 billion in 2016, its second year of consecutive growth, according to a new report by Reed Electronics Research.

10 Stadium Group Acquires Cable Power

Stadium Group has acquired the assets of Colchester-based Cable Power Ltd, a leading provider of electronic, power and single board computing solutions.

Events

For IPC's Calendar of Events, click here.

For the SMTA Calendar of Events, click here.

For the iNEMI Calendar, click here.

For a complete listing, check out SMT Magazine's full events calendar here.

EIPC Winter Conference
February 2–3, 2017
Salzburg, Austria

MD&M West
February 7–9, 2017
Anaheim, California, USA

IPC APEX EXPO 2017
February 14–15, 2017
San Diego, California, USA

China International PCB & Assembly Show (CPCA)
March 2017
Shanghai, China

The 14th Electronic Circuits World Convention
April 25–27, 2017
Goyang City, South Korea

KPCA Show 2017
April 25–27, 2017
Goyang City, South Korea

IPC Reliability Forum: Manufacturing High Performance Products
April 26–27, 2017
Chicago, Illinois, USA

IMPACT Washington D.C. 2017
May 1–3, 2017
Washington D.C., USA

Thailand PCB Expo 2017
May 11–13, 2017
Bangkok, Thailand

JPCA Show 2017
June 7–9, 2017
Tokyo, Japan

IPC Reliability Forum: Emerging Technologies
June 27–28, 2017
Düsseldorf, Germany

SMTA International 2017 Conference and Exhibition
September 17–21, 2017
Rosemont, Illinois, USA

electronicAsia
October 13–16, 2017
Hong Kong

productronica 2017
November 14–17, 2017
Munich, Germany

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Coming Soon to *SMT Magazine:*

MARCH:
The Wide World of Flex
The challenges and strategies when dealing with flex and rigid-flex circuit assembly.

APRIL:
High-speed Laminates
This issue will focus on high-performance and high-speed laminates, and what their impacts are on PCB assembly.

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