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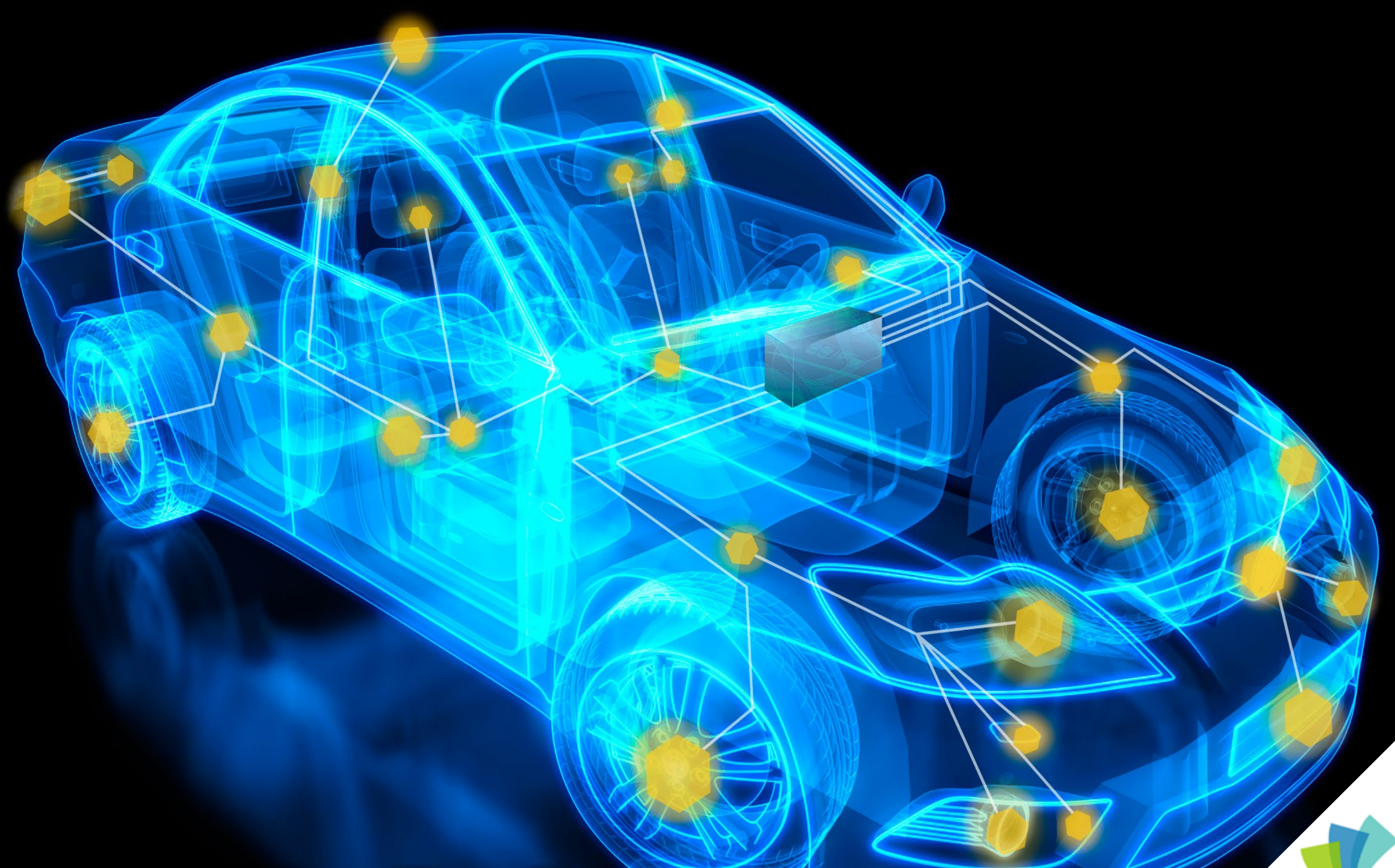

The “New Face” of Automotive Traceability

by Michael Ford, page 14

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Featured Content

CARS: A DRIVING FORCE IN THE ELECTRONICS INDUSTRY

This month, *SMT Magazine* highlights how the latest technological advances in automotive electronics are driving innovations in the electronics assembly, testing and inspection industries.

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ENGINEERING SOLUTIONS FOR PCB MANUFACTURING

CONTENTS

EDITOR'S NOTE

What's Driving Automotive Electronics?

by Stephen Las Marias
I-CONNECT007

Cars: The Driving Force in Electronics Industry

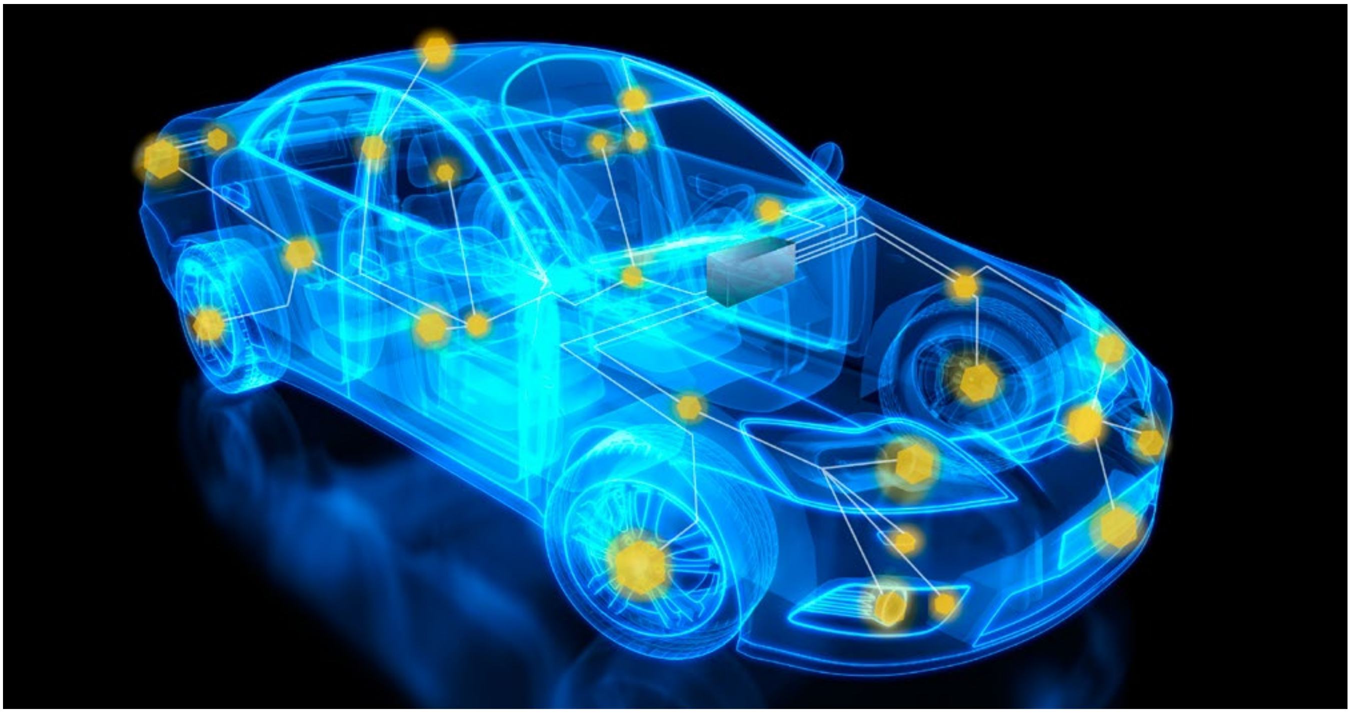
In addition to the increasing penetration of EVs and HEVs, the growing demand for advanced driver assistance systems (ADAS) and proliferation of high-end in-car infotainment systems are among the key factors fueling the increase of electronics in cars.

According to market analyst Grand View Research, the global automotive electronics market is forecast to reach $279.96 billion by 2020, up from $161.55 billion in 2013—growing at a CAGR of 8.2% from 2014 to 2020.

One of the automotive segments that are expected to exhibit high growth is the ADAS, mainly due to stringent safety regulations in modern cars. ADAS, as an array of systems and subsystems that incorporates electronic components such as sensors, microcontrollers and software under one roof, is forecast to register market growth of 14.9% CAGR from 2015–2020, according to research firm IndustryARC.

I recently interviewed Arthur Tan, president and CEO of Integrated Micro-Electronics Inc. (IMI)—the 7th biggest automotive EMS provider in the world (in terms of 2014 revenues)—about the latest developments in their automotive electronics business.

Tan said vision system is the key to ADAS; and that while we have safety features such as forward-collision warnings, lane-departure warning, adaptive cruise control, and traffic-sign recognition today, the next couple of years will see the development of automated braking, steering with forward vision, and GPS connectivity. Tan said that by 2020, cars will be able to accelerate, brake, and steer by itself—but the driver will still be required in case of emergency or system failure. Beyond 2020, driverless cars are expected to be a norm.



At the moment, IMI is adding production lines for automotive cameras to cater to growing demand in this segment.

Amid these optimistic forecasts, challenges remain in the automotive electronics manufacturing industry. The high level of complexity of devices and electronics being built into cars and the harsh operating conditions that these products are expected to operate in are some of the key issues that equipment suppliers and automotive OEMs and EMS providers are working hard to address.

This month's issue of *SMT Magazine* (as well as its sister publications *PCB Design Magazine* and *The PCB Magazine*) features some of the key players in the automotive electronics space, including suppliers and equipment makers, who discuss strategies for success and opportunities for growth in this industry.

In his article, *The "New Face" of Automotive Traceability,* Michael Ford of Mentor Graphics looks at the traceability aspect in automotive electronics manufacturing, amid the different technology advances, need for further energy efficiency, and enhanced safety. Alpha's Steve Brown, meanwhile, discusses the complexity in material considerations in light of the ever-increasing array of applications in automotive electronics in his article, *Material Considerations for Advanced Driver Assistance Systems Assembly.*

In his article, *Automotive EMS: Going Beyond Assembly,* Frederick Blancas, of IMI, gives a good overview of the automotive electronics industry from the perspective of an EMS provider. Sean Horn of Diamond MT, for his part, discussed the expanded use of conformal coatings in automotive electronics in his article, *Benefits of Paralyne Conformal Coatings in Automotive Applications.*

This issue of *SMT Magazine* also features insights from different EMS providers and equipment suppliers to the automotive electronics industry. I interviewed Sanmina's Bernd Enser, who talked about the impact of the latest development trends in cars today on the automotive electronics assembly space, as well as the qualifications required of an EMS provider to get into an automaker's AVL. My interview with IMI's Tan also discussed the challenges and growth opportunities he is seeing in the automotive space.

Jens Kokott of GOEPEL Electronic talked about the increasing need for continuous development of testing technologies to cater to the innovations happening at breakneck speed in the automotive electronics industry, while Keysight Technologies' Boon Khim Tan spoke on how test and measurements companies are addressing the increasing amount of electronics in cars.

Saki's Nori Koike provided his perspectives from an AOI technology provider point of view, while Phil Kinner of Electrolube talked about the best practices that will help automotive electronics makers select the correct conformal coating solution for their applications.

Other interesting articles in this issue include Barry Matties' interview with Brad Perkins of Nordson ASYMTEK, who talked about the current demands put on dispensing equipment, and the benefits customers can expect by investing in a high-end dispenser and coating system. Matties also spoke to Pratish Patel, president and CEO of Electronic Interconnect, who shared the new strategies and capabilities that his company is building.

We also have a technical article by Tom Hester and Dave Pinsky, who wrote about tin whisker self-mitigation in surface mount components attached with leaded solder alloys, as well as a case study on evaluating manual and automated heat sink assembly using FEA and testing, written by Michael Randy Sumalinog, Jesus Tan, and Murad Kurwa, of Flextronics.

Finally, our columnist Robert Voigt continues his piece on selecting a reflow oven, while Stephan Halper writes about the DoD's first pass at grey market regulation.

I hope you enjoy this month's issue of *SMT Magazine*. Stay tuned, because there's more to come! **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.

Surface Mount Technology Association—a New Milestone

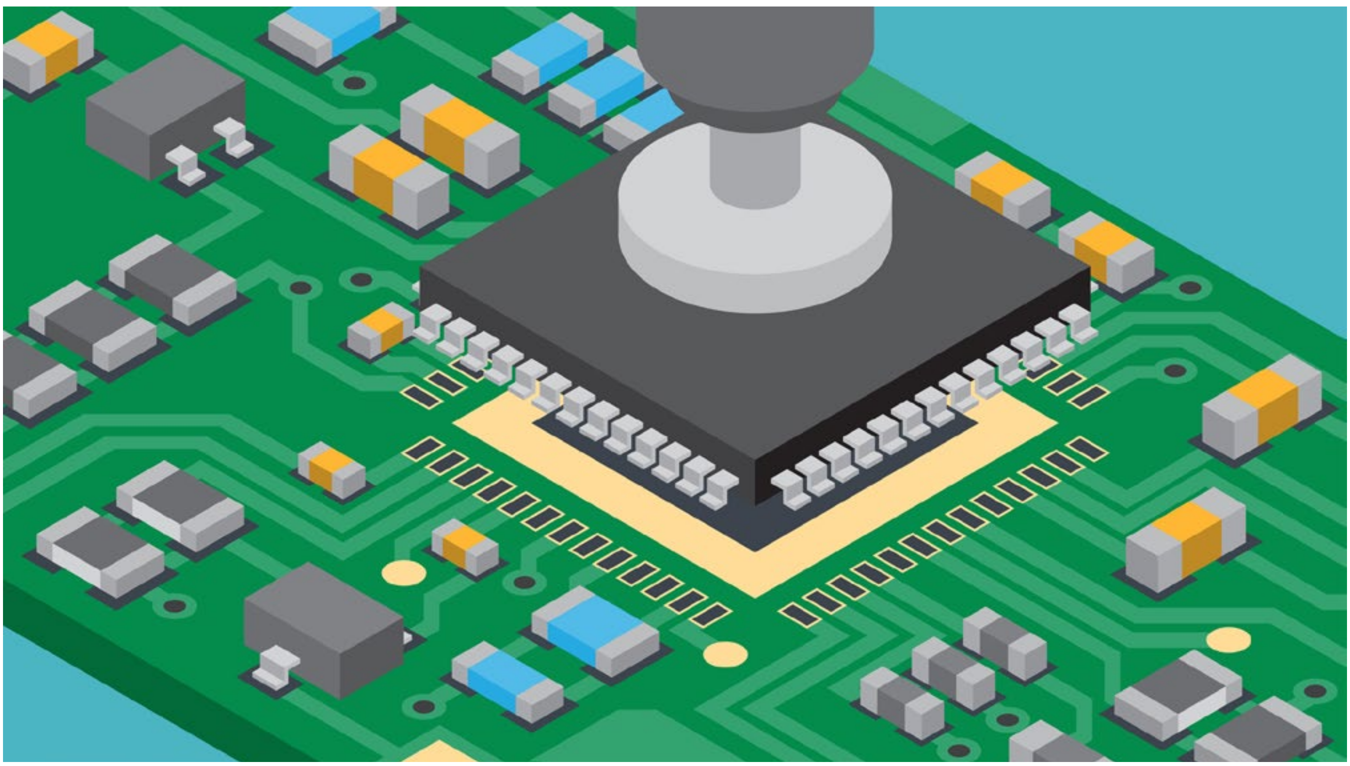
by Dr. Jennie S. Hwang
CEO, H-TECHNOLOGIES GROUP

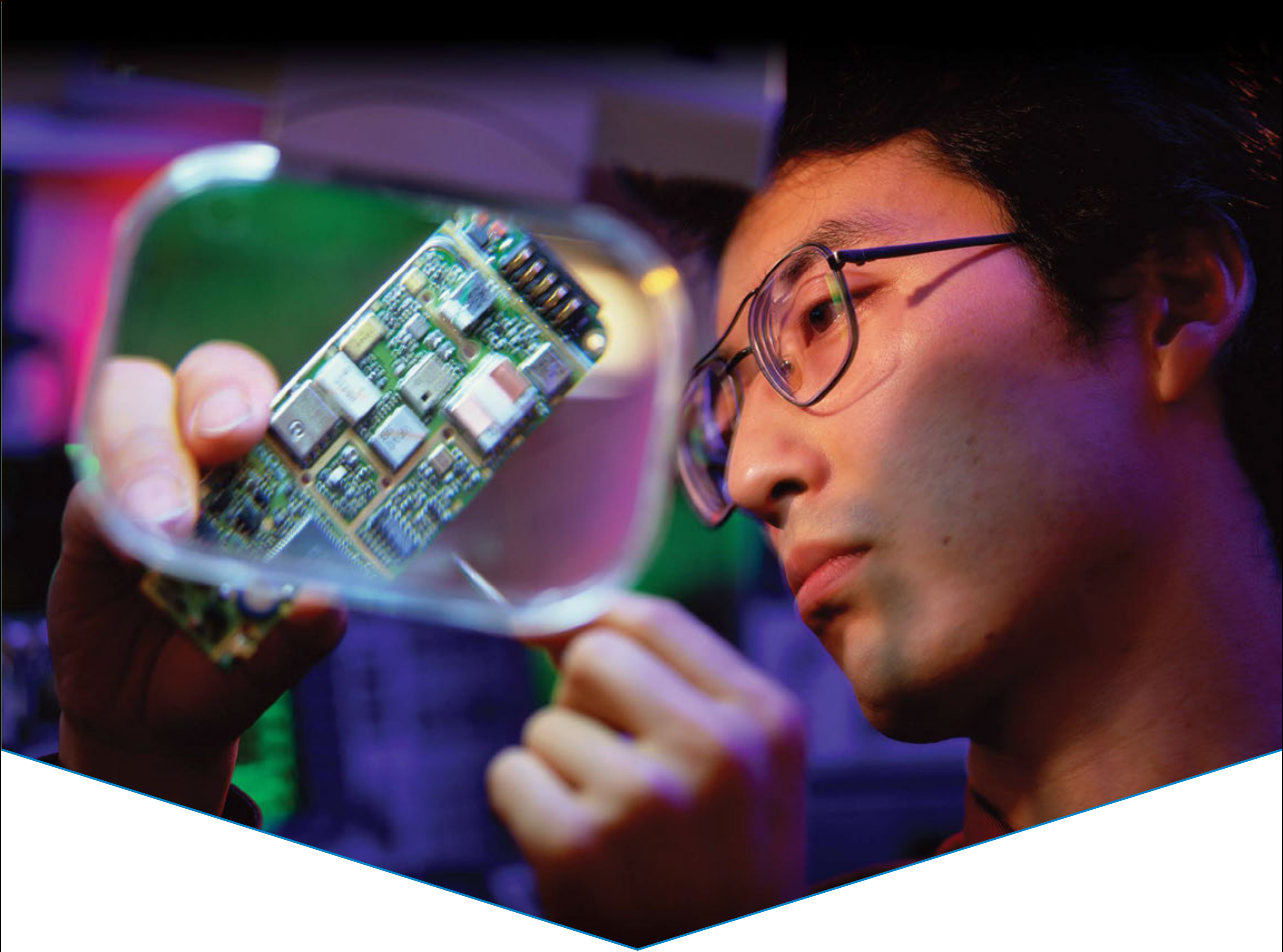
Having served as a past president (on its 10th anniversary), a board member of the organization, and being an SMT industry lifer, I hold especially profound sentiment and affection toward the marching milestones of the Surface Mount Technology Association (SMTA).

With a grand mission, SMTA is an international network of professionals who build skills, share practical experience and develop solutions in electronic assembly technologies, including microsystems, emerging technologies, and related business operations. The organization offers continuing education, as well as career and professional networking for both members and the industry. Most importantly, the organization delivers the right information at the right time to empower the workforce, who collectively advances technology, innovates new products, and serves the global industry.

Initially founded to deploy the surface mount technology, SMTA has served as the backbone of electronics manufacturing for more than three decades. It enables the manufacture of advanced electronics products that are beneficial to virtually all walks of life. The continuing increase in electronics content of products across industry sectors has made the electronics industry the largest employer at the turn of the century. Electronics miniaturization and advancement have been phenomenal, for which SMT has served as the critical manufacturing technology.

Surface mount technology is deemed to be one of the most significant and substantial developments in the electronics era, after the semiconductor. Embracing that the transistor density of integrated circuits doubles every 18 months, and that the advanced chip packaging





evolves in synchronization, SMT continues to transform electronics manufacturing. To this end, SMTA has played an essential role in helping the industry advance and produce ever-higher performance products.

As a professional organization, SMTA has demonstrated its sustained ability to embrace new technologies to meet members' changing needs and wants. The organization relishes the growth and diversity of SMTA membership and its global reach and network. Its membership spans around the world, comprising more than 40 chapters across the United States, Canada, Brazil, Mexico, Hong Kong, India, Taiwan, Malaysia, and Israel. Today, the organization offers rich resources to the workforce, including knowledge-base, publications, training, bookstore, certification, webinars, and tutorials.

> **The organization relishes the growth and diversity of SMTA membership and its global reach and network. Its membership spans around the world, comprising more than 40 chapters across the United States, Canada, Brazil, Mexico, Hong Kong, India, Taiwan, Malaysia, and Israel.**

In Roman mythology, Janus had two faces that looked at in opposite directions—one toward the past and the other into the future.

I want to reflect on what are deemed the most important elements to the successful history of our organization. During the first decade, the Association was shaping up and made major strides in serving the nascent industry. Over the second decade, business models and the global economy challenged the Association, and SMTA responded swiftly with continued success. In its third decade, SMTA has embraced crucial changes in technology and the manufacturing arena and has met the challenges head-on.

The industry has enjoyed a phenomenal growth rate and has contributed to our country and the world by providing critical manufacturing technology that makes modern electronics possible, from personal computers in the 1980s to the Internet of Things today.

SMTA has provided the much needed continuing education to keep up the workforce excellence.

SMTA has enabled the crucial network needed for member companies and individual members globally.

We are fortunate that we have always had dedicated and hard-working board members.

However, behind all these good things is one steady-hand executive administrator, JoAnn Stromberg, and her operating team, which she has built and trained. For nearly three decades, rain or shine or snow storm, JoAnn's personability, wits, and shear warmth have glued all of the pieces together. With JoAnn's dedication, her team, along with the presidents and the board, SMTA has been able to survive, grow and thrive.

At the end of this year, JoAnn plans to retire. I know that JoAnn has a great team in place, and the new leader, Tanya Martin, will continue JoAnn's legacy in making SMTA a strong, wholesome organization.

For JoAnn's extraordinary dedication and contributions to our organization and to the industry, there are no adequate words to express my heartfelt gratitude except to say that from the bottom of my heart, thank you, JoAnn, and enjoy the next chapter of your life!

A celebration in recognizing JoAnn's service will be held on Tuesday evening, September 29 in Rosemont, Illinois, in conjunction with SMTA International. Please click here for details of the event.

Our gratitude also goes to all SMTA staff, members, friends and the industry for their continued support and contributions.

Looking into the future, as we are moving to another milestone, we are vividly energized for our future. And we have profound, substantive reasons to be energized and proud of our organization. SMTA is an empowering platform from which individuals exchange and enhance knowledge and skills to personally succeed in a way that leads to the collective institutional success. We are grateful for being networked together through SMTA. We are privileged to be a part of this dynamic and relentlessly innovative industry.

As we forge ahead into the fourth decade of our journey, I wish all members and friends of the SMTA community a splendid vista. In my SMTA Newsletter column, "From the President," dated January, 1994, I stated,"…As we celebrate SMTA's fulfilling ten (10) years, we also are preparing to take on the new challenges ahead of us. The challenge that our industry faces in the global economy is to-do-more-faster-with-less. In other words, achieve higher productivity, lower cost and higher quality…"

The mission to meet this challenge marches on… **SMT**

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

Researchers Develop New Techniques for Creating High-Temp Alloys

A new grant seeking to develop new techniques for creating high-temperature materials is taking advantage of Duke University's expertise in computational materials genomics—the computer modeling of novel materials to identify which might have desirable properties.

Led by NC State University's Stefano Curatolo (pictured), the new initiative addresses fundamental scientific questions that could lead to so-called "entropy-stabilized alloys." The initiative also includes the University of Virginia and the University of California, San Diego, and is funded by a five-year, $8.4 million grant from the Office of Naval Research (ONR).

"The Defense Department has a need for materials that are mechanically and chemically stable at temperatures of 2000°C or more," says Don Brenner, Kobe Steel Distinguished Professor of Materials Science and Engineering at NC State and principal investigator under the ONR grant. "These materials can have significant aerospace applications, but the number of usable materials is currently small, and those materials rely on strong chemical bonding to remain stable. At high temperatures, most materials are simply no longer stable."

These alloys are of interest for use in ultra-high temperature applications because of their unique ability to "absorb" disorder in a material's crystalline structure that otherwise would lead to the breakdown of a material.

The "New Face" of Automotive Traceability

by Michael Ford
MENTOR GRAPHICS

Historically, the perception of traceability data collection from the shop-floor has been that it presents a significant burden to the operation, yet provides value only when the most unplanned, rare, and disastrous of events take place. Automotive has always been on the forefront of traceability because safety issues are paramount, and responsibilities for failures are quite severe.

A quiet revolution, however, is taking place within the automotive electronics industry, driven by a collection of technology advances, the need for further energy efficiency, and ever enhanced safety. A wide combination of different products that previously only existed in discrete sectors have come together in the car, combining critical control and management systems, including self-drive technologies such as radar, multi-media consumer devices, and built-in telecom capabilities including Internet access.

All of these technologies have to work together in one extended system, all operating in potentially hostile environments, and yet also be economically competitive because the car is, after all, a key consumer product. This is what makes automotive unique. A glitch in a single video camera does not simply result in a poor quality picture, it may now cause a car's systems to react inappropriately in certain situations. Every electronics-based system can potentially affect every other.

A new approach to automotive traceability that brings the whole principle of traceability in electronics manufacturing up to date is now long overdue.This new "face" of traceability has a low cost of ownership because almost all data is captured electronically and automatically from every process and support operation within the factory. Assurance and compliance is enforced as operations are optimized and guided by the

relevant elements of the highly automated manufacturing control software, with traceability built-in. Depending on the level of detail, accuracy, and timeliness of data capture from areas such as quality management, manufacturing, engineering, and supply chain, traceability can become the ultimate quality-management tool, as well as bring enhanced productivity and reduced operating costs.

The Cost of Compliance

Traceability data collection has been all about recordkeeping: the list of materials used, the processes executed, exceptions that have happened during, for example, test processes. In what we can call the traditional automotive factory, the majority of processes were separate entities each supported by other disconnected functions. For example, SMT machines pick from materials that have been loaded. The machines only need to know the size and shape of materials to operate.

The setup of the materials on the SMT machines, which has to align to the setup that is expected by the SMT machine program, is still in most cases done manually as a separate process. And even the introduction of "smart" feeders on SMT machines that can transfer knowledge of loaded material content from the feeders to the machine automatically serves only to push the point of materials setup and verification away from the machine to the material setup area, where mistakes can still happen.

Another mechanism, driven by supply chain, provides logistic support to bring the required materials to the kitting area, which usually is in bulk as a kit, and requires significant manual management. The selection of those materials from the warehouse is also likely to be done by a separate entity, which in many cases still relies on manual decision-making. The receipt and put-away of materials into the warehouse storage locations was also required, often again, by a separate operation.

No wonder then that the cost of traceability information recording at key production processes is just the tip of the iceberg when it comes to "needless" operational costs incurred by tasks associated with compliance to standards for automotive manufacturing assurance.

Improved use of Existing Data and Systems

The starting point for the "new face" of traceability follows the realization that pretty much all of the necessary traceability data already exists as part of the production operation, and so as such, the recordkeeping activities were actually needless duplications of existing data. Most production processes today and the systems that support them are now automated to a greater or lesser extent.

The SMT machines are a great example. Surely every SMT machine must know exactly what material is being taken from which feeder and placed on the PCB for each reference designator because it is part of the SMT machine program. This is the origin of exact traceability. It is a critical part of the overall PCB traceability solution because it reflects the point-of-use accurately, for example, alternative or substitute materials, cases where there are multiple instances of the same material part number on set up on the machine that could be selected for use at any time, or perhaps a material is changed at a position part-way through a circuit board.

It is only right at the actual point of use and consumption that the exact traceability data can be derived; and for automotive, most materials are placed as SMT. Although the SMT machines have knowledge of this relationship of feeder and placement, it is the first critical piece of information, in addition to which other key information will need to be added.

Typical modern SMT machines will recognize materials by their part number and not recognize their unique characteristics such as manufacturer, batch number, age, MSD status, and history, etc. Therefore, the "point-of-use" traceability data coming from the machine has to be qualified against the information of the specific materials used. This material information can be acquired and associated to each material carrier using a unique ID as it is received in the SMT material warehouse. When these two pieces of information are known, there is then the need for the link to know which material IDs have been set up and used at each feeder position.

Rather than leaving this as a manual process, our "new face" of traceability can instead use further automation. Using the material consumption data coming from the machine, a "low level warning" can be created, which in combination with the work-order planning data can be made into a pull signal to trigger just-in-time (JIT) material replenishment to the warehouse. Knowing exactly what material is needed, where, and when, Lean supply-chain logistics software can select the best material available from the warehouse and send it directly to the required position on the SMT machine so that it arrives immediately before it's needed. In so doing, the traceability data of the materials is linked with that of the machine, connected by the software-driven verification process of the material on to the feeder.

Three Benefits of Automated Traceability

The live data coming from the SMT machines, associating picked materials with placements, would now be used to generate three benefits for manufacturing. The first is the automated creation of exact traceability data without manual effort or mistake, as well as the elimination of kitting errors. The second benefit is the use of Lean materials logistics, which eliminates significant stocks of materials on the shop-floor, reducing needless investment cost as well as space and handling overheads. Thirdly, the assurance that the production is being executed exactly as specified. The automotive management conformance requirements have been satisfied through the material verification process, which does not allow any machine to work unless every material has been actively verified for use only in its set position.

Three separate benefits have been achieved simply and automatically through the capture and use of one key source of data, bringing lower cost and inter-process automation between the supply-chain to manufacturing flow. Similar mechanisms exist to support non-SMT machines for manual assembly and even for repair, as well as the bare PCB and consumable items such as solder paste, all with active verification, pull material signals, and the subsequent automated association of data to create material traceability.

These additional steps, although usually representing a small fraction of the total ma-

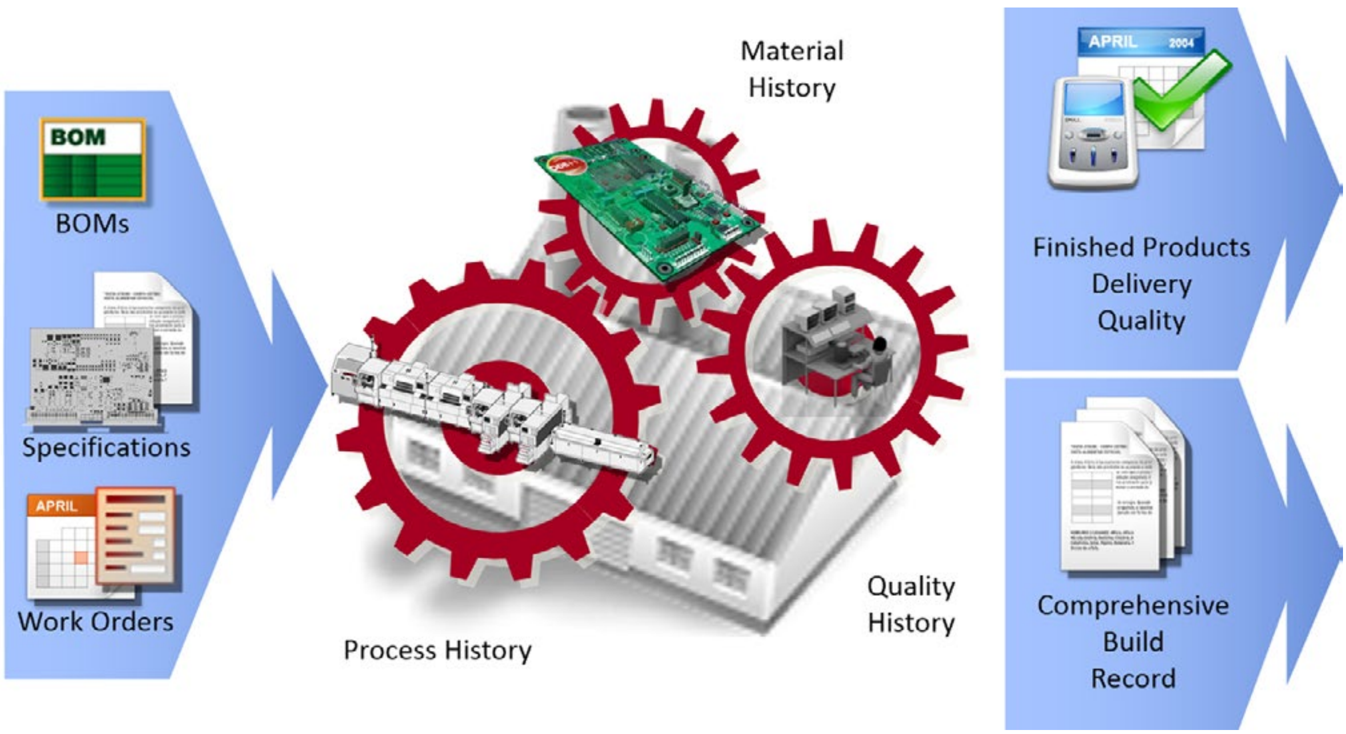


Figure 1: Full automation carries through all the necessary manufacturing data to comply with automotive management reporting requirements.

terial content of a PCB, are essential to have a complete material traceability record and to eliminate operational mistakes, as well as reducing the operational costs. It all sounds too good to be true, but these are firm principles of advanced automation of interconnected processes as suggested by Industry 4.0—applied to traceability.

Benefits Extending Beyond Materials Traceability

Material traceability is just one part of the overall traceability requirement for automotive. The need for control and tracking of PCB assemblies through SMT and related operations, from a traceability perspective, is originally centered on the test and repair process. The basic requirement was the assurance that each product had passed every required test. This immediately introduced the requirement that each individual PCB within a work-order needs to be managed separately.

In the traditional manufacturing flow, a failed test would mean that a paper-based repair ticket was issued, which would be physically attached in some way to the failed PCB which was then taken to the repair station. The critical issue was simply that the repair tickets would fall off, leaving a failed PCB that could mistakenly go forward in production without being repaired. This can be solved by creating a unique identification of each PCB that is associated with a bare PCB as early as possible in the process.

The history of labeling PCB IDs has been fraught with issues with little available space for a barcode, especially considering the need for consistent positioning across products. Newer generation scanners, etching machines, and 2D barcode technologies have all combined to ease the cost and improve the reliability.

With the unique PCB ID in place, a whole range of potential values are created. At each testing process, the test result and associated test data can be captured electronically and automatically, then associated with the individual PCB. In the case of a test failure, the captured data acts as a paperless repair ticket. Reading the PCB ID at any point can display the history and status of each individual PCB.

At the repair station, reading the PCB ID provides not only the repair ticket information, but also the complete manufacturing and history, including any previous failures and repair attempts. Serious quality issues and trends in quality can be identified and highlighted in near real-time, providing the opportunity for active quality management. Should any PCB be routed incorrectly, then the next process with a reader for tracking will prevent processing of the faulty unit, thereby ensuring that no defective PCB assemblies can get through to the next stage.

"Should any PCB be routed incorrectly, then the next process with a reader for tracking will prevent processing of the faulty unit, thereby ensuring that no defective PCB assemblies can get through to the next stage."

This tracking facility can also be used to ensure that during manufacturing all process are completed in the correct sequence and that all processes are set up correctly before execution can begin. In cases where processes are capable of making different products with the same material setup, the unique PCB ID can also be used to trigger the SMT machine to select the correct machine program, thus allowing mixed production through SMT machine lines without risk of error.

Using the same tracking information, the time taken by each PCB assembly at each process and the time lost between processes can be recorded, which can then be used in productivity reports and bottleneck analysis. This provides a great deal more depth than only capturing data about the quantities of products produced and stored. All of this information, automatically captured by the tracking system, is then available to be a part of the traceability data.

The justification for unique PCB identification can be made based not only on routing at test and repair, but also for complete material and process traceability where exact trace of

Figure 2: Total traceability pulls data from all three silos of materials, process, and quality.

materials to individual PCBs as well as product manufacturing and test histories are required.

Adopting the three key principles of the "new face" of traceability creates a whole new paradigm of technology that is based on the creation of value and benefit to manufacturing. The ability to collect all of the required data for traceability through the use of automation means that there is little cost for the data acquisition. The data is also more accurate because there will not have been manual data entry or data manipulation, and it will also be more immediate because it is collected from the processes during the normal course of operation. The data collected can also potentially be far more detailed than when using manual methods because there is very little overhead on how much data can be collected.

This all leads to a rich traceability environment for little cost. The key for automated traceability value is focused on combining all of the different sources and formats of data, piecing together every fact and event that happens.

Care should be taken for accurate interpretation of the data so that traceability is built into a neutral format that is not dependent on any proprietary formats from machines or processes. Traceability retention for automotive electronics systems can stretch to many years, sometimes over a decade, which means the sheer volume of the data can require the adoption of the latest "big data" technologies.

Even this requirement for the retention of traceability data can provide more benefit than cost. Apart from the headline-grabbing, market-recall scenarios, bringing the need for immediate help to identify the exact scope of vehicles with a particular issue so as to reduce recall costs, traceability data can serve as a sophisticated internal and market-quality tool.

Because of the nature of production with traceability, there will be very few issues in the market, but if any issue, even a minor one-off defect should be found, possible root causes can be found with the significant options for analysis of the complete build records for those products. For example, the defect could be found in a product that was one of a 1,000 unit work-order, which were all made at the same time and in the same way.

There has to be a reason, however, that one of those products out of the 1,000 had a variance—a slightly different circumstance or combination of circumstances that created this defect. Using the fully detailed traceability build record, covering all processes and materials including all sub-assemblies, it is far more likely that the specific exception that may have occurred, such as a specific combination in the use of alternative materials, deviation of the reflow process temperature, or a particular repair that was actioned, could have been the unique trigger to cause the defect.

Once known, the specific set of circumstances can be engineered out of the production operation so as to prevent the defect from recurring. Without traceability, finding the root cause would have been almost impossible.

The approach to the need for traceability in today’s automotive manufacturing environment should no longer be a simple reaction to what is required by a customer to meet some specified standard, especially where products with complex use categories are made together. The real traceability solution lies with the full consideration of the ability of key processes such as SMT and key supporting functions such as supply chain, engineering, production management, and quality to communicate in automated ways, sharing data that can be made visible and used to obtain multiple operational benefits, and as a result, a complete and detailed traceability record. Doing this should make adherence to any standard imposed from the customer something that becomes just a routine “tick in the box,” because everything is covered as a fundamental part of the production operation, in a way that is a benefit, rather than being a potentially costly add-on control and management function. **SMT**

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

New Graphene-based Catalysts for the Energy Industry

Researchers at the Universitat Jaume I in Spain have developed materials based on graphene that can catalyse reactions for the conversion and storage of energy. The technology patented by the UJI combines graphene and organometallic compounds in a single material without altering the most interesting properties of graphene, such as its electrical conductivity.

The technology, developed by the Group of Organometallic Chemistry and Homogeneous Catalysis (QOMCAT) of the UJI, is of great interest to the energy industry and is part of the so-called “hydrogen economy.” An alternative energetic model in which energy is stored as hydrogen. In this regard, the materials patented by the UJI allow catalysing reactions for obtaining hydrogen from alcohols and may also serve as storage systems of this gas.

It is a novel technology since it uses graphene for the first time as a support of organometallic compounds. These hybrid materials have catalytic properties and are modular and recyclable. Thus, the catalyst developed at the UJI can be recycled ten times without suffering a loss of activity, a very attractive property from the industrial viewpoint.

The new material is also obtained from a novel system of obtaining hybrid materials in a single step. An easy and affordable system that allows that all the technology that is currently based on graphene can be easily converted using these new materials. Thus, the patented materials can be used both in the development of catalysts as well as storage batteries or other energy types.

Automotive EMS: Going Beyond Assembly

by Frederick Blancas
INTEGRATED MICRO-ELECTRONICS INC.

As the amount of electronics that go into a car increases, the car is becoming less of a mechanical thing consisting of a few electronics and more of a computer with wheels.

The electronics' share of vehicle value for a state-of-the-art automobile is already at 40% for traditional, internal combustion engine cars, and it could reach 75% for electric or hybrid electric vehicles. This percentage value will definitely rise in the next few years.

Automotive electronics rose by 7.3% in 2014 to about US$205 billion and will continue to grow at the same growth rate to 2020, at close to US$315 billion based on a report by Research and Markets.

The advanced driver assistance systems (ADAS) market will have a 14.9% CAGR from estimated revenue of US$39 billion in 2015 to US$78.2 billion in 2020, according to Industry ARC.

According to New Venture Research, of the $91.2 billion worldwide automotive electronics assembly value in 2014, 86% was done in-house by the OEMs; 1% by the ODMs; and 13% by the EMS providers.

The automotive industry continues to grow rapidly as a high-growth market for EMS providers as it transitions steadily from mechanical to electronics. The total automotive EMS value of $12.1 billion in 2014 was contributed mainly by the top players that include Flextronics International; Hon Hai Precision Industry Co. Ltd (Foxconn Technology Group); Jabil Circuit Inc.; Zollner Electronik AG; and Integrated Micro-Electronics Inc.

Merely board stuffers—these are not today's EMS providers in the automotive space. They've gone far beyond board stuffing.

The EMS providers are end-to-end solution providers, assisting the automotive electronics makers or automotive manufacturers in product realization. They engage in design and product development, advanced manufacturing engineering, and test and test system development. Their manufacturing expertise includes PCB and FPCB assembly services, module assembly, and box build assembly. They can offer high-volume manufacturing as well as low-volume and high-mix manufacturing.

Some EMS companies can do product reliability and failure analysis, calibration, and product repair services.

Further, while it is common for the tier-one EMS providers to have plastic injection capability, there are also mid-tier EMS players that can offer plastic injection.

We can say that the automotive EMS players have expanded their role through vertical integration and venture into the realm of non-electronics manufacturing.

Manufacturing

The trend toward outsourcing in the automotive industry continues as automotive manufacturers strive to capitalize on the technical expertise and cost effectiveness of the EMS providers. Contract assembly is a core competence of these EMS companies.

Challenges in Manufacturing: Maintaining high quality and reliability of the products that are being manufactured specially for products related to safety are among the major challenges in automotive electronics manufacturing. The EMS providers' customers expect zero defects. The goal is to eliminate risks because risks could lead to a life and death situation for car drivers or passengers. The entire supply chain should cover that objective from design to manufacturing.

The automotive industry's product development framework such as the advance product quality planning (APQP) is strictly being practiced by tier 1 automotive suppliers and their sub-suppliers to ensure that proper planning and manufacturing process design will be in place before the production line begins mass production. The APQP produces the plan needed for the development of a product that will satisfy the customer. The plan also helps the people behind the manufacturing services adopt the right automotive mindset—they should be able to anticipate potential problems, immediately act on the situation, and always on the lookout for continuous improvements to make the job more efficient.

Another challenge is the pressure of yearly price reduction from the tier 1 suppliers. Various lean manufacturing techniques like the val-

ue stream mapping (VSM) and JIT inventory strategy are some of the tools that automotive EMS providers are using to identify opportunities to improve their process and reduce their manufacturing cost.

Value Stream Mapping: In every automotive EMS process, VSM is a lean manufacturing technique used to document, analyze and improve the flow of information or materials required to produce a product or service is also applied. It is another part of the whole process development action once mass production begins. The VSM provides optimum value to the customer through a complete value creation process with minimum waste in design (concept to customer), build (order to delivery), and maintenance (in-use through life cycle to service). Through VSM, customer gains are maximized with clear vision and plan connecting all improvement activities. VSM recognizes and eliminates wastes.

To further help tier 1 suppliers reduce their product cost, EMS providers can offer unique processes that can provide cost improvement opportunities in the product design. One such capability is the chip-on-board (COB) process. This process allows design engineers to consider the use of bare die semiconductors instead of packaged semiconductors. The cost difference may range from $.25 to 1USD depending on the actual buying price difference between bare die and packaged. One product that benefits from this capability is the automotive camera. There are plenty of benefits in using bare die imager sensors for camera modules. Aside from the cost difference, camera modules that use bare die imager sensor have better optical performance as compared to the packaged imager sensors.

Design and Development

The life of any new automotive electronic product begins with design and development (D&D). A good D&D process employs product development life cycle (PDLC) that details the various processes for hardware, software and mechanical design.

PDLC: A typical PDLC entails gathering of all customer requirements and creating the product specifications. It specifies the product planning requirements and outlines the methodologies to be used in executing the design. It also specifies in detail how the product's performance will be validated. It involves general updates to comply with the latest versions of quality standards, simplified processes, coming up with templates, risk assessment and traceability in product specifications and technical plan definition.

Design Failure Mode and Effects Analysis (DFMEA) is an important requirement when designing for the automotive sector. Here, the design team identifies as many possible failure modes that can possibly occur in the design. These are then classified according to severity and likelihood and appropriate mitigating actions are identified.

For example, one of the major products that IMI has designed and produced is the automotive camera. Future vehicles will have multiple cameras which will be used for both sensing and viewing applications. Viewing cameras are already widely used to avoid obstacles while

backing up. They are also seen to replace side mirrors in the future. Lane departure warning, collision avoidance and night vision are some examples of what sensing cameras are capable of. They can also be used for passenger monitoring and for surround view applications.

For automotive cameras, it is crucial to precisely align the lens to the image sensor. IMI performs active alignment using a 6-axis alignment setup that was developed in-house. Active alignment is used to ensure the most optimal optical lens position relative to the image sensor in order to yield the best possible focus quality across the entire image area. The use of 6-axis active alignment significantly improves the accuracy of the algorithms used by advanced driver assistance systems than single axis alignment would allow.

Challenges in D&D: One of the challenges in D&D is the tedious requirement to comply with established standards for automotive development. In the planning stages, design implementation only starts after the product architecture is fixed and the architecture has been partitioned into the appropriate modules. Feasibility studies must be undertaken when considering various options. A DFMEA must be conducted to assess risks and set the appropriate risk mitigating actions and it has to be updated periodically.

Traceability has to be incorporated in all aspects of the design process. Each design feature must be traceable to the product specifications, which in turn are traceable to the customer requirements. It is important that all customer requirements are covered. Validation must likewise be traceable to product specifications. Periodic design reviews have to be conducted, decisions and tradeoffs have to be documented.

It is very tedious to conform with requirements of design for functional safety, and as such, it is one of those challenges that EMS providers have to address. For this reason failure simulations have to be conducted down to the component level.

Design Reviews: To meet these challenges, EMS companies continuously reviews and streamlines processes. To ensure the design quality and ensure strict adherence to established processes, IMI's D&D department, for instance, conducts periodic audits and provides continuous education programs.

Test and Systems Development

In automotive electronics, leading edge products integrate more functionalities which present new challenges in product testing and custom tester development. The test and systems development (TSD) process is organically linked to the APQP applied in the development of these new products.

APQP Framework: The APQP, as discussed earlier, is a method used by EMS providers for detailed planning of design and production processes to satisfy customer requirements and anticipate issues before they occur. It is the quality planning process in every advanced manufacturing engineering stage that takes place before a product is manufactured and shipped to the customer.

Development of a New Test Solution: There are basically five stages involved in the development of a new test solution: project planning; test system design; system build; system buy-off; and project closure or endorsement. All these stages are managed with "gate check points" compliance to quality standards and customer requirements. Of these stages, the test system design and system build are the most challenging.

For automotive applications, new product testing covers multiple technologies and scientific applications. In automotive camera testing, a typical camera test solution for camera focus and alignment includes not only require electronics circuits design and measurements, but also optics measurements, as well as robotic precision handling. Integrating all these technologies and processes in a platform to meet the unique functionalities and test requirements of the products of customers is always the main challenge in test system design.

Multi-disciplinary technical team: For EMS companies, technical challenges encountered in TSD are addressed through the collaboration of various engineers with different specializations—optics or applied physics, electronics engineering, materials science and mechanical design. This technical team also engages customer engineers in technical workshops to make sure the end test solution is usually unique and innovative.

Value-add solutions: There is no such thing as a basic solution to every customer's test requirement. EMS engineers determine ways to innovate test to meet all customer requirements. For example, one test solution proposed for a customer with an automotive rotary position sensor product went beyond simply measuring rotor position sensor (RPS) product parameters. A parallel test system with an embedded ink or laser marking system was integrated in the test platform solution to improve production throughput and efficiency.

With regard to pressure sensors, for instance, manual handling is minimized, therefore minimizing labor cost component. With TSD, the reliability of the product assembly is further improved.

Rapid Development and Cost Competitiveness: Implementing a test solution from a concept is equally challenging. For instance, as IMI offers turnkey test solutions, procurement of parts for both standard and custom materials is critical in the development process. IMI TSD Group leverages on its supply chain network managed by IMI's Global Materials Team for the sourcing of standard parts as well as hard-to-find materials. This leverage helps the test development—it enables a faster tester development time and makes tests solutions cost competitive and compelling to customers.

Integrated Technology: More new and diverse technologies integrated in a single platform solution are the future of TSD. Innovative products from customers will require more specialized processes and measurements in their test requirements. These new products are now integrating new technologies like micro-electromechanical systems (MEMS), which in its most general form is also known as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of microfabrication. It can combine computers with tiny mechanical devices such as sensors, valves, gears, mirrors, and actuators embedded in semiconductor chips. Testing MEMS devices or their functionality in a product brings new excitement in TSD.

Integral Part of the Supply Chain

Today, only the high-end automotive brands are fast turning into smart cars or connected cars. Soon, the rest of the automotive brands will have their versions of the future-car-in-the-present. The EMS companies have geared for this with assembly services as well as value-add services like product design and test systems development. They are here to prove that they are an integral part of the automotive supply chain. **SMT**

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Electronics Industry News
Market Highlights

Smart Home Devices and Systems to Top 7 Million Support Requests in 2015

A new report from Parks Associates finds that smart home devices will prompt over 7 million support requests this year, with adoption at 16% of U.S. broadband households and nearly 40% planning to buy a smart home product in the next 12 months.

Smart Robots Market to Hit $7.85B by 2020

The total Smart Robots Market is expected to reach $7.85 billion by 2020, at an estimated CAGR of 19.22% between 2015 and 2020, according to market research firm MarketsandMarkets.

Worldwide Smartphone Market Posts 11.6% YoY Growth in Q2

According to the latest preliminary release from the International Data Corp. Worldwide Quarterly Mobile Phone Tracker, vendors shipped a total of 337.2 million smartphones worldwide in the second quarter of 2015, up 11.6% from the 302.1 million units in 2Q14.

Automobile Sector Drives Global Smart Sensors Market

The global smart sensors market is expected to reach $9.22 billion in 2018, growing at a CAGR of 11.53% from the period 2014–2020.

SEMI Sees Sustained Growth in Fab Tool Spending

SEMI forecasts that the total semiconductor equipment market will grow 7% in 2015 to reach $40.2 billion, and expand another 4% in 2016 to reach $41.8 billion.

Biometrics on Smart Mobile Devices to Redefine Digital Identity

Acuity Market Intelligence forecasts that between 2014 and 2020, nearly 12.9 billion mobile biometric apps will be downloaded to smart mobile devices by 2.2 billion mobile biometric users.

Chinese Automotive Semiconductor Revenues to Hit $6.2B in 2015

Total automotive semiconductor revenue in China reached $5.6 billion in 2014, and revenues are expected to grow nearly 11% year over year in 2015 to reach $6.2 billion, according to IHS.

Weak Q2 Demand Pushes Down 2015 LCD TV Shipment Estimates

The global shipments of LCD TVs in the second quarter totaled 48.25 million sets, down 6.4% from the prior quarter, according to WitsView, a division of TrendForce.

Apple Accounts for 20% of Global Sapphire Demand

Sapphire is the key material for LED manufacturing. But in 2015, 20% of sapphire will be used in Apple's iPhone, for the camera lens, fingerprint reader and heart rate monitor covers, and the Apple watch's window, according to a Yole Développement report.

Tsunami of M&A Deals Underway in the Semiconductor Industry in 2015

Market share expansion, Internet of Things opportunities, rising costs of R&D, and China's aggressive new focus on the semiconductor industry are all driving the recent M&A surge, according to IC Insights.

Big Strategies for Success

I-Connect007's Barry Matties speaks with Pratish Patel of Electronic Interconnect about the new strategies and capabilities the company is building. The conversation also covers Electronic Interconnect's move into the automotive industry and how strategies for buyers could help to lower cost and improve quality.

Barry Matties: Why don't you begin by telling me a little bit about your company, and what you do?

Pratish Patel: We are a U.S.-based domestic PCB manufacturer—that's our core business. The majority of the business comes from thermal management within the circuit board fabrication with materials and things like that. We have been in business for the last 30 years—established in 1985. In 1995, we took separate relocations, and this year, we are planning to move to another location. So we have been expanding for 30 years.

Matties: Is the expansion based on the need for a larger manufacturing area?

Patel: No, the purpose of the expansion is primarily for capabilities, not capacity; on the capacity part of it, Asia has already taken care of everything. What we need in the U.S. right now is high-mix, low-volume in the high end of the technology, where we can meet the automotive and avionic needs, as well as a lot of the defense needs. It is going to require a little bit more technology work here and then that's all going to be in the U.S. We see that. So we're expanding just for the capabilities right now.

***Matties:** What kind of capabilities are you adding? Direct imaging and that sort of thing, or other processes?*

Patel: The capabilities mainly are twofold: The first is to enhance more into thermal management. The second is RF material, mainly for avionic needs. Those things are important for us.

***Matties:** In our last conversation, you were mentioning that Electronic Interconnect has become certified for the automotive industry as well, recently.*

Patel: Yes. To expand your capabilities, you also need a certification to go along with that. That certification assurance allows the customers to know that we have the ability to further expand our capabilities going forward. That's the reason we are looking at certification right now, mainly the AS9100 and TS16949 certifications.

***Matties:** With regard to the automotive industry, what sort of market opportunities did you see that compelled you to move into that arena?*

Patel: We have our manufacturing reps all over the U.S., and one of the things we hear in our regular conference calls and meetings, and of course the data indicates this as well, is a need for high-mix, low-volume types of business. Once we have AS and TS certifications done, it will allow us to further pursue the production side of it. And it's not exactly just for the purpose of testing, either; it's more for a mid-production purpose for the domestic market. That's where we want to fit in.

A lot of production overseas has the AS and TS certifications, and if we have to put some of those parts into our short runs over here, we should be capable of handling it over here as well.

***Matties:** What sort of demands do you see the automotive industry putting on you that may be different? Is there more inspection or are there other requirements that you have to adhere to?*

Patel: It's more flexibility of inspection. That's what it really boils down to. What we really need and what we're expanding into is more inspection units and more AOI units. These mainly take up more space and need more training. We think our best bet is to move into a different building and expand the capabilities where we can accommodate this equipment, because you need space for automation.

***Matties:** With automotive, the cost of failure is so high they're willing to pay for a lot of extra inspection.*

Patel: Exactly. Not only for automotive, but the same thing goes for the avionics sector. Anywhere quality is absolutely crucial they are willing to pay, but they want to make sure that all the documentation is available for their records when it's necessary. That also allows us to follow that data because a lot of times, when in a hurry, people will say, "Okay, get it done fast." What happens? People take shortcuts, go through quickly on inspections, and miss the details. At that point if we are AS and TS certified it enforces the documentation and you have a clearer picture of what's going on for high-mix, low-volume. People do that also with comparison data. Automotive is looking for a circuit board fabricator like us that not only deals with speed but also can keep track of the traceability. That's where we come in and why we're going to be data sharing with the others.

***Matties:** Traceability is a big issue, not just for quality, but also for liability. For example, we see these ignition switches failing, and so on. They want to go back and now look at it on a component level to figure out where the blame lies. We're seeing more and more of that with the accountability issue going on. Is that how you see it as well?*

Patel: Yes, absolutely. I think that when anything fatal happens or a catastrophe occurs, everyone is going to look at everything under the microscope. We want to assure that every question raised during an investigation can be answered through our traceability. That's the reason it's all about traceability at the moment.

EIC building.

Matties: You're 30+ years into this business; what are some of the most surprising things that you've seen in those 30 years?

Patel: What's surprising in this industry is that things are changing faster than we can accept the changes. More and more complex products are coming onto the market very fast because of the component situations we have and fabricators must be accommodating to the component placements from the transporting and reliability point of it. Some of the things we don't have enough data yet to prove that the new processes can be relied upon. People want speed versus high-reliability, and we don't have enough data to prove both ways or at what point we can switch and make the transition into the newer technology or newer processes that can allow you to get a more reliable product.

That's where it's changing. I think that in the last six to seven years, that was the biggest change we were experiencing. Every single day it is changing faster than before. By the time we change over to something, a new change is coming in. We don't have enough time to do analyses and figure out if this is what we expected. And why are we going for the new technology? Because sometimes we hold onto the old technology to satisfy ourselves and what do we lose? What happens during that time? We lose business because we didn't have the capability. You're chasing your tail here. Who comes first, the chicken or the egg? Yes, we'd love to have new technology coming in but at the same time the risk associated with the reliability is just too high. That is the biggest challenge fabricators are facing right now. That's the bottom line.

Matties: I would think that the other influence on that situation is everybody wants the product for a lower price, which takes money out of your R&D and capital equipment investment funds.

Patel: Yes, I was at an IPC conference recently and being one of the smallest manufacturers in the team, one of my biggest challenges came up: How does a small fabricator survive when they don't have enough resources to go out and do enough research and data collection to prove why a new technology or process is adequate for their shop? We don't have the data, and when you don't have the data how can you make the right decision? That's when you are chasing your tail. When there is a failure people ask us, "How is it this can happen?" I say, "This was not the intention, number one. Number two, when we did it our intention was to give you better product, better copper, etc. If the process fails at some point on your end of it, we don't know what happens, so we need time to go back and we need to redo it to find and fix this problem."

This is exactly what happens and now they don't have the patience. They say, "Well, it's your capacity, or you don't have the capability." I say, "Let's look at every element that came out of here." Sometimes when I look at the samples after, permutation combinations may lead into these failures, and this is where nobody knows. Nobody knows because [there are] millions of permutation combinations.

Matties: What is the solution? What do we do? Somehow we have to break through this, right?

Patel: Yes, we want to break through it. The way I see it, the fabricator needs support at the point a product is in R&D, especially when it is going to foreign agencies and out of the country to be made. What data can be shared so that we can have better records to help fabricate it within the U.S.? If things go outside the U.S. we don't have anything. There's no data or communications for what is happening outside the U.S. When we learn about something new or hear it in the news they say, "Well, this goes to China or offshore." We have no communications or data at all about what comes out of it there. What issues occurred? How were they corrected? What happens is that we figure out, instead of learning from each other, we have to learn from our own mistakes, which becomes very costly. That is the biggest challenge we are facing. If we allow open communications with offshore manufacturing I think we can learn a lot more.

Matties: A lot of the work that was going offshore. Do you see some of that coming onshore and are you experiencing any of that firsthand?

Patel: Yes, we are experiencing onshoring, absolutely. What has happened is they come back to onshoring because the demand is low. They don't come back to onshoring because they say, "Okay, now I'm doing a million digits in offshore. Let me bring a million digits in domestic." No, those types of products don't come back. The only thing that comes back here is when the demand goes slow and those products are legacy products; then the work comes back here.

Matties: In your expansions, when you look at your facility, do you look at automation as a direct labor cost reduction? And if so, how much reduction do you expect to get out of automation?

Patel: We are looking at it more from a reliability and quality standpoint, or what we call the yield factor—moving through more yields than labor. We still need people either way. Either you pay them a certain extent or you pay them for maintenance. You're paying somebody somewhere. What we calculate is it's going to help us more on our primary goal, which is to increase the yield and productivity. Between those two, our objective is about a minimum of 20–30% for the product yielding phase of it. That is the key—the combination of yield and speed.

Matties: So you eliminate handling; that's where most of the errors are produced. That increases yields and reliability, of course. I would think that it does have an effect on your labor cost, but what you're saying is it's not your primary motivation.

Patel: We calculated that and it's not really impacting a whole lot because you need those people. Technically what you are doing is you're giving the people the right tools so they can produce more. I have 85 people over here. Do I plan on reducing them? No; not a single one. I would rather give them better tools so they can become more productive. I can shape more with the same people. I'm not planning to add any more people though, that I can say.

Matties: The result is you add capacity without adding additional people. What you're saying is you can grow without the impact of higher labor

and you're going to have the benefit of the improved quality because the handling issues will have been resolved through automation.

Patel: Absolutely.

Matties: What sort of growth do you see coming in the next year?

Patel: This year, it's kind of hard to say right now. I know a lot of people are experiencing a downturn. A lot of shops and fabricators are slow right now. Somehow domestic fabrication took a little dive, maybe because of the summer or whatever. We are seeing our offshore supply chain take a little dip, and our partners have seen this as well. We are seeing some very soft landing right now in this arena, the fabrication of the circuit board. It could just be a matter of the Chinese crises coming into play. Inventory is going to deplete and it's going to get shorter. I think we are probably going to have the same business growth, which is about 2–3%, but I'm not expecting growth to take a spike. In the range of 2–5% is normal for what we have been seeing the last few years. I think we are going to continue to grow that way.

Matties: Revenue growth is one thing, but you can also increase profit through better systems. Are you focused on improving your systems as well, in order to find and eliminate waste?

Patel: We talk about two kinds of waste over here. One we call yield; there is waste that comes out of that. We call the waste on the other end EPL waste. Another EPL factor is whether we can recycle the water or retreat the water and find an effective way of getting the water clean so we can put it back into the system. EPL waste is one of the factors or areas we constantly watch so we make less waste or chemistry. That adds to the bottom line.

Matties: There are two parts to this when I talk about waste. I'm talking more about streamlining your process because, in most manufacturing processes, we have steps involved that create waste in time, energy or resource. For example, if we're doing an inspection where an inspection isn't really required, that becomes waste. Or having to fill out extra forms in redundancy, the second one becomes waste.

Patel: Yes, we've reduced our waste in these types of processes and increased our efficiency through our new IT system, for example. We have fully developed IT systems where you don't need to fill out the forms—it's all done through the system. We can check on orders quickly to see what's going on. The most important point of it is that it's real-time information. If my engineers or my sales people meet a customer, at any stage of the process they can see immediately where it's at on the screen. Also, when a new change comes in, they see they need to implement it. Our IT system is one of our major strengths and how we differentiate ourselves from other shop floors. It transfers from start to finish all the records and data needed. It is real-time; nobody needs to roam around to find out where a job is currently. They click on it, and boom, it is there.

That's how we work currently. You're definitely right, though, in the past our processes were very wasteful. A lot of times somebody would need to find an order only to learn it had already gone through the tank and it was too late. Our IT system has helped streamline that process and reduce waste.

Matties: It sounds like you have a good data strategy at your facility. What advice would you

give someone who is looking to purchase circuit boards for lowering their total cost? Not necessarily for lowering your profit, but how do you help your customers lower their cost?

Patel: That is one of our major strengths as well. We reveal their data as we look at their design for manufacturability. We use high-end CAM software, like UCAM, and the software's scripting helps tell us what to look out for from the very beginning, when the customer sends us a file and before it goes out in the process. All the detailed pictures in the software do it for them already. It lets us know these are the areas that are going to bring a low yield because the chemistry and some of the processes are not selective. It goes through the process and warns if we are going to have fallout in a given region, or failure is going to occur in this area.

We go back to customers and say, "Look, according to our analysis if you change your design, do some minor rerouting in certain places, add proper balance, and add a couple parameters to it, we can bring the cost down to X percentage here." They really admire that. They ask, "So instead of doing this, can I do this?" I say, "Sure! We can do this as long as you don't have a problem, we can increase our yield, and it works." We do this all the way from the Gerber or fabrication layouts to the final finish. A lot of times they have very exotic fabrication requirements with very stringent tolerances. We come out and do design for manufacturability and we get approval from them first. We do all this stuff upfront at the time of the quoting. We get it done and we show them how to reduce the cost. I give multiple presentations on design for manufacturability all the time.

Matties: What's the most common error that you see designers making in circuit board design?

Patel: There are a couple of major areas we encounter all of the time. Number one is the data applications—designers that just don't do the data. Usually the second is small panel layouts. They don't understand the shop-end side of contract manufacturing their panel layouts. Maximum yield and material to realization are

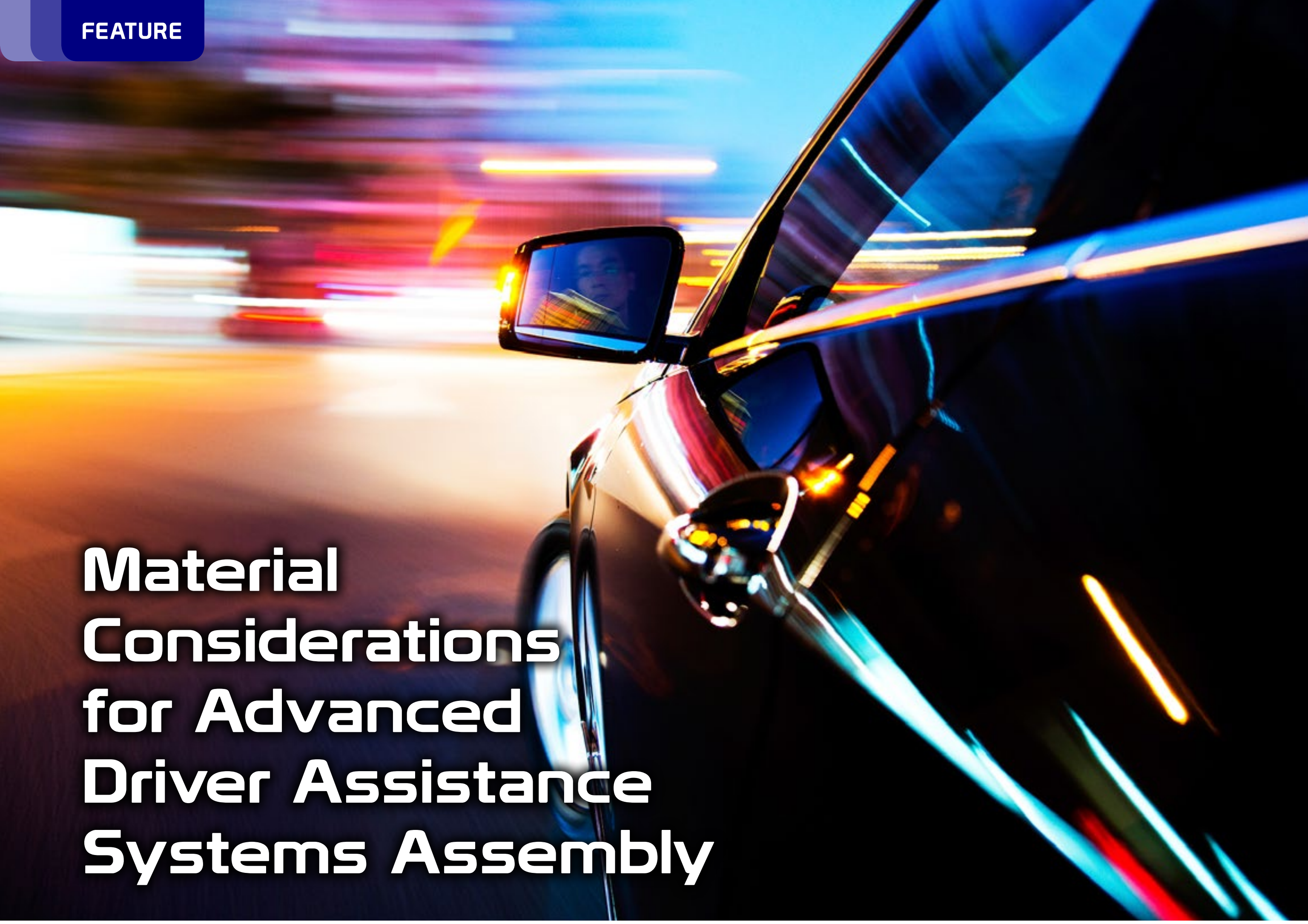
concepts a lot of engineers still don't understand. We come out and we help them figure out how to maximize material to realization in fabrication. That's where we come in and where a major holdup usually occurs. The third one is usually final finish challenges and helping them decide what they are looking for. That's where we give someone recommendations and suggestions.

Matties: Nice. It sounds like you guys are doing a great job. You're investing in your company and you're investing in automation. What about employee training? What sort of programs do you have for ongoing employee training?

Patel: First of all, the number one training that we have is our production meetings that we hold every day. Then we have our monthly meetings. So any issues in fabrication, processing, or any of those areas, our department of quality will separate each issue and continually educate on them during the monthly visits. If there is any hiccup or a major issue happens, we call up a meeting immediately and give the training. We also of course have IPC trainers on our staff, including myself, and we use that knowledge to our advantage all the time.

Matties: I really appreciate you taking time to talk with us today.

Patel: Thank you so much. **SMT**



Material Considerations for Advanced Driver Assistance Systems Assembly

by Steve Brown
ALPHA

For many years, the expanding scope of electronic systems in vehicles has been built on a very conservative design ethos, with a considerable focus on reliability. It is well known that automotive electronics was, by far, the largest electronics market segment to be exempted from 2006's EU RoHS legislation, which included the removal of lead (Pb) from electronic assemblies. The core argument during the successful lobbying of the EU, and subsequent exemption for the automotive electronics companies, was that there was insufficient reliability data of the Pb-free alternatives. Now these exemptions are coming to an end, and this growing segment is rapidly employing the most common alloy group which the majority of other segments had adopted before 2006. This solder alloy group is the standard Tin-Silver-Copper alloys, based close to the ternary eutectic point at Sn Ag3.8 Cu0.7.

Added complexity in material selection comes from the ever-increasing array of applications in automotive electronics, and one of the newer applications is the deployment of an array of vision and detection systems for driver assistance, collectively known as advanced driver assistance systems (ADAS).

The Evolution of Vision and Detection Systems

Parking sensors have become commonplace in the last 10 years, making the process of getting your car into a tight parking space a much less risky proposition. This is based on relatively simple radar technology and provides the driver with an increasingly audible alarm as the object to be avoided comes closer.

In more recent years, a number of vision and detection systems have started to play a much more critical role in the driving experience. One of these examples is lane departure warning system (LDWS). This system uses AOI vision technology to track the edge of the road or the lane

markings, and provides the driver with a warning if the vehicle veers over the line without indicating. The system interprets the absence of purposeful use of the indictors as a likely result of the driver losing concentration, or in its extreme form, falling asleep. The first generation of LDWS activated a significant vibration alert in the seat in order to alert the driver to imminent danger. The second generation took things closer to automatic intervention with a low-torque nudge of the steering wheel to put the vehicle back "on-course". The reliability of such a system is clearly more critical than the simple parking sensors, as the operation is designed to work at speed and prevent high-speed collision.

An increasingly common feature in vehicles is cruise control. This has been available for decades and like many features which enter the market on luxury vehicles, has become standard for any vehicles intended for distance driving. The new generation of cruise control is emerging, and is known as "active cruise control." This technology not only regulates the speed, but also maintains a minimum distance between the vehicle in front, automatically reducing the throttle, and in some cases activating the brakes automatically, and then only returning to the set-speed when the distance to the vehicle in front allows. This radar based technology is integrated with the braking and throttle controls to achieve its function, and so its performance is absolutely critical to safety.

The fourth and final area we will consider is the new generation of parking aids. Supplementing the radar-based parking sensors is the integration of rear-view cameras with superimposed guidance lines to help the driver with reversing into a parking space. This passive parking technology is already being advanced with some active systems which will actually assess a parking space and automatically steer the vehicle into a parking space requiring the driver to only operate the throttle and the brake pedals. This technology uses a combination of radar and cameras to provide this advanced parking function.

Design and Manufacturing Constraints and Considerations

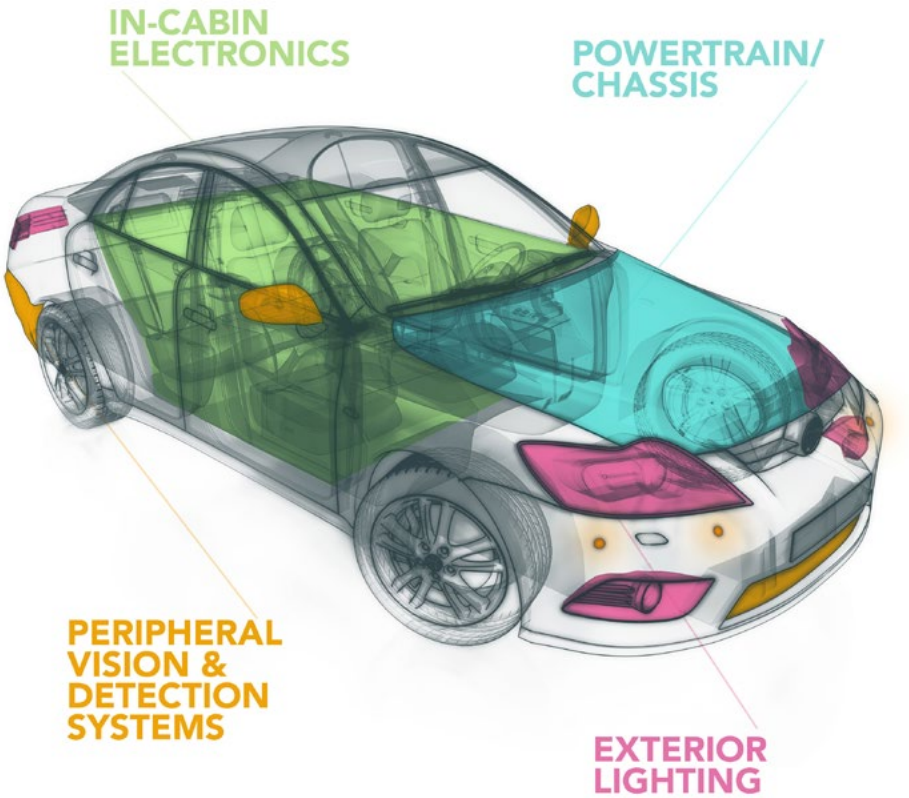
So what does all of this mean? It means that a complex array of cameras and sensors are being integrated into the vehicle's periphery, which has two major challenges to the assembly process. The first challenge is that these units need to be small and discreet to meet both weight and design integration requirements, and the second is that that they need to be robustly reliable.

Automotive vision and detection systems typically utilise camera technology which has come straight from the mobile device market, which by definition is highly miniaturised. This is convenient for successful and discreet integration into the vehicle, but also poses a challenge to meet the extended lifetime demanded by increasing vehicle warranty terms. To achieve these goals the assembler must consider the following aspects of material and process selection.

1. Mechanical reliability
2. Electrochemical reliability
3. Process performance requirements

Taking each of these factors in turn:

1. Mechanical reliability: There can be no universal mechanical reliability test for automotive electronics as there is great variability in operating conditions from one electronic system to the next. For example, an engine control unit sees much harsher conditions than an in-car audio system. For vision and detection systems, the solder joints need to be able to provide adequate strength and creep resistance to survive the temperature and vibration conditions to which the unit is exposed. This would require that the solder alloy and all solderable surfaces be characterised to ensure performance is met. It is of particular importance with small area array bottom terminated lead-less components.



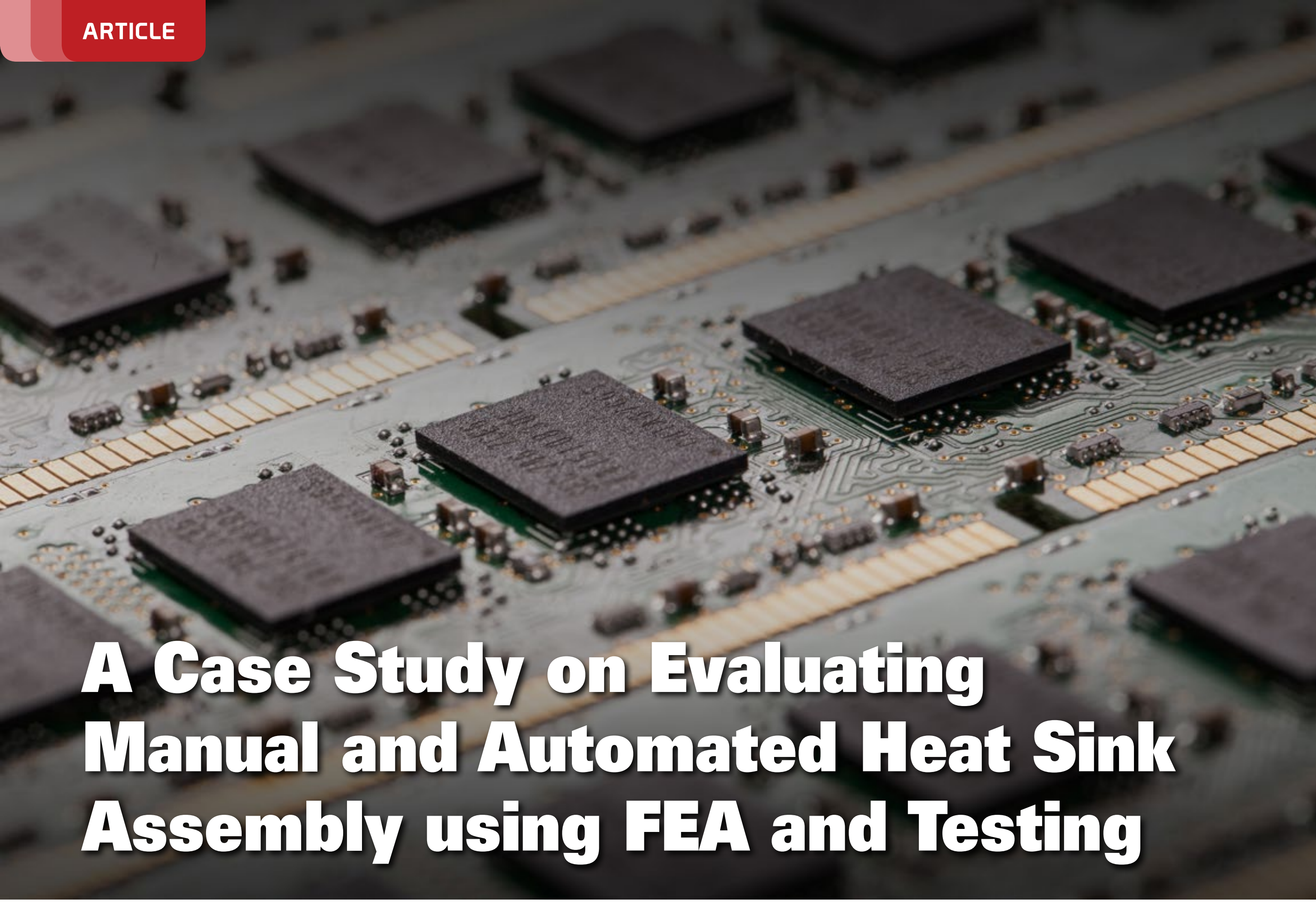
2. Electrochemical reliability: Material selection and process parameters are of paramount importance for such sensitive applications. There are two major factors which bring this aspect of reliability into sharp focus for vision and detection systems: Firstly, the small gaps between conductors require that any residues left on the assembly from fluxes or PCB fabrication chemicals to be extremely benign and secondly, the harsh and variable climatic conditions under which the modules need to operate. While there is no one test which can characterise materials for these applications, a broad range of SIR, electromigration and corrosion tests exist, which in combination can give a strong indication of material suitability.

3. Process Performance Requirements: A lot of expertise in assembling miniaturised electronics exists in the hand-held devices sector, but for automotive this is a relatively new experience. Process performance will directly affect product reliability in several ways. It starts with a robust and repeatable solder paste printing process to ensure that solder joint volume is maintained on critical small footprint devices such as cameras, active and passive devices. Solder paste formulation and stencil design know-how is the key to a repeatable print process. Beyond printing, a major focus needs to be on thermal processes to ensure that both solder joint formation and correct activation of the flux has been achieved. This is most critical in the use of any liquid fluxes in a wave/selective process typically used for connector attach.

In conclusion, it is imperative that design and manufacturing engineers consider the cost of product failure versus the cost of processes and materials, or in other words, “the total cost of ownership.” There is continual pressure on automotive tier 1 suppliers to reduce costs, but at the same time it is widely understood that the choice of assembly materials can make the difference between a product surviving its warranty period or not. Assembly materials typically cost approximately 1% of the BOM for a vision detection unit, and as a result it is somewhat surprising that compromises are sometimes made on alloy choice and material selection. The cost of product failure in the field is the full cost of recall and unit replacement, which is of course >100% of the original BOM costs. **SMT**

Steve Brown is the director of automotive OEM marketing for Alpha.

ARTICLE



A Case Study on Evaluating Manual and Automated Heat Sink Assembly using FEA and Testing

by Michael Randy Sumalinog, Jesus Tan, and Murad Kurwa
FLEXTRONICS

Abstract

Proper assembly of components is critical in the manufacturing industry as it affects functionality and reliability. In a heat sink assembly, a detailed manual process is often utilized. However, an automated fixture is used whenever applicable. This paper will illustrate the use of strain gauge testing and finite element analysis (FEA) as a simulation tool to evaluate and optimize the heat sink assembly process by manual and automated methods.

Several PCBAs in the production line were subjected to the manual and automated assembly process. Strain gauge testing was performed and FEA models were built and run. Results were compared with the goal of improving the FEA model. The updated FEA model will be used in simulating different conditions in assembly. Proposed improvement solutions to some issues can also be verified through FEA.

Introduction

As ball grid array (BGA) package sizes continually decrease, PCB failures due to over-flexure during various assembly and test processes have been an increasing concern in the electronics industry. Board flexure control using strain gauge testing has been proven to be an effective method in analyzing different assembly processes. Strain gauges are devices whose resistance changes under the application of force or strain[1]. In a heat sink assembly process, an automated fixture is ideal but may not always be readily available. As such, production lines have utilized operators to do the manual work. Strain gauge measurements were done to evaluate both manual and automated assembly.

An FEA assembly model was generated to assess the strain and compare with experimental data. Several iterations were made and adjusted with the goal of optimizing the FEA model. The model was used in evaluating board strain at different conditions, such as moving the BGAs at another location.

Strain Gauge Testing

Several PCBAs were assembled and tested. Four straight fin heat sinks are placed on top of four BGAs at different locations on the board and assembled with push pins. In a manual set-up, the operator uses a handheld fixture (Figure 1) with two protruding metal rods designed to press the push pins into place on the board. The operator repeats this step four times until all the heat sinks are assembled into the board. During this process, strain gauges were placed to monitor board flexure. The strain gauge testing was conducted per IPC/JEDEC-9704 guidelines. Gauges were placed on all four corners of each BGA, with the center located at the intersection of lines offset from the package edge at about 3.6 mm[2].

Strain gauge testing was also done using the automated fixture. The board is placed into position on the fixture. A pneumatic press is activated with eight metal rods forcing down the push pins in place at the same time (Figure 2).

FEA Model

The PCBA was modeled (Figure 3). Symmetry boundary condition is utilized in some PCB edges to reduce calculation time. The support is constrained in all six degrees of freedom. After several iterations, it was determined that an imposed displacement can be applied on the push

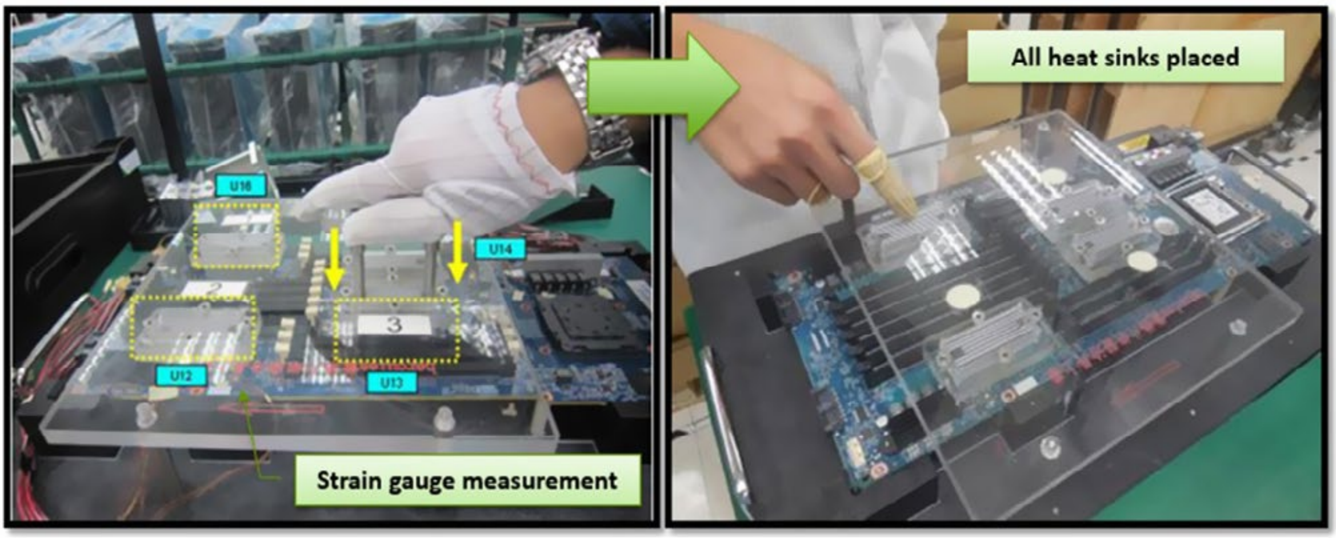


Figure 1: Strain gauge on manual assembly set-up.

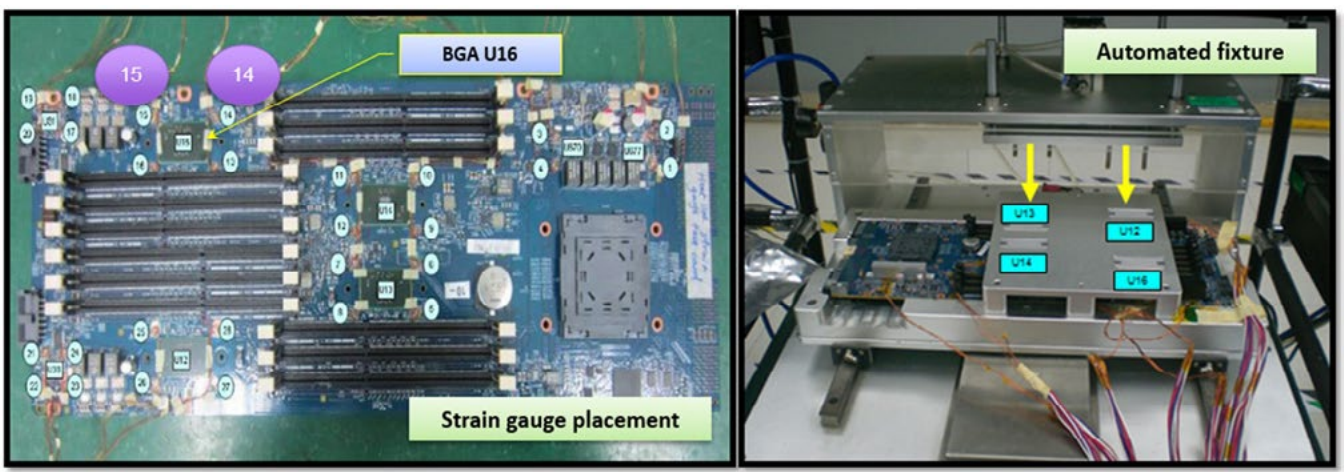


Figure 2: Strain gauge on automated assembly.

pins to enhance behavior by avoiding fluctuations thereby representing reality[3]. Since the numerical results will be compared to experimental data, specific nodes were simulated in the same place where the strain gauges were positioned in actual testing, which is about an intersection of lines at 3.6 mm offset from the package edge.

Many factors affect board flexure, which include component placement. The optimized FEA model will be used in analyzing some cases in evaluating the BGA location for improvement.

Material properties used in the simulation are listed in Table 1. For the PCB, assumed core material is FR4 with a conservative modulus of elasticity.

Results and Comparison

Strain Gauge Analysis

The maximum principal strain for the manual assembly is about 283 με located at sensor 15 (near BGA U16). For the automated assembly, the maximum principal strain is slightly higher at 339 με located at sensor 14 (also near BGA U16). Both values are within the acceptable level of IPC/JEDEC-9704 guidelines. Looking at the graph in Figure 4, the strain fluctuates until a peak strain is reached. As measured by a force gauge, the operator applies a varying force during manual assembly. This force increases slowly as the operator adjusts to the push pins snapping to the board and releases when assembled. This process would account

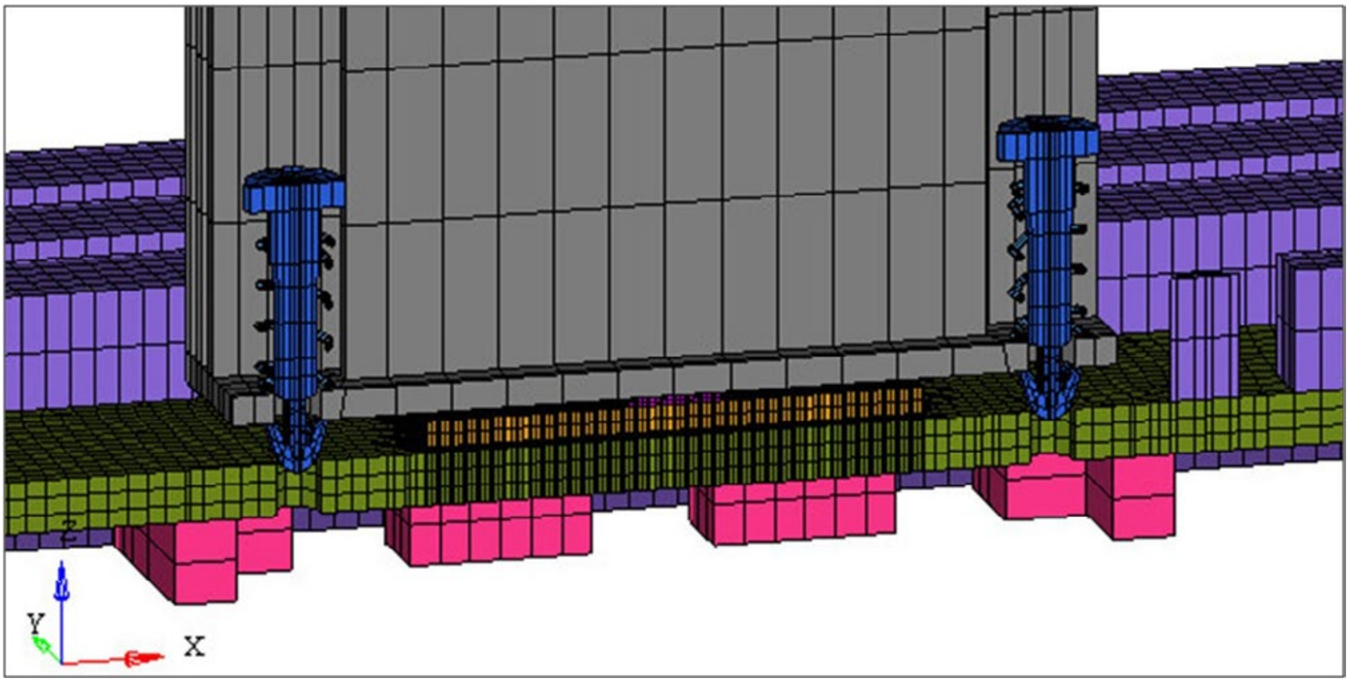


Figure 3: FEA model.

Material	Type	Young's Modulus (MPa)	Poisson's Ratio
PCB	FR4	15,000	0.14
Solder	SAC	45,000	0.35
Plastic	Nylon	3.500	0.4
Substrate	Ceramic	22,000	0.25

Table 1: Material properties for FEA.

for the irregular strain graph as observed. The process is different for the automated assembly. Force is applied in a faster and constant rate. The fixture then stops for a few seconds before lifting up the push metal rods. This results to a more stable strain graph, as shown in Figure 5. The differences in the strain rate graph are also evident in Figure 6.

FEA (Manual Assembly Analysis)

Several iterations of the analysis were conducted to approximate the manual assembly process. As shown in Figure 7, there are some differences in the strain results when experimental data is compared to simulation for the manual process. Varying factors can cause this such as actual material properties, operator

Sensor	Principal Strain and Strain-Rate				Diagonal Strain and Strain-Rate		Below 400µe Strain	Below 10000µe/s Strain -Rate	IPC 9704A Spec
	Max Strain (µe)	Max Strain-Rate (µe/s)	Min Strain (µe)	Min Strain-Rate (µe/s)	Max Strain (µe)	Max Strain-Rate (µe/s)			
9	24	-207	-100	834	74	638	Yes	Yes	Acceptable
10	31	185	-38	358	30	296	Yes	Yes	Acceptable
11	101	-597	-46	-638	98	656	Yes	Yes	Acceptable
12	34	-362	-84	698	54	439	Yes	Yes	Acceptable
13	-93	-583	-155	811	127	867	Yes	Yes	Acceptable
14	14	215	-200	1113	111	556	Yes	Yes	Acceptable
15	30	523	-283	2228	271	2164	Yes	Yes	Acceptable

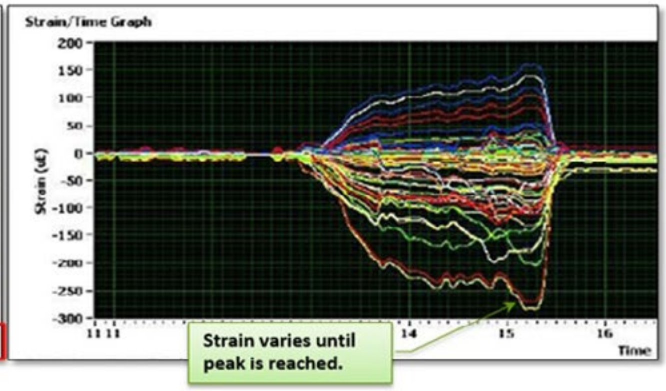


Figure 4: Max. strain and graph of manual assembly.

Component	Sensor	Principal Strain and Strain-Rate			
		Max Strain (µe)	Max Strain-Rate (µe/s)	Min Strain (µe)	Min Strain-Rate (µe/s)
U13	5	237	-3428	-32	-888
	6	114	-1829	-111	-1879
	7	127	-1696	38	799
	8	332	-4390	120	-1580
U14	9	32	-534	-46	552
	10	92	-1228	-15	-503
	11	223	-3118	-43	-933
	12	49	-720	-72	1206
U16	13	137	2963	-212	4372
	14	-29	1579	-339	-6469
	15	-37	2296	-169	-2997
	16	40	984	-188	-3100

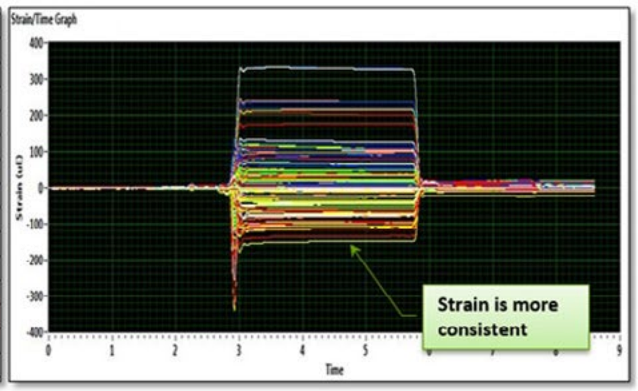


Figure 5: Max. strain and graph of automated assembly.

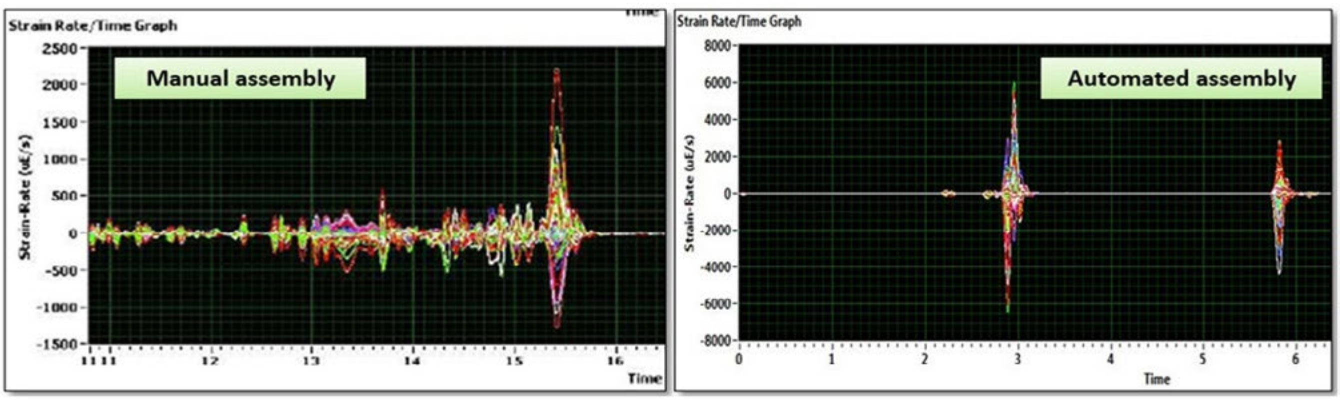


Figure 6: Strain rate graph (manual and automated).

strength, strain gauge misplacement, or pin dimensions. However, the objective is to establish a trend in the finite element model. In this case, both lines increased until a peak strain is noted at the end of the process.

The predicted maximum principal strain plot is shown in Figure 8. The yellow arrow points to the approximate location of sensor 15 in the strain gauge testing, wherein strain values are higher. Typical in a press-in process, the push pin develops plastic deformation in the snap-fit features. The resulting contact forces generate the strain on the board. For the manual process, the highest strain is predicted when the push pin is about to exit the PCB hole.

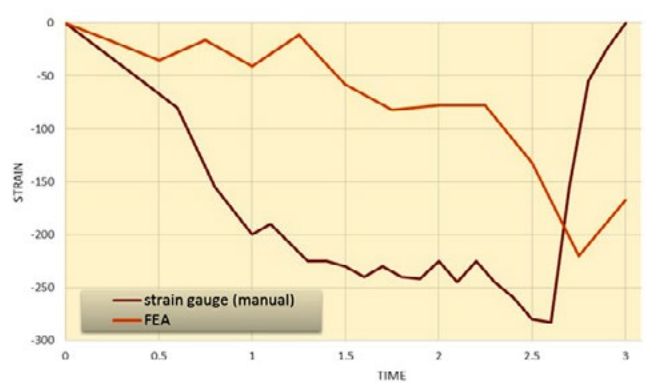


Figure 7: Max. strain graph (comparison for manual process).

FEA (Automated Assembly Analysis)

Several iterations of the analysis were conducted to approximate the automated assembly process. As shown in Figure 9, the graph indicates an early peak strain and decreases into a consistent value. Both the experimental and simulation graph lines show similar trends. For the automated process, the push pin is assembled to the board at a faster rate. Strain is stable when the push metal rods maintain maximum displacement for a few seconds.

The predicted maximum principal strain plot is shown in Figure 10. The yellow arrow points to the approximate location of sensor 14 in the strain gauge testing, wherein strain values are higher. Similar to the manual process, the highest strain is predicted when the push pin is about to exit the PCB hole. As the pin is pushed deeper in the PCB hole, the contact area

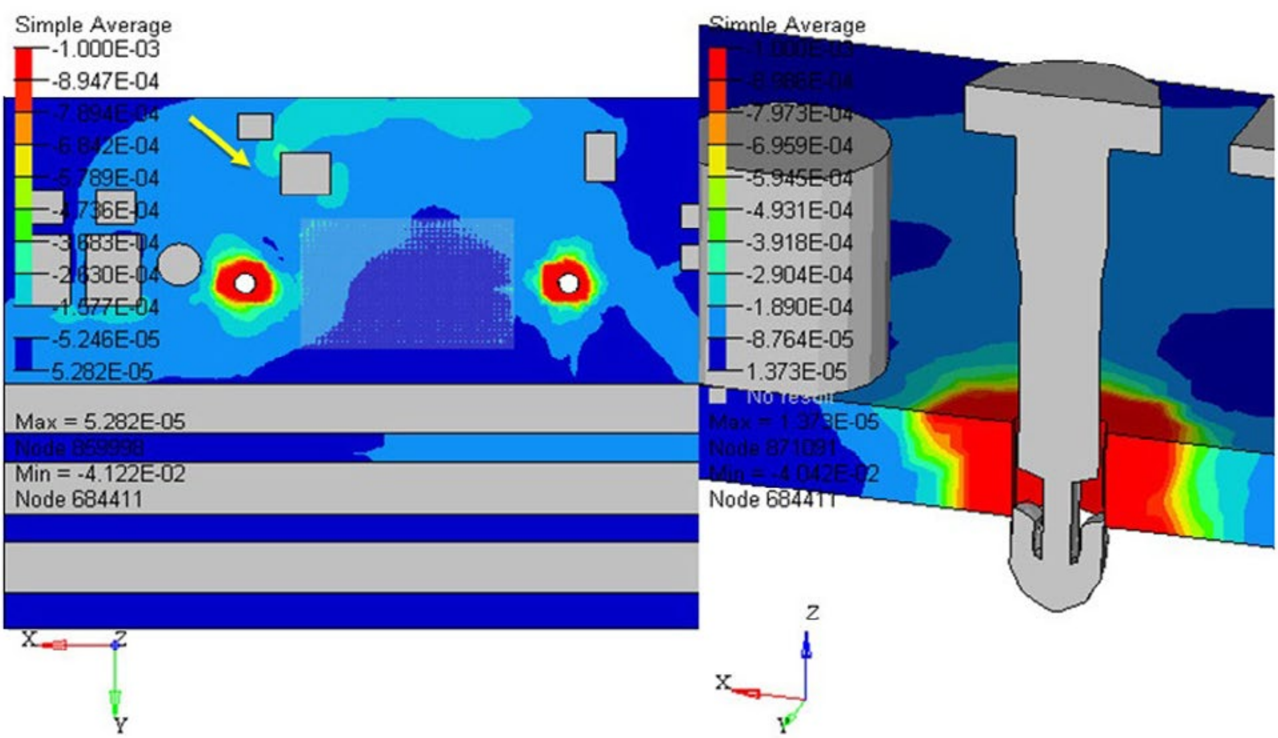


Figure 8: Max. principal strain (manual).

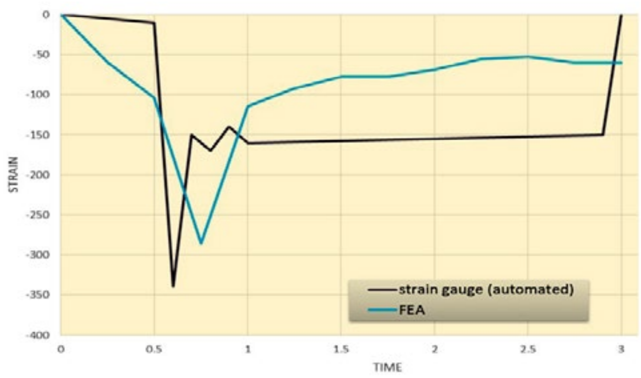


Figure 9: Max. strain graph (comparison for automated process).

and force increases leading to the high developed strain.

FEA (Impact of BGA Location)

For this analysis, the FE model for the automated process assembly is used for reference. The original design is referred to as Case 1. For Case 2, the BGA was moved in the Y axis (vertical), 1 mm away from the board edge. In Case 3, the BGA was moved in the -X axis (horizontal) direction by 1 mm. As shown in Figure 10, a significant decrease in strain is observed in Case 2 while in Case 3, there was a slight increase in the predicted maximum principal strain.

Summary

The finite element models for FEA of a heat sink assembly by manual and automated processes have been presented in this paper. Based on results, automated assembly is preferred to the manual assembly process. The results of the analysis were compared to experimental data gathered through strain gauge testing. After several iterations, the differences between experimental and numerical results were reduced and trends were noted to achieve optimized FE models. These FE models can be used to perform other studies to improve strain values and avoid damaging board flexure. One such factor is the location of the BGAs on the PCB.

Further studies can help improve the FE model. Actual testing for material properties can be performed. Other factors affecting BGAs can also be included in a DOE matrix. **SMT**

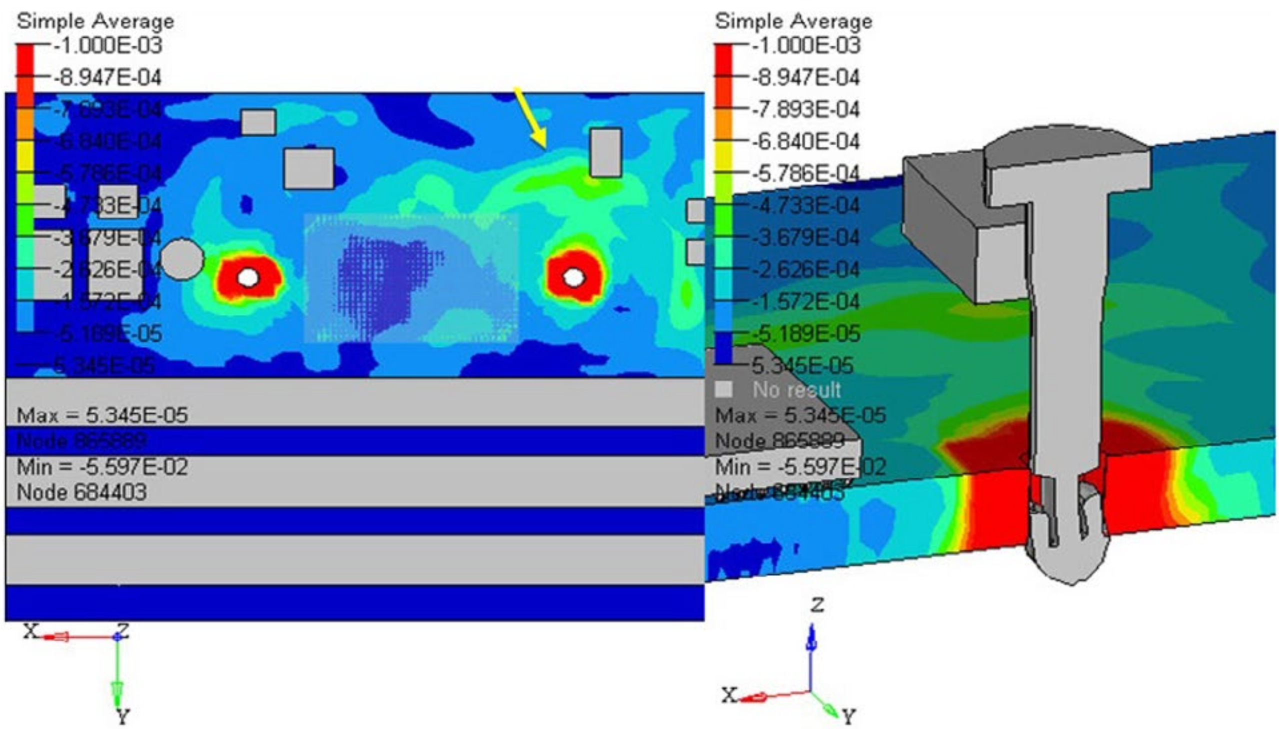


Figure 10: Max. principal strain (automated).

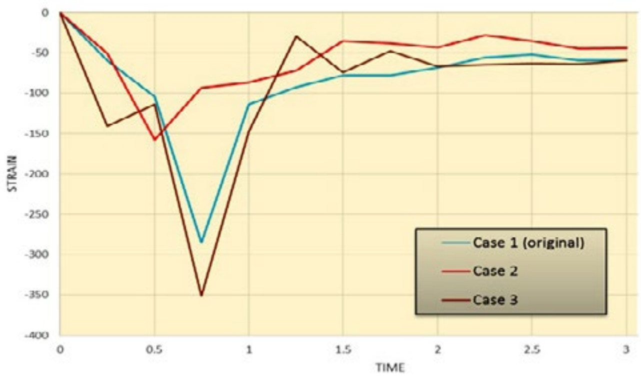


Figure 11: Max. strain graph (BGA location change).

Acknowledgement

The authors gratefully acknowledge the support of Flextronics B11 production team, especially for Andrew Qi, AEG-Asia RTC Arnel Camacho, and AEG-Asia DFX manager GP Li.

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3. Altair: RADIOSS solver manual.

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PA STEM Students Learn about 3D Printer Technology by Building One

The best way to learn about 3D printer technology is to build a printer. That's the idea behind 3D Printer Summer Workshops conducted in Pittsburgh, Harrisburg and Allentown for students in the Pennsylvania Cyber Charter School STEM program. This is the third summer for the week-long 3D printer build workshops.

Joel Cilli runs the online school's STEM program and leads the workshops. He has created and posted a series of how-to videos to guide not only workshop participants, but anyone who undertakes to build Printrbot Play 3D printers from a kit.

"I made all the assembly videos at home over the summer and shared them via youtube," Cilli said. "My instructions are now linked on the manufacturer's website so that anyone in the world can follow along with the same build instructions we use in the workshop. I video recorded how to do the steps because still pictures just aren't clear enough," he said. During the workshops, "The videos play at the front of the room and the students follow the steps. We walk around to each person's desk to check their work and offer assistance."

Cilli said the Printrbot Play is an all-metal-body 3D printer that was released this summer.

Workshop students pay a discounted equipment fee of $200 for the kit and take it home with them – it's theirs.

Workshops were held at PA Cyber regional workshops in Allentown, Harrisburg and Wexford, near Pittsburgh. Staffer Karen Cummings assisted with the Harrisburg and Allentown workshops.

Experience is Key

by Stephen Las Marias
I-CONNECT007

One of the leading EMS providers worldwide, Sanmina Corp., has over 20 years of automotive electronics manufacturing experience. The company is fully compliant with all regulatory standards including TS 16949, advanced product quality planning (APQP); product part approvals (PPAP); process failure mode & effects analysis (PFMEA); design failure mode & effects analysis (DFMEA; and part change notice (PCN), and incorporates stringent manufacturing and quality procedures based on lean manufacturing, Six Sigma and zero-defect initiatives.

In an interview with I-Connect007's Stephen Las Marias, Sanmina's Bernd Enser, VP of Global Automotive, discusses the impact of the latest development trends in cars today on the automotive electronics assembly space, as well as the qualifications required of an EMS provider to get into an automaker's AVL. He also explains why experience is essential to becoming successful in the automotive electronics space, and offers his outlook for the industry.

***Stephen Las Marias:** How has the automotive electronics industry evolved over the past decade, and what major changes have you witnessed?*

Bernd Enser: Today's automobiles have far more functionality and advanced electronics than they did 10 years ago. Many areas have been impacted including safety, passenger comfort, driver experience, energy saving, and CO_2 reduction. The technology we use in our living rooms and other places such as infotainment, tablets and GPS has been introduced to the car. Advanced functions such as parking assistance and collision-avoidance systems have been incorporated. These designs require Internet access and other connectivity to provide the mechanisms to identify and sense other vehicles and buildings. And with the introduction of hybrid cars, elec-

tronics are needed to optimize energy efficiency.

***Las Marias:** How does Sanmina help automotive electronics customers ensure high-reliability in their products?*

Enser: Sanmina has invested in equipment such as AOI, solder paste inspection (SPI), and AXI, as well as high-speed, high-accuracy pick-and-place machines, reflow ovens and best-in-class printers in order to accommodate the complexity and durability required from sophisticated automotive manufacturing.

Feature sets in the new equipment intended to support increased factory automation such as software protocols and machine-to-machine interfaces are carefully reviewed within the context of all the regulatory requirements of TS 16949. Some of the newer features not only advance the capability to place the more complex fine pitch devices now being included in automotive electronics, they also provide features which enable greater traceability and efficiency and more robust manufacturing.

Experience is the key. Expertise in the technology, applications, processes and applicable supply chains is crucial in a manufacturing environment where OEMs require zero defects from EMS providers. Sanmina pioneered the use of pin-in-paste technology as part of the SMT process for large automotive connectors, which enabled us to reduce cost and improve reliability. We were able to develop this technology by leveraging expertise from other industries.

***Las Marias:** High-tech manufacturers are increasingly under pressure to shorten product lifecycles and drive innovation. What unique capabilities does Sanmina offer to the table to help customers address this challenge?*

Enser: Sanmina provides expertise in a variety of key areas to help automakers get their products to market faster. Our manufacturing system is already TS 16949 certified, and we have a global network of automotive electronic manufacturing facilities. We have significant experience in designing and manufacturing electronics in other highly regulated industries such as medical and aerospace. We have worked with OEMs in other industries to solve technology challenges that develop as the electronics content increases. For example, we have been manufacturing electronics PCBAs with BGAs and LGAs in other industries for over a decade. We leverage this expertise to solve technical challenges for automotive OEMs. This enables them to access technology faster and speed time-to-market while meeting regulatory requirements.

> **"Automotive designs are increasingly using consumer electronic components that were not originally specified and qualified for use in automotive applications. This means that designers and manufacturers have the additional challenge of designing in "functional safety.""**

Another key area is functional safety. Automotive designs are increasingly using consumer electronic components that were not originally specified and qualified for use in automotive applications. This means that designers and manufacturers have the additional challenge of designing in "functional safety." At its most basic level, functional safety means that designers and manufacturers need to identify how a component and sub-system will fail and design in mechanisms for it to fail safely. If a car travelling at 60MPH is going to have a failure it must be brought to a stop in a safe manner. An example of this is using components originally specified for consumer or entertainment use. Usually they have a narrower specification and do not need to be able to withstand extremes of temperature or other environmental parameters inherent in a vehicle mission profile. When these components are designed into the car, the temperature range they must operate within is much wider—the heat created by the engine as well as the external environment. There's a huge difference in the environment of a car in the north of Sweden in winter to a car operating in Florida in July.

In addition, the placement of electronics under the dashboard or hood of a car with all the moving parts, fluids and exposure to weather is a much harsher environment than most consumer electronics were originally designed to operate within. One way to deal with these challenges is to create heat sinks and additional circuitry around the components, which keep their environment within the consumer component technical specification while providing a buffer zone to manage the harsher automotive environment.

***Las Marias:* From a manufacturing/PCB assembly perspective, how do you ensure the accuracy and reliability of your products and processes?**

Enser: The short answer is keeping on top of all current certifications along with extensive internal and external auditing. This includes the implementation of all the supporting elements such as FMEA, PPAP and APQP. The long answer is the time, investment and effort we put into ongoing monitoring.

Sanmina has put in place IT systems, processes and infrastructure for manufacturing that are developed centrally and deployed globally. Everything we produce in eight different industries is monitored at a product, customer program, plant, regional and global level on an ongoing basis. This means the lessons learned by our design and manufacturing engineers, customers and audit bodies are collected worldwide and evaluated. The system is highly mature and benefits from the best practice and continuous improvement activity based on thousands of new products introduced each year.

The growth of electronics and technology in automobiles poses challenges for regulatory compliance and technical innovation. As a result, we've taken a leadership role in trade organizations such as ZVEI and SAE. These organizations are critically important as they are at the forefront of developing the necessary standards to safeguard consumers. With experience in other regulatory industries such as medical, aerospace and communications Sanmina is well positioned to contribute to the development of future solutions to the challenges new technology poses to critical safety requirements.

***Las Marias:* How has the increase in automotive electronics impacted your business?**

Enser: The quantity and complexity of technical challenges coupled with the increase of non-automotive components used in automotive applications have affected the business. Automotive OEMs are constantly seeking to shorten development lifecycles. We have built the capability to drive down the time-to-market from what an OEM might traditionally plan would take years for the prototype and NPI phase to a few months. The increased complexity in automotive electronics is something we are already very familiar with from technology and complexity increases in other markets such as communications, high-speed computing and storage. As the technical challenges grow with the need for more connectivity, bandwidth and speed, we expect automotive OEMs will need to leverage the advanced technology that Sanmina provides in multi-layer high density PCBs, optical components and state-of-the-art manufacturing automation.

Traditionally, the automotive industry has been based on mechanics. The increase of electronics in automobiles requires significant investment in manufacturing technology, facilities and human resources. Automotive OEMs do not want to make this investment and so they turn to EMS companies who have a deep knowledge of the industry and can help them to comply with the regulatory requirements. In our experience, our customers are looking for partners who can provide end-to-end services throughout a product lifecycle, starting with design support, DFX analysis, prototype and NPI, volume manufacture, component engineering obsolescence support and aftermarket services.

Las Marias: How do you address the increasingly strict regulatory requirements in automotive electronics manufacturing?

Enser: All automotive designers and manufacturers must adhere to the automotive functional safety standard, ISO 26262. For every step of the supply chain, component engineers must assess and control the reliability for automotive parts that may pose a functional safety risk. Our experts have deep knowledge of the rigorous requirements needed to meet automotive regulatory standards, such as the TS 16949, robustness validation and part production approval process (PPAP). With more than 20 years experience working with these automotive regulatory standards, Sanmina has gained practical expertise in developing manufacturing and design processes to deliver compliant products.

In many cases Sanmina is contributing to the development of new regulatory requirements through leadership positions in organizations such as ZVEI and SAE. The increase in complexity, density and the use of components not originally designed or qualified for automotive applications drives the need for new approaches to ensure automotive electronics are fully compliant with all regulatory requirements.

Las Marias: What qualifications are required for your company to get on an automaker's accredited vendors list?

Enser: Automotive OEMS are looking for EMS partners like Sanmina that have demonstrated experience in the automotive industry. They require their partners to have an established automotive regulatory framework, and are also looking for a commitment to zero defects strategy, robust reliable manufacturing processes and systems, flexibility to respond to changing business needs and proven success with cost optimization throughout the product lifecycle.

Las Marias: What do you see as the biggest driver of automotive electronics innovation?

Enser: The biggest driver will be in the safety area with major innovations as we go towards the driverless car. This will have significant safety implications for the driver and passengers and also for the security of the network. The implementation of the driverless car will give rise to new passenger on-board experiences and the introduction of more entertainment and other "living room" applications.

Las Marias: What is your outlook for the automotive electronics industry?

Enser: Electronics in today's car already exceed 20% of the total vehicle value and this is estimated to increase to 35% within the next six years, according to an Infineon report. Consumers are increasingly basing their car buying decisions on the availability of advanced infotainment, connectivity and safety options. The majority of these features will be driven by innovations enabled by complex electronics. Products using very high density components such as LGAs and BGAs as well as components introduced from non-automotive applications will require innovative manufacturing solutions. Not only will manufacturers need to comply with the automotive regulatory requirements such as TS 16949, they will also need to help automotive OEMs develop functional safety compliant designs and manufacturing solutions when non-automotive components are used. **SMT**

MilAero007 Highlights

IPC Releases Report on Lead-free Electronics in Mil/Aero Applications

IPC's new market research study examines the current and future state of lead-free usage in high-reliability applications, as well as the impact usage will have on the industry.

IPC Seeks Support to Stop Costly EU Conflict Minerals Directive

In May, the EU Parliament overwhelmingly passed regulations requiring the mandatory certification and reporting of conflict minerals throughout the supply chain. Under the proposed regulation, EU importers of tin, tantalum, tungsten and gold would need to be certified by the EU to ensure that they do not fuel conflicts and human rights abuses in conflict areas anywhere in the world.

Plexus Posts Record Revenue of $670M in 3QFY2015

Plexus earned record revenue of $670 million in the fiscal third quarter ended July 4, 2015.

Libra Industries Installs Fifth Juki Line

Libra Industries has purchased and completed the installation if its fifth line from Juki Automation Systems Inc. The new line consists of a GKG Precision Machine Paste Printer, KE-2070E, KE-2080E, TR6DER and Shenzhen JT Automation RS-800II 8-zone oven.

Sparton to Highlight Technologies at DARPA

Sparton Corp.'s technologies will be on display at the upcoming Defense Advanced Research Projects Agency (DARPA) "Wait, What Conference" being held in St. Louis from September 9–11, 2015.

Plexus Appoints Oliver Mihm as Leader for EMEA

To be based out of the Plexus' Darmstadt Design Center in Germany, Oliver Mihm assumes leadership responsibilities for the strategy and execution of all aspects of Plexus' business within EMEA.

Erapsco Named Superior Supplier by US Navy

Sparton and Ultra Electronics' joint venture Erapsco has been recognized by the U.S. Navy as a Tier 1 Superior Supplier.

Kitron's Profitability Improvement Continues in Q2 2015

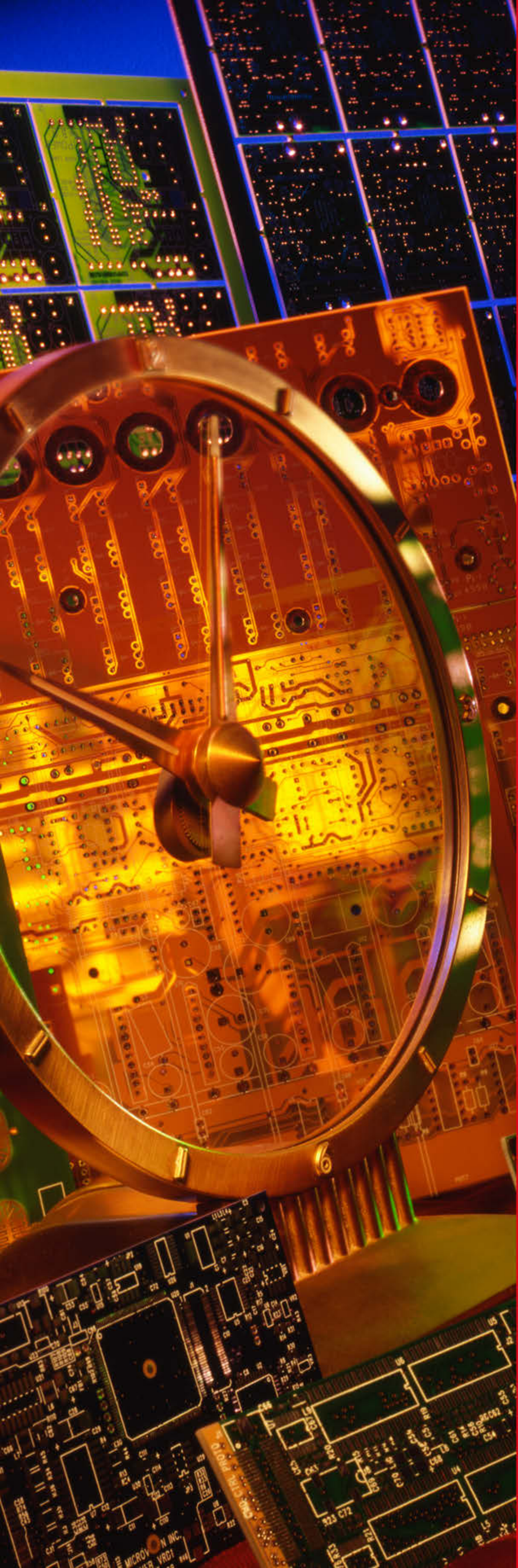
Kitron ASA has reported the fifth consecutive quarter of improved profits, due to a combination of growing revenue and better margins.

Ultra Electronics-Sparton JV Lands $16M in Foreign Contracts

Ultra Electronics USSI, a subsidiary of Ultra Electronics Holdings plc and Sparton Corp., has landed subcontracts valued at $16.1 million from their ERAPSCO/SonobuoyTech Systems joint venture.

Nortech Systems Reports Second Quarter Results

Nortech Systems Inc. has reported net sales of $26.8 million for the second quarter of 2015, and total net sales of $53.3 million for the first six months of the year.



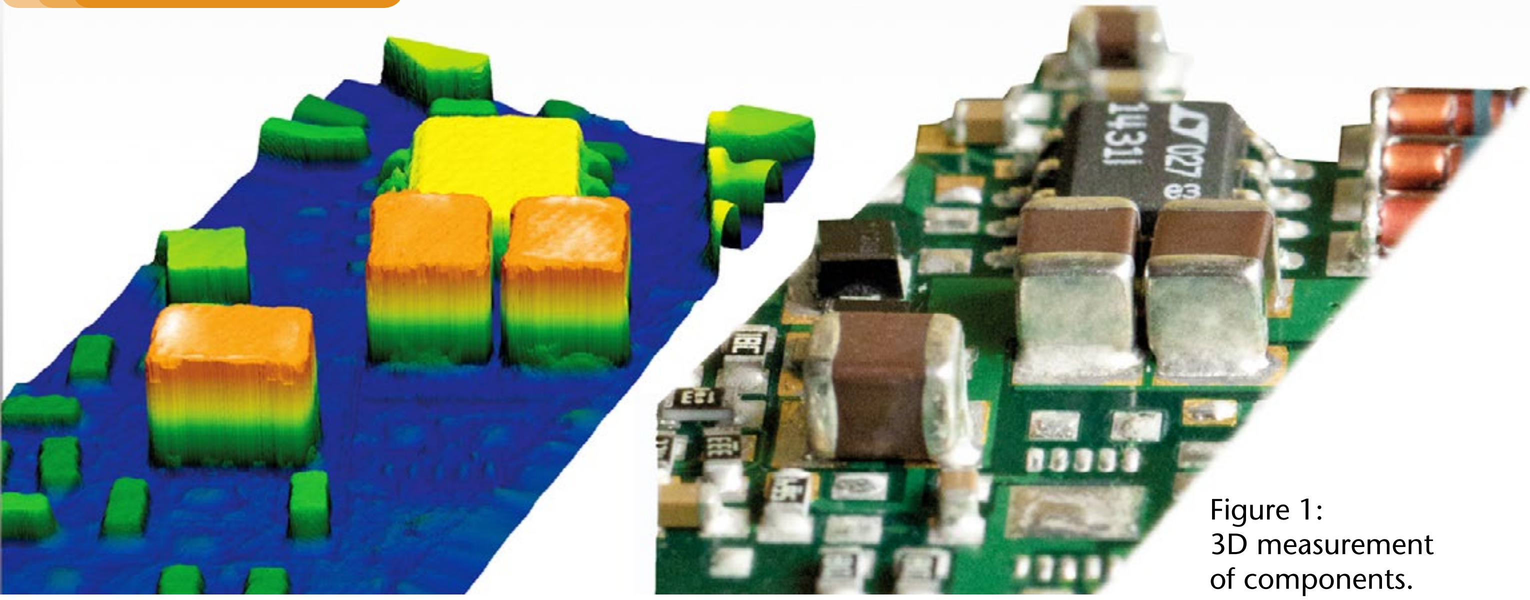


Figure 1:
3D measurement
of components.

From Inspecting to Measure: How Automotive Electronics are Driving AOI Developments

by Stephen Las Marias
I-CONNECT007

In an interview with I-Connect007, Jens Kokott, head of AOI systems at GOEPEL Electronic, discusses the increasing need for continuous development of testing technologies to cater to the innovations happening at breakneck speed in the automotive electronics industry.

Stephen Las Marias:* *Please tell us about the major changes or trends you have witnessed during the development or evolution of the automotive electronics industry.

Jens Kokott: In the automotive electronics industry, the challenges regarding 100% functionality of all components are growing constantly. That means maximization of quality assurance and inspection depth in production processes. In connection with new innovative components and production technologies, this requires permanent development of inspection technologies. We experience an increasing transition from “inspecting” to “measure,” especially when it comes to different kinds of application (e.g., distance measurement of components or spatial allocation of components [3D measurement]). Furthermore, Industry 4.0 is on the horizon: requirements according to different MES (manufacturing execution systems) connections have established themselves in the meantime to an extremely important part of the overall system.

Las Marias:* *What are the impacts of these trends for test and inspection companies?

Kokott: Through the use of new components and introduction of new innovative production technologies, continuous development of testing technologies is necessary. Permanent contact with the automotive manufacturers and electronic manufacturing companies is necessary to know new requirements. High investments in development are inevitable to prepare the test and inspection systems. Cooperation with research institutes and suppliers is essential to incorporate the latest technical developments into the systems. Especially regarding

the optics, strong and innovative partners are important. In this case, we have a good basic position in the city of Jena, which is a centre for optical science and technology and home of optical companies like Zeiss or Jenoptik.

Las Marias: How do you help automotive electronics companies address the cost of test issue?

Kokott: A major point in the concept of the GOEPEL AOI systems is modularity and upgradeability of components. The systems can contain a wide range of inspection and measurement technologies, for instance, multispectral illumination—from UV to IR—360° inspection with rotatable angled-view camera module; wide array of measurement functions; and top/bottom inspection in one single system. Even the electrical adaption and functional test of optoelectronic components, such as LEDs and displays, is a possible feature. To be up-to-date even with older systems an upgrade path is possible until far into the past. Lastly, this saves costs for the expense of acquiring new systems.

Las Marias: What are some of your toughest challenges when it comes to providing solutions targeted at automotive electronics?

Kokott: Customer-specific adaptations, which deviate from standard systems are of particular interest: mechanical system modifications, specific inspection tasks, transport of special assembly forms or integration of individual camera modules in test cells of manufacturing equipment suppliers, just to name a few. In the majority of cases, all this is easily implementable due to high-production depth and available development and production capacities at GOEPEL electronics. For example, a special system was developed for the aviation industry which allows inspection of special assembly with a length of up to 1.60 meters.

Las Marias: How do you address the increasingly strict regulatory requirements in automotive electronics manufacturing?

Kokott: By working closely together with partners, cooperating with research institutes and having the possibility of developing customer specific solutions, we cope with the high regulatory requirements.

Las Marias: What qualifications are required for your company to get on an automaker's accredited vendor's list?

Kokott: Typically, there is a multi-staged evaluation process for system selection between different providers, starting with a paper benchmark followed by visiting the suppliers, and finally test installation of a system in the production line. Furthermore, the growing internationalization requires an extensive service and support network. The certification according to ISO is a basic requirement.

Las Marias: What will be the key driver for automotive electronics innovation?

Kokott: There are many kinds of innovation drivers. Increased comfort in the car and high-class infotainment systems are becoming more and more important. A special point of interest is electromobility: Integrated power electronics generates completely new types of assemblies.

Las Marias: What is your outlook for the automotive electronics test and inspection industry?

Kokott: The inspection in all directions is an important issue (e.g., 3D measurement of solder joints, components and even entire assemblies). We follow the strategy of combining different test and inspection technologies for maximum error detection—for example the combination of AOI and AXI. And of course, Industry 4.0 will set the direction of the next decade regarding data exchange, networks and intelligent production control.

Las Marias: What are some of the other main drivers for new products in your business?

Kokott: In the first place, it's the customer with his demand. But it is also the cooperation and partnership with research institutes that leads to new ideas and possible solutions. However, this can also cause new challenges: It is a long

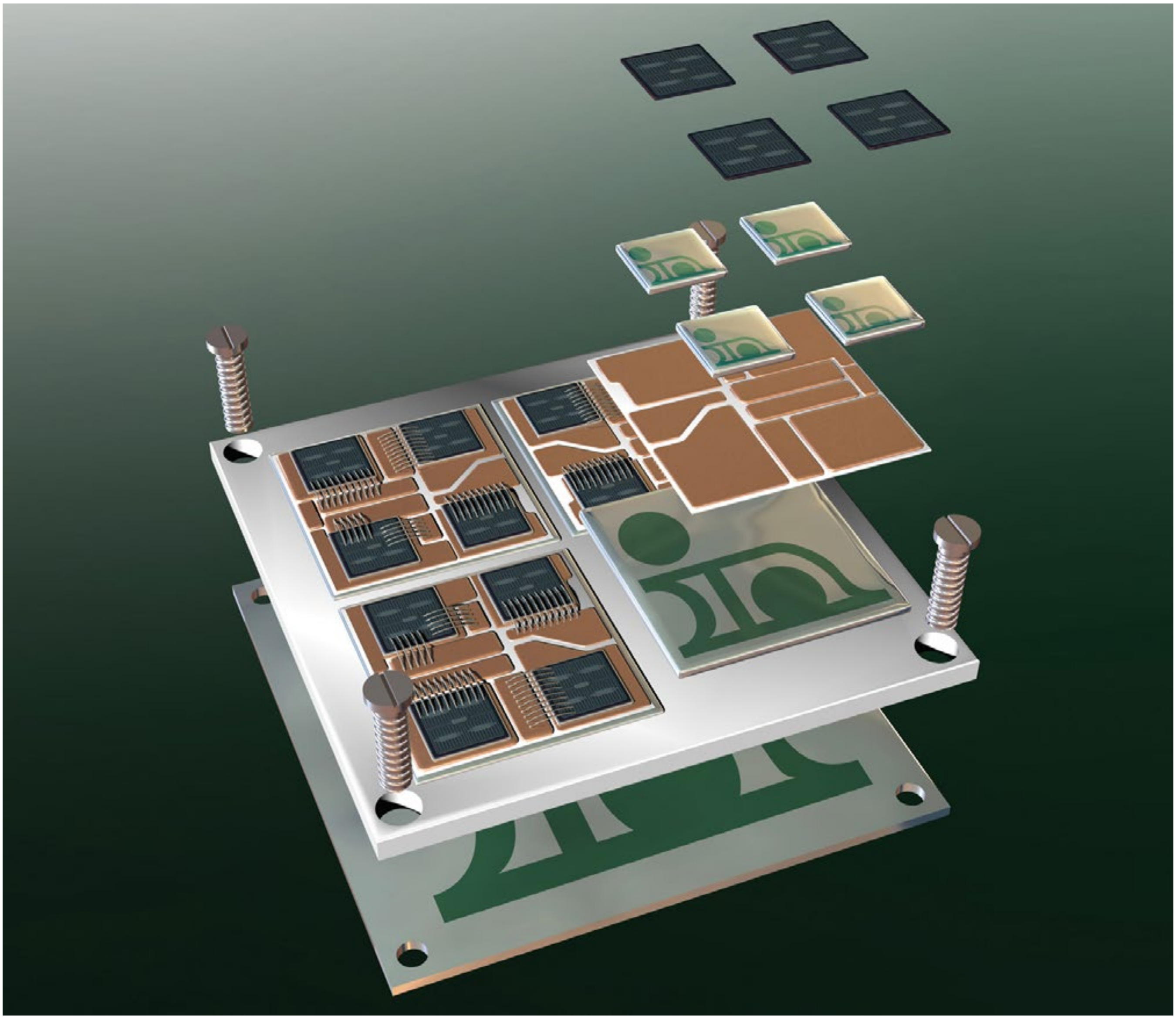


Figure 2: System layout of an integrated power module (Image provided by Indium Corporation).

way from prototype to series production. A laboratory differs from industrial application.

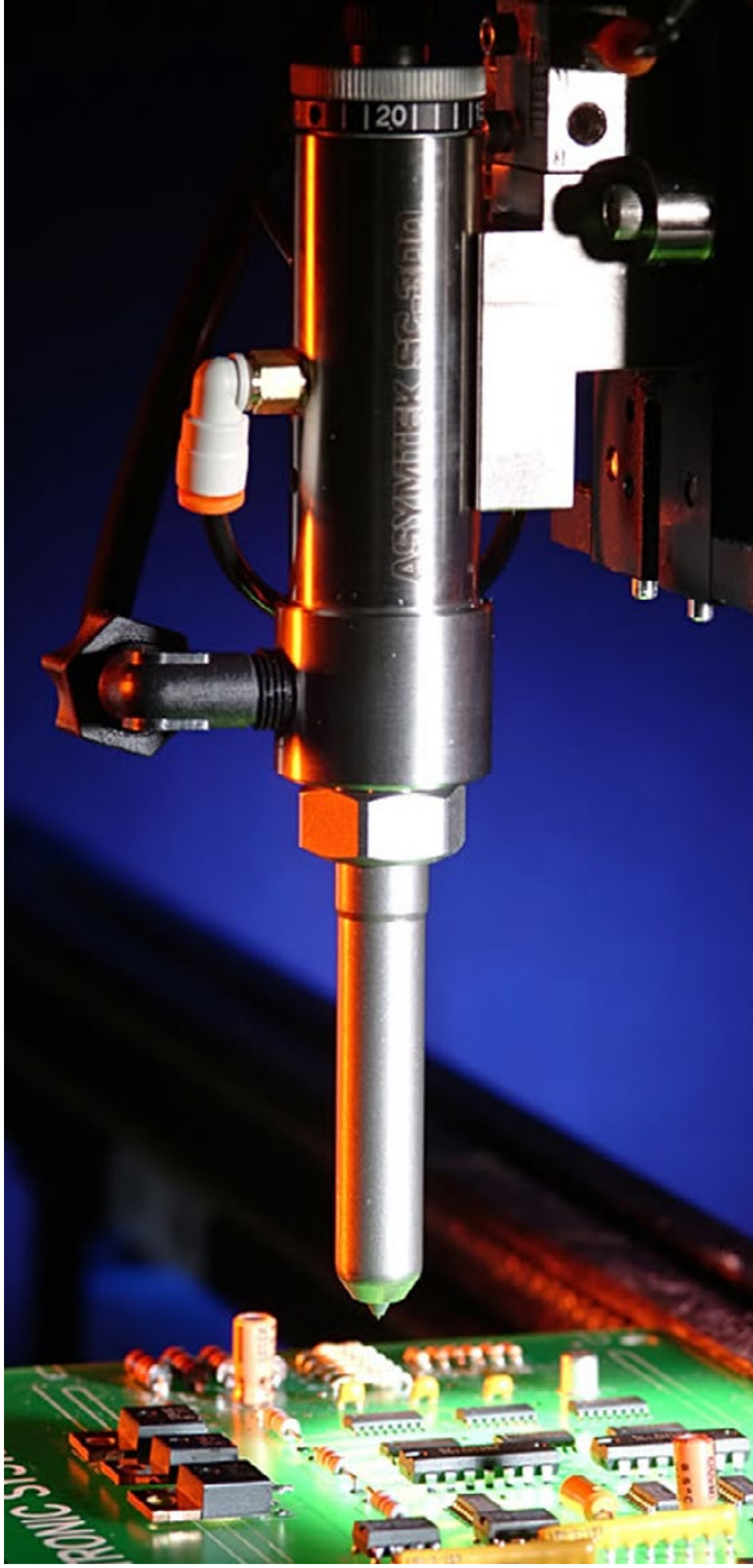
Las Marias: Could you enlighten us on some of the latest developments in AOI technology aimed at addressing the high-reliability requirements of automotive electronics?

Kokott: The use of 3D measurement in electronics manufacturing has brought a significant development of AOI systems. AOI suppliers have to develop the application possibilities of the 3D measurement systems, starting from simple component recognition to coplanarity measurement and determination of solder volumes. Increasing the speed of inspection and higher detail recognition of smallest errors will constantly be a challenge. Apart from the integration of 3D measurement methods, in the foreseeable future no revolutionary advancements in AOI technology are to be expected.

Las Marias: Jens, thank you for your time.

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

The Demands on Automated Fluid Dispensing



I-Connect007's Barry Matties speaks with Brad Perkins, general business manager, Americas, of Nordson ASYMTEK, about the current demands put on dispensing equipment. Perkins discusses the benefits of investing in a high-end dispenser and coating system.

***Barry Matties:** Why don't you just talk a little bit first about what ASYMTEK does?*

Brad Perkins: Nordson ASYMTEK is a manufacturer of automated fluid dispensing and coating equipment. We supply primarily high-volume customers. That's really where our niche is: supporting those 24/7 manufacturing environments across the world. We have a global footprint and have the ability to support large multinational customers with any of their requirements worldwide.

***Matties:** What sort of demands are customers putting on you these days?*

Perkins: The general industry demand that we're seeing is for lower cost of ownership of the equipment in the manufacturing process, so that as you look at the floor space associated with a piece of equipment you ask, how may a customer generate more revenue out of that floor space? Higher yields and faster throughputs are associated with that, as well.

***Matties:** What strategies do you look at to reduce your process time or their overall cycle time?*

Perkins: There are two aspects that really come into the process time and the cycle time aspects of it: The first is utilization of the equipment. We're a manufacturer of fluid dispensing equipment, so the more time that the part is able to spend in the equipment actually being dispensed on is going to be advantageous for us. We've done things to reduce our load time and our fiducial find time or pattern recognition,

Brad Perkins, general business manager, Americas, Nordson ASYMTEK.

and reducing the general overhead processes associated with that. Sometimes that comes through technological advantages and sometimes it comes through multi-conveyor systems so that we can load one lane while dispensing on another. We're really trying to utilize as much of the time the parts are in the machine as possible.

The second aspect that comes into that is faster dispensing. One way that's done is through multiple heads on the system at a time, so that we're dispensing parts in parallel rather than in a series. The other way would be through faster applicator dispensing techniques—jets that are firing from 100Hz or 200Hz to 500Hz to non-jetted solutions that have higher flow rates through higher flow augers or similar technologies.

Matties: What's the typical cycle time now?

Perkins: A great question, but it's really challenging to answer because it's extremely dependent on the size of the parts, the amount of material that's being dispensed, and how many parts we're putting into the machine at one time. Obviously, we don't want to be the bottleneck within the line, so we work within the parameters of the higher cost equipment that is bottlenecking the line and make sure that we have a solution that's faster than that bottleneck rate. Depending on that, it may mean multiple machines, multiple valves, multiple heads, etc. It's very application dependent.

Matties: You're down in Carlsbad, California—that's a nice area. Is that where all your manufacturing is done?

Perkins: The majority of the products are manufactured out of that location. We were founded in Southern California in 1983 and have had the majority of manufacturing there since then.

Matties: How many people work there?

Perkins: Between all the buildings, we're in the neighborhood of 500 people. We're part of the Advanced Technologies Group within Nordson. Within that group, we have MARCH, YESTECH, EFD, and DAGE. YESTECH and MARCH are also on that same campus in the Carlsbad area. We have DIMA in the Netherlands, which was a recent acquisition last summer, and offices in Europe and throughout Asia.

Matties: So with your tilt dispensing technology, that's part of the process improvement and cycle time, right?

Perkins: Yes, with tilt dispensing, again, as we go back to that original statement on producing higher yields for the customers, as you're looking at packages that are becoming smaller in your XY footprint, there's a need to come in at a tilted angle to deposit fluid for many applications. Because, aAs we're shrinking boards, we need the ability to deposit fluid in the correct location without contaminating other areas. That's where the tilts are coming in as a capability enabler.

Matties: What are the demands that are brought on the conformal coating part of the business?

Perkins: From a general demand standpoint, it's going to be basically those same higher throughputs and higher qualities associated with it. When we look specifically at conformal coating, the challenges that are coming in are with shrinking keep-out zones. With any conformal coating process, you typically have three zones: the must coat, the must-not coat, and the tolerance area.

That tolerance area is continuing to get smaller. You're having more components that are being put onto the circuit boards that are intolerant to conformal coating, or more test points that are associated with it that need to be kept clean. You're seeing higher challenges in working with those. While you're both increasing throughput and increasing the speed of the process and trying to decrease your other areas, those variables sometimes work against each other. That's really where the biggest challenge is.

A secondary challenge that's coming in is the demand for a lot more traceability, especially as you get into automotive and the like—dealing a lot with factory information systems, MES interfaces, and closed-loop processes that are able to write back to those systems and verify that we've done what we said we'd do.

Matties: Every process has tended to be a silo, right? Now, they're connecting these systems to do a few things. One, of course, is to increase product reliability and quality. The second is to find out who is liable for the defects because somebody's got to pay.

Perkins: Absolutely. You've got hard cost associated with replacing parts. Then, you have liabilities associated with them, especially as you get into medical and automotive.

Matties: Is your core market the higher-end market, such as medical, automotive, and military/aerospace?

Perkins: We're really going to be supplying to companies that are interested in having premium technology and the premium yields associated with it. We're going to cater more towards those more challenging requirements.

Matties: Is there anything that I'm not asking that we should be talking about?

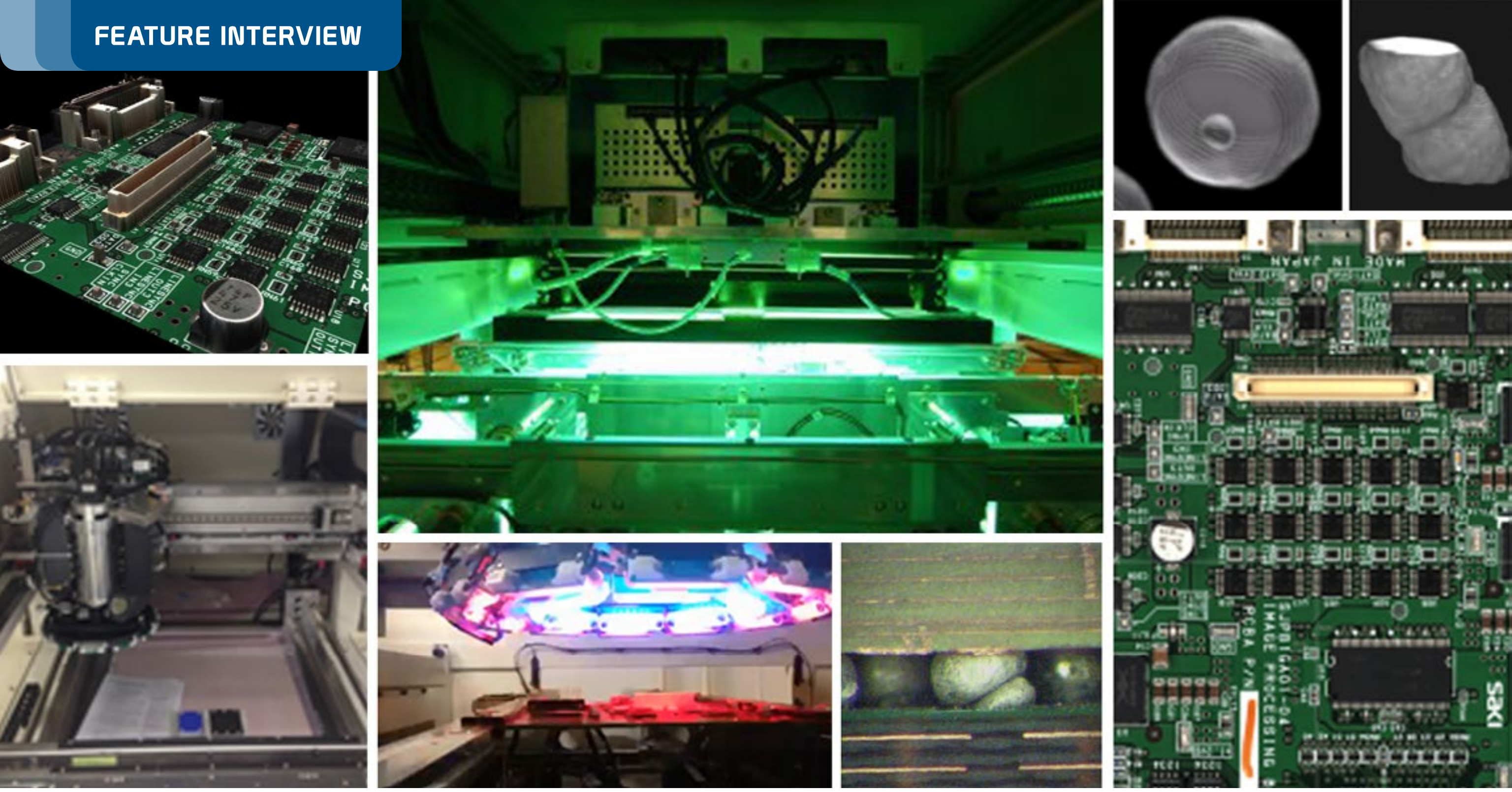
Perkins: Well,the really interesting part with fluid dispensing is we work with fluids from 10–15 centipoise, water-based agents, up to high -onductivity thermal interface material that have specific gravities of three and a half and are a couple million centipoise. When you look at the fact that we can basically dispense any back-end liquid, there is such a huge range of applications that we can get in, which a lot of the general industry comments say are "faster and more accurate."

We also have more flexible equipment. As you look at the contract manufacturers, they're now saying, "I might have a project that lasts for a year to two, but then I'm going to want to reuse this equipment after that for my next project." Now they're looking at how to reconfigure that same equipment to be able to do their next job and to work today with an underfill application and next year to change that to an edge-fill application, or something else. How do you make the equipment both lower in cost for driving down the manufacturing cost, but keep it highly flexible and highly reliable?

Those, I think, are the big industry challenges and we've got a great design team down in Carlsbad with a lot of experience. I've had 15 years with the company and I still a junior person within a lot of those teams. That speaks to the company's expertise in what the industry is looking for and where we can take some of those past successes and leverage them to be able to play in the 20 centipoise to 2 million centipoise neighborhoods.

Matties: Great. Thank you very much for the interview.

Perkins: My pleasure. **SMT**



Addressing the Need for Reliable, Accurate Inspection Results

by Stephen Las Marias
I-CONNECT007

Nori Koike, COO of Japan-based Saki Corp., one of the leading providers of AOI systems, discusses with I-Connect007's Stephen Las Marias how the latest trends in the automotive electronics space is driving the developments in AOI technology.

***Stephen Las Marias:** What major changes or trends have you witnessed in the automotive electronics industry?*

Nori Koike: From the SMT equipment point of view, obviously the amount of production has increased. This has been stated by various automotive electronics manufacturers, but it is a fact. Various functions in the automotive are changing the structure to use the PCB, and this trend shall continue. While it has acted as a replacement of old functions which contributed to improving the function, except navigation, now it will add value that automotives didn't have in the past (i.e., auto driving, traffic control, network, and electric power source), to name a few.

***Las Marias:** Automotive electronics manufacturers need to build reliable electronic products with increasing density, complexity and sophistication. Where does Saki come in to help your customers achieve this?*

Koike: Saki is an inspection company using various image processions. We acquire images through 2D, 3D, and X-ray, because inspection is becoming impossible only with 2D, when considering the increasing density and complexity of the boards. Any kind of inspection needed for parts on the PCB will be covered by these technologies. Also, many of the automotive electronics manufacturers grow their business on a global base. They will need to control the quality at the same level in each area. To realize this, they need the same inspection result in the same production. Looking from the inspection point of view, it will need simpler programming with higher accuracy. 3D and X-ray technologies will contribute in this area us-

ing height and cubic measurement. When using this additional 2D information, we will be able to provide simpler programming with low false calls, which contributes to operational efficiency and moreover, improves the accuracy.

***Las Marias:** What about shorter product lifecycles and keeping costs in check?*

Koike: Basically, it will be the same story as the above. Shorter lifecycle and innovation means low volume, high mix. On the other hand, they cannot increase the cost to program, and lowering the quality is not an option. They need to improve the quality. This is why we provide 3D AOI and true cubic 3D X-ray inspection.

Nori Koike, COO of Japan-based Saki Corp.

***Las Marias:** From your perspective as an AOI equipment provider, what are some of your toughest challenges when it comes to providing solutions targeted at automotive electronics?*

Koike: In the initial period, it will be the regulatory requirements, but once we go through this it will not be a big challenge. Regulatory is regulatory. We just accommodate it until it becomes perfect. Changing technology under this quality and regulatory pressure for automotive electronics will be tremendous; on the other hand, technical requirements will be emerging, which means that we periodically need to update the technology. Creating the balance between these will be the difficult part.

***Las Marias:** What do you see as the biggest driver of automotive electronics innovation?*

Koike: I cannot clearly say as it depends on the area and company, but overall, until now, the driver was efficiency—and will be at a certain extent due to the limited energy problem. Adding to that, the driver from now on will be the additional value I mentioned earlier.

***Las Marias:** What are some of the other main drivers for new products in your business?*

Koike: We think further automation will be necessary in the future. Words like "Industry 4.0" and "IoT" are starting to show presence and the requirement toward these are emerging. This will certainly be a driver and we are preparing to deal with this by having any inspection in the process of SMT and THT.

***Las Marias:** Nori, thank you for speaking with us today.*

Koike: Thank you, Stephen. SMT

Technica's Annual Tech Forum a Success

Technica USA hosted its Annual Technology Forum Event July 22–23 in San Jose, California. The event was co-sponsored by ASM Assembly Systems, with active participation from Koh Young Technology and Rehm Thermal Systems.

Just as last year, the technical presentations were conveyed at the conveniently located Club Auto Sport Event Center. The morning session began with a presentation by Jeff Schake, senior advanced technology specialist at ASM-DEK. Schake's many years of experience in managing printing focused process investigations for DEK enabled him to focus his presentation, titled "Blueprint to High Yield Stencil Printing," on best practices of printing process design and execution. He presented examples of print process defects and corresponding cause and effects that were later demonstrated during the afternoon session.

Koh Young's Dr. Eric Jeon, director of R&D Center, and David Suh, technical support and applications engineer, co-presented on the best method to improve production yield. Their presentation focused on the value of using the data retrieved from SPI to improve process yields, and provided many examples on how 3D solder paste inspection could immediately provide engineers with information that could effectively address issues that arise in printing. The presentation also emphasized the value of creating an environment to utilize the data from the 3D SPI and 3D AOI to make corrections in the process in real time.

In his presentation, "The Main Reasons for SMT Placement Defects and How to Prevent Them," Tom Foley, quality manager for ASM-Siplace, provided a perspective that was unique when thinking about placement defects. He provided an overview of how the process of reducing defect begins from when the component materials arrive at the facility. Foley presented the latest in produc-

tion methods including advancements in software and hardware designed to error-proof the SMT placement process.

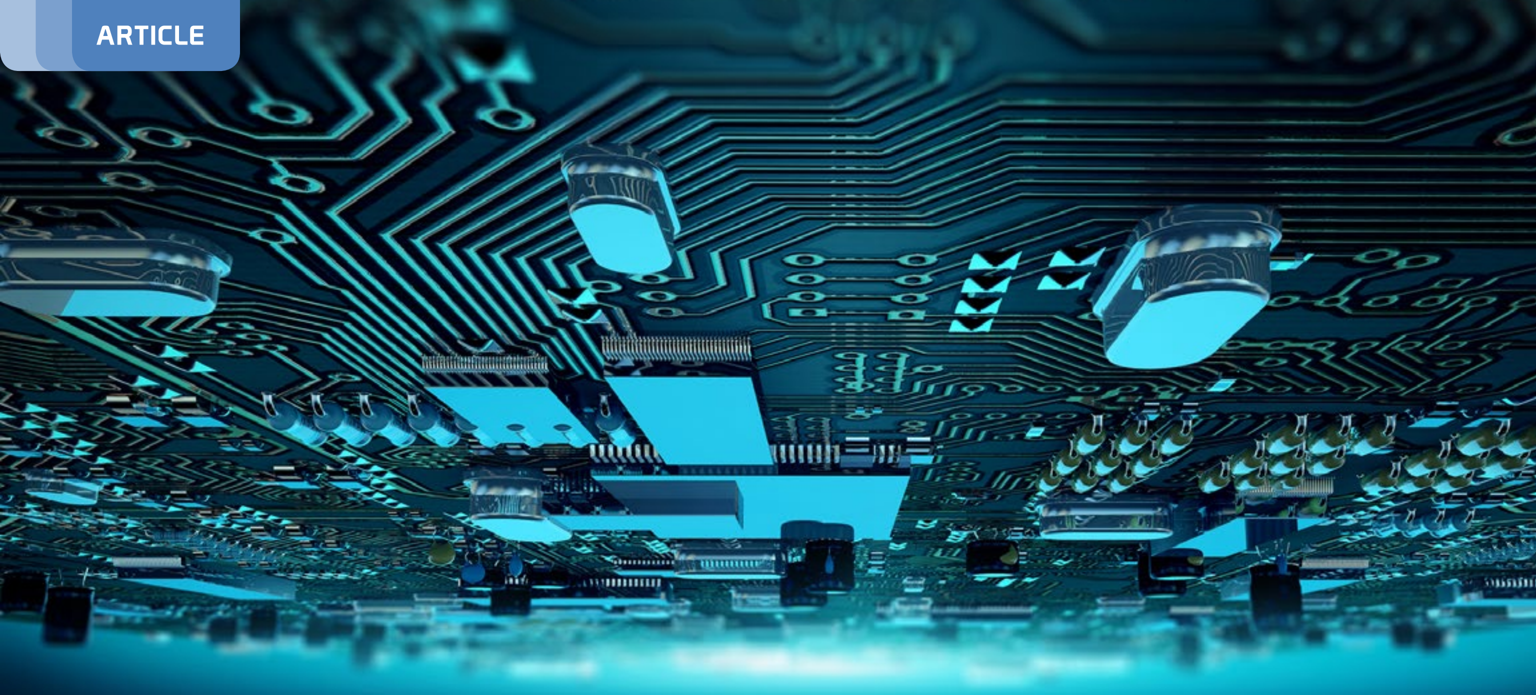
Helmut Ottl, head of product management at Rehm Thermal Systems, delivered the last presentation titled "Today's Challenge – Complex Boards with 03015 Parts Up to Large Components". Ottl's presentation was based on the results founded through a consortium effort established in Germany where he and the team at Rehm Thermal System were intimate in the study. ASM-Siplace and a few other companies were also involved in this effort. Ottl went on to provide the results of this study in detail.

After the hosted lunch at Club Auto Sport, the afternoon portion of the agenda took place at Technica's Demonstration and Training Center nearby the event center. It was here that each of the companies involved in the morning sessions were able to demonstrate the cause and effect of process defects, how to detect them, and how to resolve them by utilizing technologies that are available today.

Frank Medina, president of Technica, said, "Everyone involved was very pleased with the results of the day's activities. We had a great turnout each day and it appeared that everyone found the information that was provided in the technical presentations and the demonstrations conducted in the afternoon to be valuable."

Technica will also be hosting its annual Pre-Holiday Customer Appreciation evening on October 28.

For 2016, Technica has already scheduled the Tech Forum Event for July 20–21.



Tin Whisker Self-Mitigation in Surface Mount Components Attached with Leaded Solder Alloys

by Thomas Hester and David Pinsky
RAYTHEON COMPANY

Abstract

Tin plating can spontaneously grow filaments, called whiskers, which can cause electrical shorts. Alloying of tin with lead (Pb) is known to suppress whisker formation. This article provides the findings of a lengthy project of soldering electronic components with pure tin finishes with lead-containing solder for the attachment. The object of the project was to determine the conditions under which sufficient alloying of the pure tin finish by lead in the solder is achieved for the purpose of whisker suppression. We have coined the term "self-mitigation" to describe this effect.

The first part of the project was planned by a committee that selected commercially available surface mount components, including package styles that exhibit a variety of solderable termination heights and lengths. The sample boards in the first part of the project were of two designs: first a simple single layer circuit card; and second, a multi-layer circuit card with internal ground planes, representing the current design practice for our production printed wiring assemblies. Sample boards were assembled using standard production pick-and-place equipment and automated soldering processes.

The original project was later expanded with multi-chip module (MCM) samples containing surface mount components with pure tin solder terminations. The success criteria for tin whisker self-mitigation was chosen to be the presence of at least 3 Wt% lead in all measured solder locations. Materials analysis was conducted in multiple locations on each solderable termination, usually at egress from the package, a midpoint, and adjacent to the board contact pad. The materials analysis was primarily performed using X-ray fluorescence, and the validity of the X-ray fluorescence measurements was checked on a sample basis with cross-sectional analysis and Scanning Electron Microscope Energy Dispersive Spectroscopy. The results have suggested that a rule based upon a sum of the horizontal and vertical dimensions of a termi-

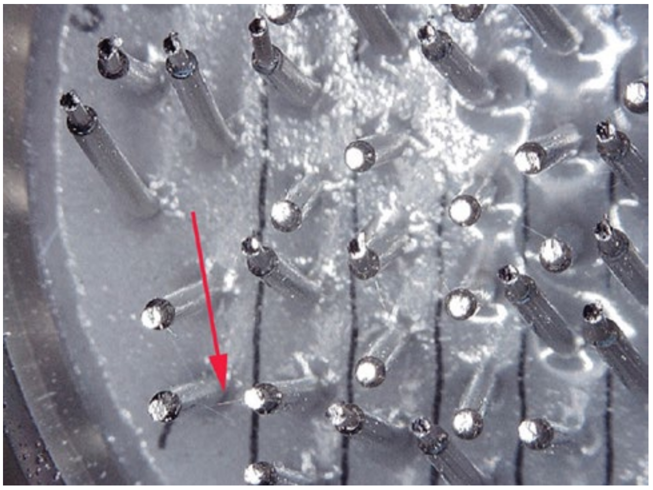


Figure 1: Tin whisker on partially disassembled connector contacts.

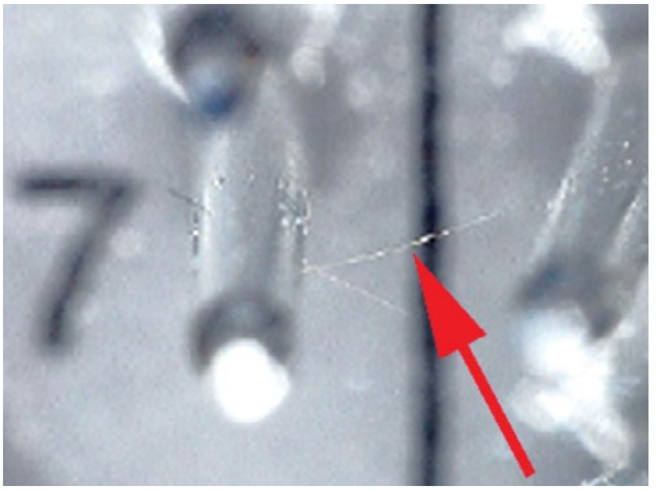


Figure 2: Close-up of tin whiskers shorting between contacts.

nation be used for predicting tin whisker self-mitigation.

Introduction

Tin whiskers can grow from pure tin solder terminations, device cases, and connector shells, and risk causing electrical short circuits (Figures 1 and 2)[1]. Tin whiskers have been shown to be the root cause of the total loss of entire satellites, shutdown of nuclear power plants, and failure of consumer electronics such as digital watches.

Tin Whisker Risk Mitigation Techniques

Accepting tin whisker risk mitigation is an alternative to rejecting parts and assemblies with pure tin[2]. Risk mitigation assumes that some level of risk must be accepted[3]. Examples of tin whisker risk mitigation techniques include removing the pure tin by plating or solder dipping, covering the pure tin by coating or potting, or performing a tin whisker growth project on the parts in question[2, 4, 5] .

Mitigation by Soldering with SnPb Solder

This is a self-mitigation or lead-poisoning technique that uses the tin/lead soldering process to add lead to the solder joint and eliminate the risk of tin whiskers. This technique has the risk of insufficient solder flow across component lead surfaces.

Qualification for Self-Mitigation

Qualification of surface mount package styles for self-mitigation is outlined in the Rev A GEIA-STD-0005-2[6] as follows:

"Tin or tin alloy surfaces and soldered areas shall be evaluated for >3% Pb content using XRF, consistent with SAE Standard JESD213[7], SEM EDS, consistent with MIL-STD-1580, Requirement 9[8], or other methods approved by the customer. Micro-sectioning shall be performed to ensure that there is adequate consumption of the Pb-free tin into the solder. The qualification shall take into account variability in the solder process controls."

Self-Mitigation Qualification Studies

Published results for limited numbers of package styles from Raytheon Goleta, Stevens et al[9], and Rockwell Collins (D. Hillman)[10] predicted specific package styles (SOICs, chip resistors, and RF transistors) would self-mitigate if the solder termination height from solder pad to the lead egress were < 0.030 inches, or about half the total package height, under optimized soldering conditions. This self-mitigation qualification project investigated multiple surface mount package styles, meeting the qualification requirements of the Rev A of GEIA STD-0005-2[6], with results showing rules based on more than just solder termination height are needed to predict self-mitigation.

Raytheon Parts and Libraries Tin Whisker Self-Mitigation Project

A. Overall objective: Validate printed wiring board design, component selection, and solder assembly guidelines that will assure mitigation of tin whisker growth risk when using electronic components with pure tin solder terminations.

B. Objective for sample part selection: Test to see if component samples with solder terminations < 0.035 inch in height, under conditions optimized for introduction of lead into the solder surface, would be self-mitigating for tin whisker risk.

C. Objective for sample PWB design: Test to see if use of Raytheon standard solder pads, multilayer printed wiring boards, and multiple grounding layers affects self-mitigation for tin whisker risk.

D. Objective for multi-chip-module samples: Validate self-mitigation of selected components in MCM for tin whisker risk.

Part Selection Criteria for PWB Designs 1 and 2

The components selected for this project included a range of termination lengths and package heights that would both have some parts succeeding and some failing the pure tin mitigation process. These were purchased from commercial sources for pure tin containing electronic components. The package height factor in self-mitigation was understood from previous studies, but in hindsight the termination length factor was not considered as it was not recognized to be important before this project.

Part Selection Criteria for Multi-Chip Module

The components analyzed for self-mitigation on the MCM were limited to surface mount chip resistors size 01005 and surface mount capacitors ranging in body height up to 0.065 inch. No other components on the MCM were analyzed for self-mitigation.

Sample Designs

Two sample PWBs and a multi-chip module were created. The first sample board was a simple two-layer circuit card with standard manufacturer's suggested solder pad sizes. A second sample board was developed with features selected to challenge the ability of components to self-mitigate, which included multiple layers, multiple ground planes, and Raytheon selected solder pad sizes, which are larger than the manufacturer's suggested sizes. Photographs of the test boards are shown in Figures 3 and 4. These factors were considered important in simulating worst-case production conditions for self-mitigation.

The MCMs are highly compact multilayer wiring boards with internal ground planes. Eight MCMs were made for this project. A photograph of the MCM is shown in Figure 5.

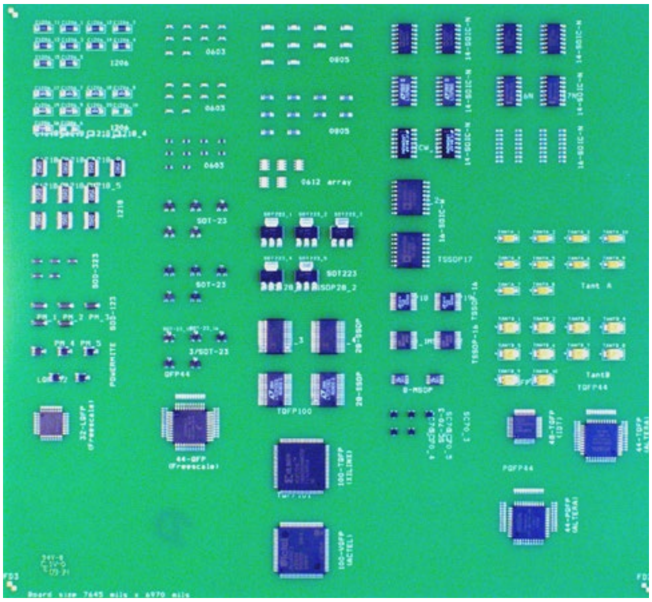


Figure 3: Sample board design 1.

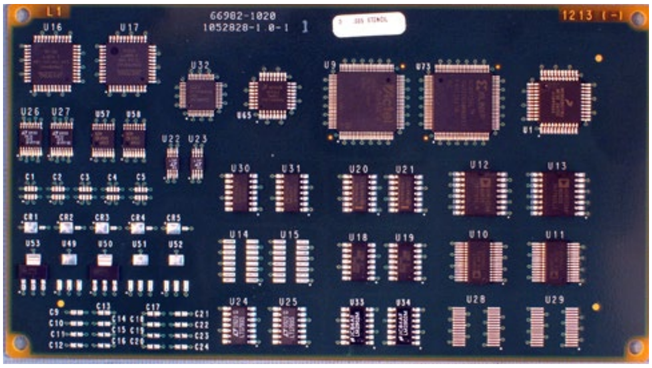


Figure 4: Sample board design 2.

Solder Paste Printing, Component Placement, and Soldering Conditions

A. Sample Boards Design 1 and 2

Standard production automated assembly equipment was used to apply solder paste, place components, and control solder conditions in both the assembly of the design 1 and design 2 sample boards. Raytheon standard solder process conditions were employed with both the design 1 and design 2 sample assemblies. Conditions recorded include soldering at 215°C +/- 2°C for 60–90 seconds, use of 63 Wt% tin, 37 Wt% lead solder, 5 and 6 mil stencils, and R0L0 flux. No manual touch up of component placement or soldering processes was performed, to avoid introducing variability in the project results.

We made six copies of the design 1 board, and eight of the design 2 board. A few locations on each board design were not populated with components, either due to board layout issues or insufficient sample quantities.

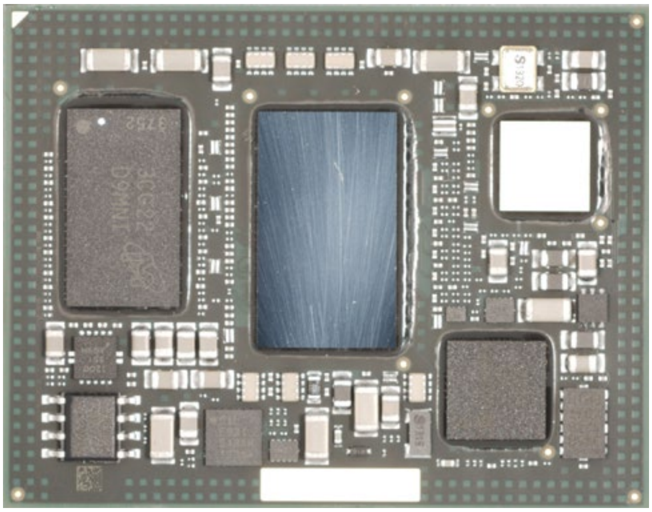


Figure 5: Multi-chip module.

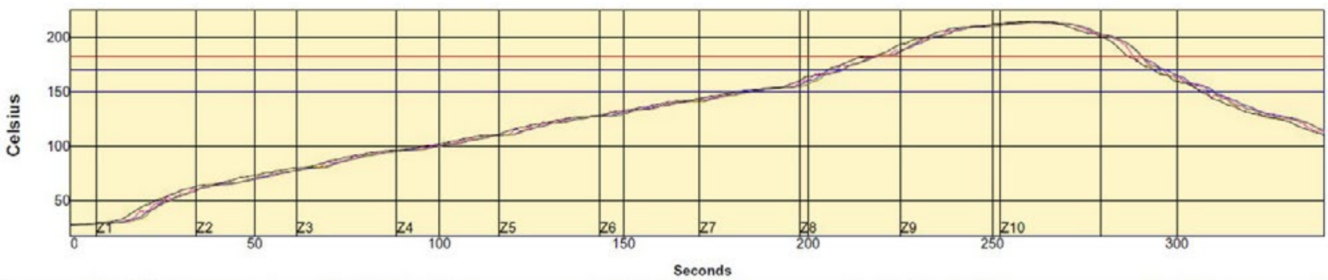
B. Multi-Chip Module

Due to the proprietary design of the MCM only the general solder process conditions are released in this article. Tin-lead solder was used with the solder profile shown in Figure 6.

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7	8	9	10
Top	97	98	115	125	150	160	170	220	260	240
Bottom	97	98	115	125	150	160	170	220	260	240

Conveyor Speed (inch/min): 29.53



PWI= 115%	Max Rising Slope		Soak Time 150-170C		Reflow Time /183C		Peak Temp	
top	1.0	49%	25.8	58%	67.7	-78%	214.2	-115%
top	1.0	50%	24.4	44%	69.5	-64%	214.5	-111%
top	1.0	52%	24.7	47%	72.3	-42%	214.8	-103%
top	1.0	50%	24.3	43%	68.2	-74%	214.8	-103%
Delta	0.0		1.4		4.6		0.6	

Process Window:

Solder Paste: snPB220 White Elec Reflow Window

Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 60 Seconds)	0.0	1.5	Degrees/Second
Soak Time 150-170C	10	30	Seconds
Time Above Reflow - 183C	65	90	Seconds
Peak Temperature	215	225	Degrees Celsius

Figure 6: MCM solder profile.

Sample Materials Analysis

The solder composition of all the assembled sample vehicles, Design 1, Design 2, and the MCM, was verified using both X-ray fluorescence (XRF) for all solder terminations, and scanning electron microscope energy dispersive spectroscopy (SEM-EDS) for selected solder terminations that were prepared by mounting and cross-sectioning (destructive physical analysis). Generally, two terminations were analyzed on each component, and between one and three locations per termination. If the component had wrap around leads, measurements could only be taken at the top of the lead, but if the component had "J" style leads three locations were measured, as discussed next. These factors resulted in multiple data points per component and multiple repetitions of the components on the sample vehicles.

The XRF and SEM-EDS data produced agreed within measurement accuracy for the two techniques at the surface locations. The XRF data was typically taken at three locations on formed terminations at the egress from the part body, just before a knee in the "J" style lead bends, and at the solder foot in all cases. The SEM-EDS data was taken in cross-section views, not on the top down views used in XRF. The SEM-EDS data was taken at near the surface of the solder (most comparable to the XRF measurements), at a mid-point representing the bulk of the solder, and then near the interface between the solder and the lead substrate material. This sample location plan took advantage of the speed of measurement and non-destructive nature of XRF, while also taking advantage of the relatively small spot size of the SEM-EDS measurement to verify the depth of mixing of the lead into the pure tin solder terminations.

A. XRF Quantitative Analysis Data Typical of Designs 1 and 2

A sample of the design 2 XRF data is shown in Figure 7. The legend in Figure 7 shows white for self-mitigating, pink for not mitigating, blue for physically impossible measurements that were excluded from consideration in the analysis, and green for locations where we verified no part was present. The blue highlights usually occurred on locations at the knee of a lead bend, and XRF data is usually not valid on a surface parallel to the direction of the X-ray beam. The X-ray beam must strike a flat surface perpendicular to the beam for typical X-ray detector function in the materials analysis. The blue highlights in this data are typically present on the second of three rows of data for a part, which corresponds to the vertical portion of the lead bend area.

However, a few locations with physically impossible compositions were excluded, as it is not possible to get 41.8 Wt % tin when the part starts out as 100 Wt% tin, and the solder paste was 67 Wt% tin. These would indicate locations where the beam alignment to the pad was off, perhaps due to pick and place irregularities.

B. XRF Quantitative Analysis Data for MCM Samples

A sample of the MCM XRF data is shown in Figure 8. The legend in Figure 8 shows white for self-mitigating, pink for not mitigating, blue for physically impossible measurements that were

	Color Code	Green = No component present								
		Light Red = Tin Wt% > 97.0								
		White = Self Mitigating, Tin Wt% <97.0								
		Blue = Invalid Measurement								
		Board Serial Number / Stencil Thickness (Mils)								
ID	PART NO.	Designator	1/0.005	2/0.005	3/ 0.005	4/0.005	5/0.006	6/0.006	7/0.006	8/0.006
234	W3L1YC474MAT1AF	C1	91.86	74.56	66.30	67.68	66.65	67.03	66.57	66.46
235	W3L1YC474MAT1AF	C1	85.29	94.33	76.65	78.44	73.54	81.12	94.70	92.72
236	ADM202EARUZ	U58	96.33	98.68	98.76	98.71	97.89	98.69	94.21	3.27

Figure 7: Design 2 XRF data sample.

excluded from consideration in the analysis, and beige for locations where the solder joints were manually re-worked prior to XRF measurement.

C. SEM-EDS Quantitative Analysis Data Typical of Design 2

SEM/EDS (Energy Dispersive X-ray Spectroscopy) analysis of a few selected components leads was performed with a SEM JSM (JEOL)-6460 equipped with an IncaPentaFETx3 detector and software analyzer. The quantitative analysis data was adjusted for accuracy using a 97wt%Sn-3wt%Pb materials standard issued by Matrix Metrologies, as can be seen in Figure 9. The test procedure was according to the MIL-STD-1580, Requirement 9[8].

Sample S/N		7	8	9	10	11	14	26	27
Ref Designator	Design Part No.	Tin (Wt%)	(Wt%)	(Wt%)	(Wt%)	(Wt%)	(Wt%)	(Wt%)	(Wt%)
C49	R2254568-476M6E	85.15	94.74	90.63	93.84	93.63	86.57	96.14	94.74
C493	R2255073-104K6A	94.27	95.22	94.12	93.31	95.02	94.68	85.83	92.67
C501	R2255073-104K6A	96.40	93.45	93.52	87.10	89.60	92.97	86.80	93.18
R920	R20003566-0015	83.49	80.17	71.74	72.07	70.76	72.04	67.63	63.62
R887	R20003566-0015	78.55	85.92	72.31	73.23	83.70	81.11	65.42	66.33
C542	R2255073-104K6A	94.01	93.32	93.32	91.51	95.98	96.04	84.47	86.68
C431	R2255073-104K6A	93.52	93.15	91.41	93.19	94.81	96.29	84.30	89.24
R1060	R20003566-0014	71.05	76.05	81.73	72.26	80.39	76.82	61.27	78.21
Reworked		Below Valid Wt% Tin				Tin Wt% marginal			

Figure 8: Typical XRF quantitative analysis of tin weight% in solder terminations for MCM's serial number 7–11, 14, 26, and 27.

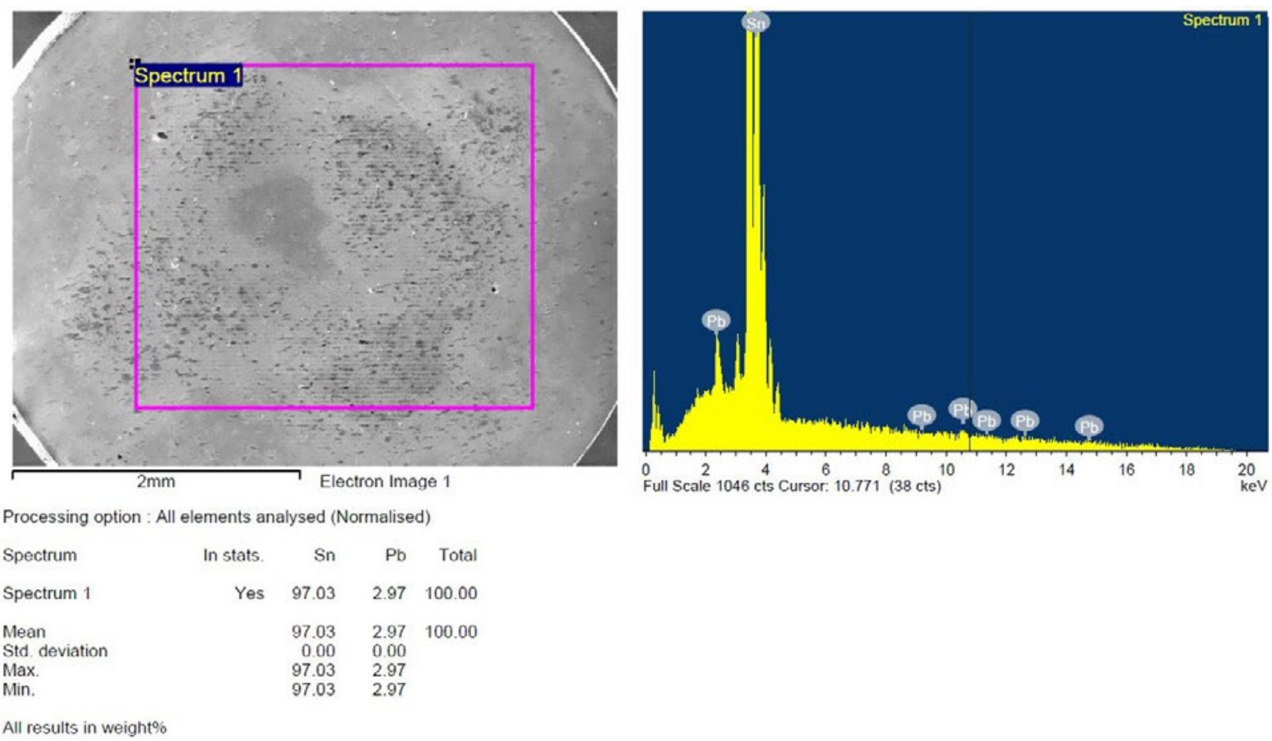


Figure 9: SEM-EDS Data for 97 Wt% tin standard.

Manufacturer Part Number	Case Size	H Max (Inches)	T2 Max	Total H +T2	Mitigation Status
RK73H1FTTBL49R9F	01005	0.0059	0.0051	0.0110	Yes
LD066D476MAB2A	1206	0.065	0.02	0.085	No

Table I: MCM component solder termination dimensions and mitigation status.

Explanation of Results

The combined tin mitigation results from sample board designs 1 and 2 are shown in Table II. Yellow highlights are placed to emphasize part types that did not self-mitigate, although application of a "half height rule" would have predicted self-mitigation. In the rows with yellow highlighting, the horizontal lead length was greater than 0.035 inches. Some of the package dimensional measurements were not listed on manufacturer's data sheets, and these were obtained directly from the part packages. The measurement count for each lead termination and package type is provided with additional division into Design 1 and 2 measurements.

The MCM samples analyzed showed self-mitigation for the relatively small chip resistors, and failure to self-mitigate for the much larger chip capacitor solder terminations (Table I and Figure 10). The MCM results summarized in Table I and included in the Figure 11 scatter Plot, are in general agreement with the data in Table II, also graphed in the Figure 11 scatter plot, and fit the proposed rules for prediction of tin whisker self-mitigation.

Explanation of Scatter Plot

A scatter plot of the horizontal and vertical lead dimensions versus the tin whisker self-mitigation status shown in Tables I and II provides a graphical emphasis for the results, as shown in Figure 11. Data points above and to the right of the red line in Figure 11 correspond to test samples that failed to self-mitigate, with solder terminations that contain less than 3 wt% lead, and data points below and to the left of the green line correspond to self-mitigating conditions.

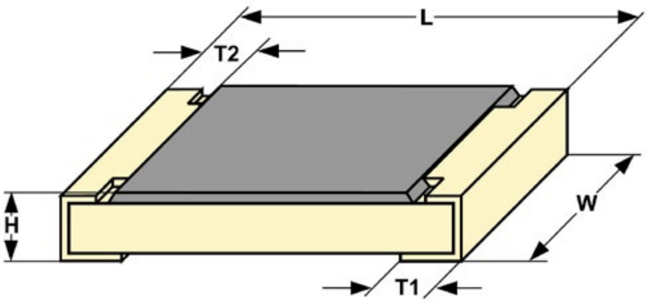


Figure 10: Typical chip component solder terminations with height (H) and top surface (T2).

Proposed Rules for Prediction of Tin Whisker Self-Mitigation

1) The horizontal component of lead length must be less than 0.035 inch, from the tip of the lead at the solder pad back to the lead egress from the package.

2) The combined dimensions of height and length must be less than 0.045 inch.

Conclusions

The current mitigation processes for tin whisker risk have serious drawbacks, including added processing costs[2], increased rework costs (removing conformal coatings), added process controls (verifying low stress in tin surfaces[3, 12]), and risk of damage to components (stripping, replating[4], and solder dipping[13]). Under certain conditions, surface mount soldering with eutectic tin-lead solder can result in the alloying of plated pure tin component termination finishes with a minimum of 3 wt% lead at no added process cost. We have termed this effect "self-mitigation" despite being a slight misnomer, as having 3 wt% lead is not truly mitigation; it effectively eliminates the risk of tin whisker growth.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Legend | **PSM**= Predicted Self Mitigating | **Design Status**, Yes = Self Mitigating, No = Not self mitigating, n/a = not available | ** Not defined | D1 LC | D2 LC

Item Number	Test Part Number	Package Type	Pkg Height	Lead Thickness	Horizontal Lead Length	Base to Lead Topside (inches)	PSM?	1st Design Status	2nd Design Status	1st Design #Lead Meas'd	2nd Design #Lead Meas'd
27	CRCW06030000Z0EA	0603	0.018 +/- 0.02	n/a	0.0118	0.0018	Yes	Yes	n/a	3	0
29	CRCW121815R0FKEK	1218	0.022 +/-0.02	n/a	0.0157	0.0022	Yes	Yes	n/a	1	0
28	CRCW12060000Z0EA	1206	0.022 +/- 0.02	n/a	0.0157	0.0022	Yes	Yes	n/a	2	0
34	MMBT2222ALT1G	SOT-23	0.035 - 0.044"	0.00505	0.02145	0.01475	Yes	Yes	n/a	4	0
19	IRLML2502TRPBF	SOT-23	0.032 - 0.044"	0.0665	0.020905	0.01655	Yes	Yes	n/a	2	0
18	LM4041BIM3-1.2/NOPB	3/SOT-23	0.035 - 0.044"	0.0060	0.02215	0.01655	Yes	Yes	n/a	3	0
32	TNPW0805100KBEEN	0805	0.018 +/- 0.02	n/a	0.0157	0.0177	Yes	Yes	n/a	2	0
21	MMSZ3V3T1G	SOD-123	0.037 - 0.053"	0.0050	0.01965	0.0203	Yes	Yes	n/a	4	0
6	LT1762EMS8#PBF	8-MSOP	0.043" Max	0.0062	0.0361	0.02035	Yes	No	No	2	96
36	ADM202EARUZ	16-TSSOP	0.047" Max	0.0061	0.04095	0.0217	Yes	No	No	2	85
14	LT3012EFE#PBF	16-TSSOP	0.043" Max	0.0060	0.03720	0.02195	Yes	No	No	2	73
26	08055A100JAT2A	0805	0.037 max	n/a	0.020	0.02205	Yes	Yes	n/a	2	0
4	EPM3064ATC44-7N	44-PQFP	0.047" Max	0.006	0.0376	0.0226	Yes	No	No	2	48
2	EPM7032AETC44-10N	44-TQFP	0.047" Max	0.006	0.04095	0.02365	Yes	No	No	2	48
22	BAS21HT1G	SOD-323	0.031 - 0.040"	0.00475	0.0168	0.02400	Yes	Yes	n/a	5	0
33	WSL1206R0150FEA	1206	0.025 +/- 0.010	0.025	0.02	0.025	Yes	Yes	n/a	2	0
5	A3PN030-ZVQG100	100-VQFP	0.047" Max	0.006	0.0408	0.025	Yes	No	No	2	96
17	MBRM140T1G	Powermite	0.033 - 0.045"	0.00680	R=0.0498	0.0250	Yes	No	No	3	51
17	MBRM140T1G	Powermite	0.033 - 0.045"	0.00680	S=0.019 REF	0.01	Yes	Yes	Yes	2	53
20	SI1304BDL-T1-E3	SC-70-3	0.035 - 0.043"	0.0050	0.01705	0.02720	Yes	Yes	n/a	3	0
35	PZT2222AT1G	SOT-223	0.060 - 0.068"	0.01090	0.06445	0.02740	Yes	No	No	10	136
10	LM2901DG	14-SOIC-N	0.054 - 0.068"	0.00935	0.0434	0.0295	Yes	No	No	2	96
23	LM2902M/NOPB	14-SOIC-N	0.053 - 0.069"	0.0087	0.04220	0.0304	Yes	No	n/a	2	96
9	IR2156SPBF	14-SOIC-N	0.053 - 0.069"	0.0090	0.04035	0.03060	Yes	No	No	8	96
38	XC9572XL-5TQG100C	100-TQFP	0.055 - 0.063"	0.0585	0.03890	0.03165	Yes	No	No	2	48
3	STAC9200X5TAEB1X	48-TQFP	0.063" Max	0.0545	0.04020	0.0317	Yes	No	No	2	48
37	MC9S08QE4CLC	32-LQFP	0.055 - 0.63"	0.0070	0.0424	0.0318	Yes	No	No	2	48
7	OP482GSZ	14-SOIC-N	0.053 - 0.069"	0.00905	0.0406	0.03220	Yes	No	No	2	96
15	DG403DY-E3	16-SOIC-N	0.053 - 0.069"	0.00915	0.04490	0.03380	Yes	n/a	n/a	0	0
8	LT1791IS#PBF	14-SOIC-N	0.053 - 0.069"	0.00820	0.04420	0.03390	Yes	No	No	2	96
30	TAJA105K020RNJ	Tant A	0.071 max	0.004	**	0.03635	No	Yes	n/a	1	0
12	ADM213EARSZ	28-SSOP	0.079" Max	0.0070	0.05200	0.03665	No	No	No	2	144
24	0603YD225KAT2A	0603	0.037 max	n/a	0.014	0.037	No	No	No	2	96
25	06035C103KAT2A	0603	0.035 max	n/a	0.014	0.037	No	No	No	2	93
16	W3L1YC474MAT1AF	0612 array	0.037	0.007	0.014	0.037	No	No	No	5	5
13	LTC3703EG#PBF	28-SSOP	0.079" Max	0.00705	0.04955	0.03830	No	No	No	2	68
31	TAJB105K035RNJ	Tant B	0.083 max	0.004	**	0.04195	No	Yes	n/a	5	0
1	MC9S08GT16AMFBE	44-QFP	0.083 - 0.096"	0.0067	0.06285	0.0435	No	No	No	8	48
11	ADM232AARWZ	16-SOIC-W	0.093 - 0.104"	0.01125	0.05795	0.0530	No	No	No	2	96

Table II: Summary of sample boards designs 1 and 2 results.

The proposed rules relate most strongly to the geometry of a component solder termination, showing the ability to self-mitigate under current industry standard design and production conditions, using three sample vehicles that varied in characteristics including overall size, board thickness, presence or absence of ground planes, and density of component placement. **SMT**

Acknowledgment

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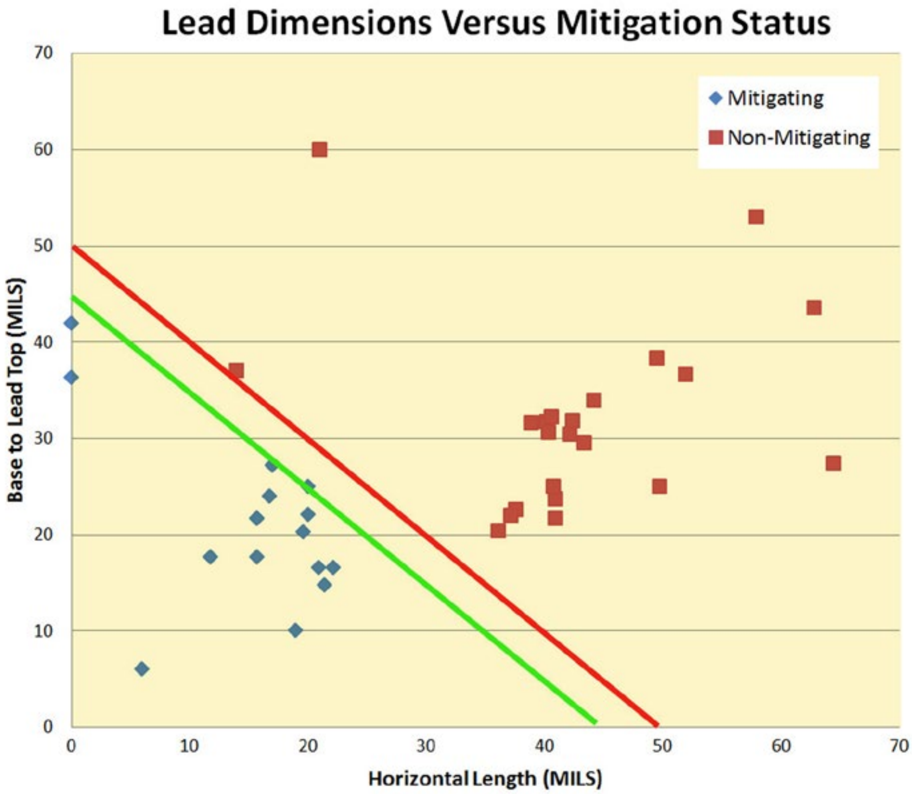

Figure 11: Scatter plot showing lead dimensions versus mitigation status.

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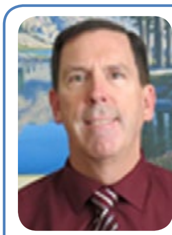

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SMT007 Supplier/New Product Highlights

Dorigo Systems Installs Koh Young 3D SPI, AOI Inspection Systems

Dorigo Systems has installed Koh Young KY8030-3 SPI and Zenith 3D AOI systems in its newest SMT PCBA manufacturing line, adding 3D measurement and inspection capability for printed solder paste as well as completed SMT assemblies.

Celestica Recognizes Avnet as Best Distributor Partner

Celestica has recognized Avnet as Best Distributor Partner through its awards program, which recognizes suppliers that support Celestica's TCOO strategy and demonstrate excellence in quality, delivery, technology, service, pricing and flexibility.

Ellsworth Adhesives Europe Now Offers New Robnor Resins Paste

Ellsworth Adhesives Europe has launched TCP091, Robnor Resins' newly launched silicone-free paste that has been specially formulated to provide efficient and reliable heat transfer across the interface between electronic components.

KYZEN Sponsors Women's Networking Event at SMTAI

KYZEN is the proud sponsor of the Women's Networking Event at SMTA International Conference & Exhibition, scheduled to take place September 29-30, 2015 at the Donald Stephens Convention Center in Rosemont, Illinois.

BEST Unveils Speaker Line Up for Annual Tech Symposium

BEST's annual tech symposium, to be held on October 1 in the suburbs of Chicago, will feature top notch speakers on the topic of microelectronics assembly challenges.

AIM Solder Strengthens Presence in China

AIM Solder has appointed Cifon Zheng to the position of Sales Manager for east of China. Cifon will promote AIM's full line of solder assembly materials to the company's rapidly expanding customer base in China.

EMEA Electro Solutions to Represent Viscom in Spain and Portugal

Headquartered in Barcelona, EMEA Electro Solutions is taking over Viscom representation in Spain and Portugal.

Mycronic Receives Order for Mask Writer

Mycronic AB has received an order for a maskwriter replacing an older system for manufacturing of display photomasks from a customer in Asia. It is estimated that the system will be delivered during the third quarter of 2016.

BAE Systems Installs ACE's KISS-103IL Selective Soldering System

ACE Production Technologies, Inc., a leading supplier of selective soldering systems, is pleased to announce that the BAE Systems' Fort Wayne operations has invested in a KISS-103IL in-line selective soldering system.

Speedline Launches MPM PrinTrack Traceability and Verification

Speedline Technologies has launched MPM PrinTrack, a new "open architecture" traceability and verification system with expansion possibilities.

Choosing the Right Conformal Coating

Phil Kinner, head of conformal coatings at Electrolube, talks to I-Connect007's Stephen Las Marias about the impact of increasing electronics in cars on conformal coating requirements. He also highlights the best practices that help automotive electronics makers select the correct conformal coating solution for their applications.

Stephen Las Marias: What major changes have you witnessed in the automotive electronics sector over the past several years?

Phil Kinner: The automotive electronics industry has evolved rapidly during the last decade. The most striking aspect is the way that the use of electronic controls, sensors, safety features and in-cabin entertainment, communications and navigation, have been adopted in mid and low-end vehicles. Automobiles are now much safer, more fuel-efficient and more comfortable as a direct result of the increased adoption of electronics.

On top of this, we have seen the emergence of electric vehicles offering a more environmentally acceptable alternative to fossil-fuel-based vehicles. These electric vehicles now have a range that is useful to most commuters (150–200km) and we are seeing a rapid installation of charging stations and other infrastructure requirements to make these vehicles more mainstream.

Finally, we've seen the emergence of smart cars that can communicate with each other, making pre-emptive interventions to help maintain safety and avoid collisions, with 'driverless' vehicles making daily journeys on highways and other roads without major incident. Who would have thought that would be close to a practical possibility a decade ago?

Las Marias: What can you say about the increasing reliability requirements in automotive electronics? Where does Electrolube come in to help your customers address this issue?

Kinner: I would say that the challenges on electronics reliability in the automotive industry are perhaps higher even than aerospace applications, due to the fact that aerospace systems usually have at least two back-up systems that automotive systems do not. The elimination of cleaning from many automotive electronics assembly processes has placed an even greater emphasis on the performance requirements of the protective coatings.

Given the volume of automotive parts produced, the use of solvent-containing products is

Phil Kinner, head of conformal coatings at Electrolube.

discouraged to help meet solvent-emissions targets. The list of prohibited substances for use in automotive applications continues to grow. The manufacturing processes need to be lean and provide one piece flow at the maximum possible, defect-free, manufacturing velocity.

As an ISO14000 company itself, Electrolube is dedicated to producing products that can help automotive manufacturers achieve all these requirements. Whether it is the demonstrably higher performance solvent-free conformal coatings, encapsulation resins for more demanding applications, high-performance lubricants and greases for enhancing switches, bearings and other moving parts or advanced thermal management for keeping assemblies cool to extend their lifetimes, Electrolube has a great portfolio of products to help enhance the reliability and productivity of automotive electronics.

Las Marias: As a conformal coatings provider, what are the main challenges that you encounter from your customers in the automotive electronics space?

Kinner: We see our customers needing to achieve ever higher operating temperatures as the electronics continue to become more powerful resulting in higher temperatures; also, historically electronics have been considered in-cabin or under-hood, with greater requirements for under-hood applications. We are seeing a blurring within these boundaries and a drive towards using one material in both applications to simplify manufacturing processes.

From a performance point of view, thermal shock, the rapid transition from extremely cold towards maximum operating temperatures, originally intended as a destructive test methodology, has become an important acceptance criteria for customers, with the number of cycles increasing from 1,000 towards 2,000. This poses real challenges for some solvent-free chemistries, especially UV curable materials, so popular because of their manufacturing attractiveness from a lean and one piece flow point of view.

Balancing the requirements of environmental acceptability, manufacturing acceptability and end-product reliability continues to be the main challenge facing coating formulators. Electrolube will be proud to introduce a new range of conformal coatings at Productronica 2015 to help users address all of these issues simultaneously.

Las Marias: Are there different types of conformal coatings suited to automotive electronics? Please highlight some of the best practices that help automotive electronics makers select the correct conformal coating solution for their applications.

Kinner: There are many types of conformal coating that may be suitable for automotive electronics from acrylics, urethanes and silicones that have been used historically, through to modern UV curable hybrids and even ‘ultra-thin’ coatings. The correct choice will always be dictated by a combination of performance requirements, manufacturing requirements and environmental considerations.

From a performance requirement point of view, the manufacturer must consider the end operating environment and determine likely minimum and maximum operating temperatures, consider the likelihood of splash or immersion in water or liquid spills, humidity/condensation and chemical exposures (e.g., salt-spray), corrosive gases or unintentional oil spills. From an environmental point of view, the use of solvents needs to be considered, along with other chemicals that may be banned by company policy or international regulations such as RoHS, REACH, etc.

Finally, the manufacturer must give consideration to the possible coating application methods that may be used to manufacture the assembly and assess likely impacts on manufacturing throughputs, floor space requirements, Work in Process (WIP) and manufacturing velocity. They must also ensure that their application process and material selection work together to give an acceptably defect-free process that meets their end reliability requirements.

Considering these key areas together, a manufacturer may find that a material that performs well in all three consideration factors may be more suitable for their purposes than a material that has excellent environmental characteristics, but does not suit their manufacturing processes.

Las Marias: What new advances are available for conformal coatings?

Kinner: We have two new advances in conformal coating, along with several key improvements to existing technologies. One is a new, non-flammable, liquid applied ultra-thin coating material being launched at Productronica in November 2015. The key benefit of this technology, apart from the non-flammable nature, is the ease of processing—the entire assembly can simply be dipped in the liquid material without needing to be masked. The material provides a degree of protection against humidity, condensation and corrosive gases. The other is a range of VOC-free, polyurethane materials, designed to be selectively coated and cured within 10 minutes at 80°C. These materials have been extensively tested and proven to provide outstanding performance under a wide range of conditions, in particular thermal shock resistance, humidity, condensation, salt-spray and chemical resistance.

Electrolube has worked hard to produce improved conformal coatings that offer enhanced application properties, especially sharp edge coverage, as well as improving thermal shock resistance and adhesion. For example, Electrolube has developed a demonstrably stronger adhesion, solvent-based acrylic, with exceptional scratch resistance and sharp-edge coverage, designed especially for selective coating processes.

Las Marias: Has the increase in automotive electronics had an effect on your business? If yes, please explain.

Kinner: Apart from the increased fiscal benefits, the main effect has been the requirement to implement more robust systems and procedures, to ensure we can make a quality product precisely, consistently, efficiently and safely, to provide our customers the level of confidence they require from their suppliers. Year on year, our automotive clients raise the bar with their expectations from both a manufacturing perspective, but perhaps just as importantly from a product development point of view. We are consistently driven to produce products that solve the ever-increasing challenges in process and performance issues faced by our customers and innovating new solutions to meet the rapid advances in electronics manufacturing, which is the foundation of our culture and our success.

Las Marias: What qualifications are required for your company to get on an automaker's accredited vendors list? What about approvals or certifications?

Kinner: It is necessary to have a strong quality management system, but more than that, to have an attitude towards continuous improvement and minimizing defects and errors. This needs to be part of the company culture and a willingness to supplement the quality framework with additional tools and procedures to satisfy the particular requirements of the automotive manufacturers. It is more an attitude towards quality then blindly following the procedures.

Automotive electronics manufacturers are looking for a partnership rather than the traditional buyer/seller relationship, and the more flexible and open to implement different ideas we can be as a supplier, the more we can earn the trust of our partners.

With this confidence, we come to understand our customer's problems better, and understand what we can do to solve these problems. Delivering elegant solutions to known (and sometimes unknown or unacknowledged) issues adds further value to the partnership, completing a virtuous cycle.

The automotive industry, to my knowledge, only has one OEM published specification relating to material performance requirements, with many others requiring compliance with IPC-CC-830. Testing our products to above and beyond these minimum requirements ensures that our customers can be confident in both the quality and performance of these materials, and have confidence that the materials selected can withstand their expensive qualification testing.

> "The automotive industry, to my knowledge, only has one OEM published specification relating to material performance requirements, with many others requiring compliance with IPC-CC-830."

Las Marias: Which of the following do you see as the biggest driver of automotive electronics innovation: safety, reliability or efficiency?

Kinner: I think all those factors will continue to drive the development of electronics innovation in the automotive industry. Historically, efficiency was the initial driver, with the development of fuel injection systems. As our fossil fuel reserves continue to dwindle, and gas prices continue to rise, there seems little reason to think that consumers won't demand more fuel efficient vehicles, or that these developments would not be considered a key part of corporate social responsibility amongst the automotive manufacturers.

Safety was the next driver, with the development of systems such as air bags and anti-lock brakes, but the development work on self-driving cars is likely to only raise the bar on safety requirements, and this will go hand in hand with ever-increasing reliability requirements since this will be a key component of the self-driving car philosophy.

With today's always-connected lifestyles, and the advent of the smart home, the smart car is the logical next step, and this will require new electronics and new ruggedization techniques to ensure the electronics continue to work flawlessly.

Las Marias: What is your outlook for the automotive electronics industry, from the perspective of a conformal coatings provider?

Kinner: The unique reliability challenges provided by automotive electronics will continue to drive the development of new chemistries and new processes to provide ruggedization to the electronics systems. Conformal coating will continue to be a key part of that ruggedization tool kit, although perhaps not in exactly the same form as we are used to.

There is no doubt that solvent-emissions will become more closely regulated at some point in the future, so I expect low and zero-VOC coating materials to become the new normal. I expect the performance requirements of ruggedized electronics to become ever more demanding, requiring the very highest performance protection possible. With a 'do more with less' philosophy inherent in society, I also expect the need for higher yield conformal coating processes, with faster cycle times, greater manufacturing velocities and greater levels of automation to become commonplace.

Las Marias: Thank you very much, Phil.

Kinner: Thank you. SMT

Driving Innovation

by Stephen Las Marias
I-CONNECT007

Based in the Laguna Technopark in the Philippines, Integrated Micro-Electronics Inc. (IMI) today operates in multiple manufacturing sites spread out in the Philippines, China, Mexico, the United States, Bulgaria, and the Czech Republic, providing solutions to original electronics makers catering for both regional and international markets. IMI is a leading EMS provider in Asia, and ranks 7th in the list of top automotive EMS providers by New Venture Research based on 2014 EMS-related revenues. The company serves diversified markets that include those in the automotive, industrial, medical, telecommunications infrastructure, storage device, and consumer electronics industries.

Arthur Tan, president and CEO of IMI, spoke to I-Connect007's Stephen Las Marias about the latest developments in his company, some of the trends happening in the automotive electronics space, the challenges he is seeing in this region, as well as the opportunities for growth. He also touches on some of the latest technologies that will help improve the assembly processes.

Stephen Las Marias: Please tell us a bit more about IMI as well as your different groups.

Arthur Tan: IMI is a 35-year old company originally started in the Philippines. The change happened in 2005 when IMI decided to expand beyond the Philippines to become a regional and global player. In 2005, we completed an acquisition by delisting a publicly listed company in Singapore called Speedy Tech, which has operations both in Singapore and in China. In 2010, we then expanded our technology platform to include PSi Technologies, which is focused on semiconductor packaging as well as power modules. In 2011, we proceeded with our global expansion, and took over assets from EPIQ, which gave us the facilities in Bulgaria, in Czech Republic, and in Mexico. Through those acquisitions, IMI transitioned from purely a domestic player into a global player—beyond just Asia. We are now able to serve all the developing markets and developed markets in the world: Europe through Bulgaria and Czech Republic; North America through the United States and Mexico plants; and the rest of the world, through our China and Philippine facilities.

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This track will focus on critical methods and protocols to ensure that the production of Class II and III medical electronics is conducted in the most effective, efficient and quality-controlled way with full traceability and zero defects.

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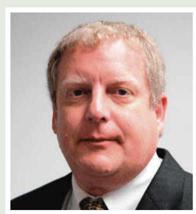

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Las Marias: Please describe IMI's operations in Asia. How important is this market for the company?

Tan: Asia is important for us because on a global basis, the world economy is actually dependent on the forward growth of Asia itself. And to us, that's a very important segment. All the tier 1 customers that we deal with are actually focused on Asia themselves, because their current markets in the developed countries that they operate in originally are actually getting flat or slowing down. The growth is actually coming out from ASEAN and Asia.

Growth drivers are primarily fueled by demographics, and then the GDP growth of the individual economies in Asia and that of China. As those numbers go up, consumption goes up, and then the need for products move from simple electronics products to more durable goods, and cars, for mobility.

China and the Philippines still comprise two-thirds of our total revenue. That's been the hallmark of our businesses. We have the most number of facilities in the Philippines and China. On a combined basis, we have about eight manufacturing sites in these two countries alone, aside from our hub in Singapore. Asia plays a very significant role so we will continue to be focused on it.

Las Marias: Over the past three decades, how would you describe the evolution that has happened in the EMS space in Asia in particular, from your perspective?

Tan: The EMS space has evolved primarily because in the beginning, it was only considered contract manufacturing, and labor-intensive type of outsourcing work. From there, the requirement has now evolved to being not only capable of producing and having the labor force for it, but understanding and having a platform of engineering and technology for it, in order to complement the products. Brand managers, the ones that own the brands themselves, are finding out that they have a big, wide product breadth that they serve the market with, but they cannot be experts in all of them. And so they need a very strong partner who will be able to provide the engineering, the technology and the manufacturing knowhow at the quality level that they are aspiring for. And these partners are what have now evolved as the EMS partners of choice.

Las Marias: The EMS industry in Asia, I would say, offers intense competition, with the big guys in Taiwan such as Foxconn and Pegatron; Singapore's Flextronics; and those players in mainland China. That's not to mention the multinational companies including Jabil, Celestica and Sanmina, to name a few. How does IMI keep up with the competition?

Tan: It's like a horse race. That's the reason it's difficult to win the Triple Crown, because you cannot have the same horse running every single race track in every single race and win in the same manner. The large EMS firms you mentioned are more focused on consumer products—which we are not. So if you take out the consumer products—let's focus on the automotive electronics parts—here we are already ranked number seven in the world, soon to be the top five. That's the part we are concentrating on.

So we are not really a volume, consumer manufacturing powerhouse—we'll never have that revenue base—but we will be able to provide the engineering and expertise that our partners need for their product realization requirement in the space that is niche in these industries that we look at: automotive electronics, industrial and telecommunications. That's our value proposition.

A lot of our customers who work with us, most of them are single-source, and the reason for it is they need a partner that they know will not drop them at the drop of a hat; has the longevity; has the financial strength to stay with them; and at the same time are aligned in the value system that they have as individual corporations for what they want to be, as a sustainable business that will make an effect for the world.

Las Marias: What are the three biggest challenges for IMI as an EMS company?

Tan: From a technology standpoint, the challenge for us is being able to tap the proper resource at the right time, and then being able to deploy it at the right place. That's always a challenge. Because over a period of time, you will have the resources, but not be able to move them at the right place; or there will not be a need for the resources that you've developed because the market has changed. So to me, managing that between the resources, the availability, and the market itself, is the challenge.

Las Marias: What strategies are you implementing, or have you already put in place, to address these challenges?

Tan: We have built centers of excellence in each of our different operating sites—in Bulgaria, in the United States, in the Philippines, and in China, so that's one way we circumvent it. We tie it up with a very strong backend IT, which means that we have access to these technologies, excellence centers, even though there are geographical distances between the different sites. So that's one way to augment it. Second, we traditionally hold a very open and flat organization so that everybody works very closely with everyone. There's very little barrier that we put among the different sites and among our people. We have a very diverse management team. Even though we are a Filipino company, only about 33% of my executive staff are actually Filipinos; the rest are multinationals.

Las Marias: From your perspective, how has the automotive electronics industry evolved over the past decade, and what major changes have you witnessed?

Tan: In 2004, we saw that only about 4% of the total value of the car is related to automotive electronics. Ten years later, in 2014, 35% of the vehicles' value was automotive electronics. It's projected that in 10 more years, up to 70% of the value of the car will be automotive electronics. That change in the amount of automotive electronics in the value of the car is what drives us.

Las Marias: What strategies do you have in place to help automotive electronics customers achieve the high-reliability requirements and at the same time drive innovation?

Arthur Tan, president and CEO of IMI.

Tan: For us, it's a continuing evolution of strategies. We have a very clear vision of what the end-market is evolving to. It's the path of how we get there that we constantly use all the emerging technologies, all the different policies that governments are imposing on, and then the consumer public itself—because you can have the technology that everybody thinks is great, but the consumer public is not willing to pay for. That itself is going to make it challenging. And so those are the different pieces of the strategy that we incorporate on a monthly and yearly basis to our own manufacturing and developmental business strategies. And that's how we adjust to it.

We have a unique proposition in the sense that because of the diversified products that we build—all the key strengths that you need in order to be successful in each of these market segments—we have. So applying those different capabilities for specific products and services that our customers need to become successful in an emerging market, I think, is what makes doing business with IMI a unique experience.

Las Marias: ***Earlier on, you mentioned about being a preferred supplier of Bosch, and being a direct supplier to two of the biggest auto makers in the world. What qualifications are required for your company to get on an automaker's accredited vendor's list?***

Tan: Each of these tier 1s has its own list of parameters. The consistent one is always quality, of course, and then on-time delivery, and then the last part would be a very cost-competitive pricing model. And you should be able to scale with the company, which means you have to have the financial wherewithal to be able to back the projects that these car companies are getting into.

To us, these are our advantages, and the clear barriers that IMI has already evolved to, that right now, Bosch has already accepted the fact that we're one of the very few EMS companies in the world that can actually produce products to the level that a company like Bosch would produce.

Las Marias: ***Are lead-free parts a problem? If yes, please explain.***

Tan: It was. We're one of the pioneers of producing lead-free products in the automotive space; now it's becoming to be a requirement, and we're well ahead of it. But building a lead-free product doesn't mean just taking out lead in your material phase; it's being able to re-profile your entire manufacturing flow—from your ovens to your mounters to your soldering and everything else—to make sure that you still meet the reliability requirements of being in the car, but at the same time make it less hazardous in terms of material by making it lead free.

Las Marias: ***What do you see as the biggest driver of automotive electronics innovation?***

Tan: Safety is always the number one. People, this has been documented, regardless of stature, of social hierarchy, regardless of price of vehicle that they are buying, their number one concern is safety.

Las Marias: ***Please talk about ADAS.***

Tan: Automated driver assistance system (ADAS) is a system whereby the car would be able to supplement the driver and help provide a safety level beyond the driver's ability to react. So this is the system itself. To be able to do this is not just a static system; it's a dynamic system that integrates all the key functions of the vehicle and allowing the vehicle to react on its own, and to be able to react to obstacles external to its environment. And that's the reason why you need a vision system, and you need the interconnection between the vision system and all the other systems—braking, fuel, chassis—that is what ADAS is.

Las Marias: ***And IMI provides most solutions for this system?***

Tan: IMI is one of the few companies that actually have certified components that go into the ADAS.

Las Marias: ***Vision is one of the key drivers for this ADAS?***

Tan: So far, right now, it's the only technology that we know of that can allow the car to sense what is going to happen around its surroundings.

Las Marias: Is that the reason why you have been adding manufacturing lines for automotive cameras?

Tan: Yes, because what started off as an option for high-end cars is now becoming to be a standard safety device in all cars. And that's when the volumes kick in.

Las Marias: What is your outlook for the automotive electronics industry?

Tan: Very bullish—I still think that the percentage of the value of the vehicle that is going to become the automotive electronics base is going to happen.

Las Marias: Definitely there is always room for improvement when it comes to electronics manufacturing and assembly. From your perspective, how could the assembly process be improved?

Tan: The automation itself is going to be a very key component of that. Companies that are able to then not only use automation, but actually build cost-effective solutions in their own factories will be clearly at an advantage, and that's where we have put in our engineering resources in.

Las Marias: What can you say about the electronics manufacturing landscape in the Philippines?

Tan: In terms of productivity, it still has one of the highest productivity indexes among all the different manufacturing sites we have globally. So that's a good point. The logistics and supply chain needs to be improved; that's something that not only IMI has to deal with, but as a country we'll have to deal with in order to expand our electronics manufacturing segment.

That's the challenge that I have in the Philippines. Advantages: we have a very diverse workforce; they are young, literate and educated, and English speaking. So there are some levels of advantages that we can bring to offset some of the issues that we have as far as the country is concerned. Overall, I am still very bullish on the Philippine electronics manufacturing—not just electronics, but manufacturing in general—to find the Philippines as a plausible haven for what companies can do in the future.

Las Marias: What are the opportunities for growth here?

Tan: It's still very good. Especially now that the Philippines has finally got into the radar screen as a possible location hub for manufacturing in order to serve the ASEAN market. I am very bullish about that part.

Las Marias: You mentioned ASEAN. Come the end of 2015, we will be having the ASEAN economic integration (AEC). How does that work for the company?

Tan: It works very well for us. I see it more of an opportunity rather than a problem, because for one, I am already integrated globally, so we are not one of those that are domestically-centric, and worried about everybody coming here. I am already out there with everybody, and them coming here would just be fine.

Las Marias: One of the things that are helping manufacturers cope up with the high rate of change is by automating processes in their manufacturing lines. From your perspective, which processes in the electronics manufacturing can easily be automated?

Tan: Anything that requires such high levels of repetition and precision is a candidate for automation. So the moment that there is a small batch, or quite a bit of adjustments and judgment and all of these that have to be done on a product, this doesn't lend itself well to the automation. So what I see is that the evolution is going to be a very hybrid model, where certain parts of the manufacturing flow would be automated, and certain parts would still require highly skilled workers—and this is where the advantage comes from because in the Philippines, we have built up a workforce that's highly skilled.

Las Marias: ***What about the risks and challenges when a decision has been finalized to automate certain assembly processes?***

Tan: The risks are always the changes: They could be policy changes, market changes, or they could be design changes, and so on. The way to hedge that is the amount of preparation and engineering you do ahead; if you have a very robust new product introduction system, you will be able to alleviate those risks.

Las Marias: ***From a production standpoint, how does automation benefit the company?***

Tan: One, it gives you the quality level that you are shooting for, and two, it provides the productivity that you have anticipated for that particular standpoint. Those are easily the clear benefits that you can have. It's not because you take out labor, it's just that you are now able to redeploy the talent that you have to more creative and innovative things. Because the machines can never innovate; only people can. Therefore I still need that core group of people to innovate the system, the whole manufacturing flow.

Las Marias: ***Could you give your comments on Industry 4.0?***

Tan: I think this enables making the right decision at the right time, because clearly by being able to do a lot more data analysis, optimization can then occur. If you are able to monitor a lot more steps than just the beginning, you can optimize those individual steps. That's where the Internet of Things, the monitoring, and the automation comes in.

Las Marias: ***What is your long term outlook for the EMS industry?***

Tan: It's going to transition. There are going to be some consolidation necessary. A group of people will be concentrating on the consumer side; another group will be concentrating on the highly reliable niche automotive and industrial and non-consumer applications. Because inevitably, the skill set, the systems, the mindset in order to produce one from the other cannot overlap. And so I see that there's going to be a bipolar distribution of EMS players: those that are going to go after scale, and those that are going to go after quality. We have decided that we are in the quality side.

Las Marias: ***How do you see the EMS industry changing over the next three to five years?***

Tan: The industry is changing. In the past, they [customers] say "This is my product, I build everything in it." And then you saw the transition; although they own the entire product, they already outsource pieces of it. I think what's going to happen is that the consolidation of the systems will happen, and then the partners of choice will now have a larger percentage of that piece, out of the entire car, or out of the entire appliance, or out of the entire computing structure.

Las Marias: ***Do you have any final comments?***

Tan: In spite of the volatility in the global market, I think the trends are very clear, and that the continued expectation that the market is going to grow, driven by the growth in the consumption in Asia in general, is going to happen.

Las Marias: ***Great, thank you very much, Arthur.***

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

DoD's First Pass at Grey Market Regulation

by Stephan Halper
SECURE COMPONENTS INC.

More Vendors, More Problems

The government acquisition process is a complex one. It is not set up to be nimble, nor is it structured to keep pace with the commercial sector, of which the majority of grey market material is supplied by. The U.S. government gets a great deal of heat for many things, including fostering the introduction of counterfeit components into the supply chain, but when you really study how their procurement process is setup, when you break down the layers, it's not hard to see how a counterfeit component or suspect material can find its way in. Think about it this way: AVL management is often considered the first line of defense in protecting the supply chain. Now consider how vast and far reaching the government's AVL is, and it's easy to see how what passes as quality control can vary from agency to agency.

Over One Million Counterfeit Semiconductor Devices in DoD Supply Chain

The reliance of DoD's supply chain on the global grey market as it pertains to lifecycle management for semiconductor devices can be traced back to the Perry Memo written in 1994 by Secretary of Defense William J. Perry. The release of the Perry Memo increased the procurement of commercial items (COTS) and systems, in addition to an increase in the use of commercial practices and specifications. The rapid change in key technology sectors and the military's new-found dependence on COTS items have had an adverse effect on the supply chain, influencing the decisions of the PEOs and PMs responsible for the acquisition of components and equipment in the sustainment phase of a weapon system.

Additionally, the burden is also felt by the OEMs and Integrators in the construction phase of a weapon system. For example, it is not uncommon to have a fleet of subs or surface ships constructed by the same prime contractor to have different components installed in the same control panel in ship 1 compared to that of ship 2, manufactured just one year later. The control panel design did not change, but the electronic components used in the design of ship 1 may have become obsolete in the building of ship 2, leading to the possibility of the semiconductor in ship 2 to be superior to that in ship 1. Circling back to the sustainment responsibilities for ship 1 and ship 2, the sustainment team is faced with different parts used for the same ap-

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EVENT SCHEDULE

Tuesday, October 13 – Wednesday, October 14

Exhibition, Panel Discussion and Technical Presentations on 3D, WLP and MEMS

Thursday, October 15

Professional Tutorials

- **T1:** Introduction to Fan-Out Wafer-Level Packaging
- **T2:** 3D IC Integration and 3D IC Packaging
- **T3:** Adhesion Science & Practice with an Emphasis on Temporary Bonding of Electronics (Wafers, Displays, Devices)
- **T4:** Wafer-Level Packaging for MEMS and Microsystems Technologies for Size and Cost Reductions

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CONFERENCE SPECIAL EVENTS

Tuesday, October 13

Keynote Breakfast Address
High Density Fan-Out: Evolution or Revolution

Rama Alapati, *GLOBALFOUNDRIES*

Panel Discussion
Fan-Out WLP Panel Processing: Will it happen and What will it be?
Moderator: Jan Vardaman, *TechSearch International*

Exhibitor Reception
Join us in the Bayshore Ballroom for the Exhibitor Reception where over 60 exhibitors will showcase the latest products and technologies offered by leading companies in the semiconductor packaging industry. This evening reception offers attendees numerous opportunities for networking and discussion with colleagues.

Wednesday, October 14

Keynote Address
2.5D/3D IC – Examining Low Cost Alternatives

Sitaram Arkalgud, Ph.D., *Invensas Corporation*

Panel Discussion
Interposers, 3D TSVs and Alternatives: What are the Options and Where do They Fit?

Moderator: Françoise von Trapp, *3DInCites*

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plication. The program manager responsible for generating a DMSMS plan in order to support the weapon systems is always looking for ways to increase readiness, assure reliability, and do it at lower cost. The grey market has been used as source for DMSMS issues in the past, and its use continues today. For many years, the grey market was sold by the actors in the market as a place where excess inventory could be had for pennies on the dollar. This is attractive to PEOs and PMs who were looking for solutions that allowed their project to be delivered on-time and under budget. The grey market was, and still is today, and will be going forward, a market for which the government directly supplies product through DRMO sales by DLA depots. However, the grey market and those entities that supply product from this market are now looked at as the greatest threat to the supply chain. This notion became fact when the NDAA 2012 mandated the implementation of Section 818, based on the findings of the 2012 Senate Armed Services Committee, which disclosed that there were over 1 million counterfeit Semiconductor devices are in DoD's supply chain.

> "The grey market was, and still is today, and will be going forward, a market for which the government directly supplies product through DRMO sales by DLA depots."

Regulation

The Senate Armed Services Committee inquiry into "Counterfeit Electronic Parts in the DoD Supply Chain," and the development of Section 818 in NDAA FY 2012, spurred the development of DFARS Case 2012-D055, which became Fed. Reg. 26092 on May 6, 2014. This regulation gave credence that the grey market supply chain had grown into a global supply chain that was no longer to be considered an ally, but rather a threat. China was identified as a major contributor to the counterfeit electronic components discovered in the DoD supply chain.

The release of the final DFARS are clear in the fact that the twelve system criteria of Section 818 is specifically limited to "covered contractors" and states that the initial implementation of the rules "has limited application at the prime contract level to CAS-covered contractors." The reality of the situation is that the flow down requirement causes the rule to affect all subs in the supply chain, which includes small business. Considering that CAS does not apply to small business, set-asides for small business are not held to the fiscal reliability and liability a CAS faces should an escape occur. 79 Fed. Reg. 26105 states, "This rule (Section 818) does not apply to small entities as prime contractors." So while this limits the application of the DFARS when DoD purchases from a small business, it does not affect the flow down of Section 818 criteria from covered contractors.

Yet, at the end of the day, all levels of the supply chain have the potential to introduce a counterfeit or suspect-counterfeit electronic item used in the end items manufactured by CAS contractors and then integrated into a weapon system. Therefore, small business entities that want to do work with CAS covered contracts must accept the flow downs, and have procedures in place to flow them down to their vendors. In addition, small business must have the means for which to detect counterfeit components in order to prevent their introduction into the supply chain, as it stands, this includes embedded software or firmware.

DoD/DLA

DFARS Case 2012-D055 Detection and Avoidance of Counterfeit Electronic Parts 79 Fed. Reg. 26092—Final Ruling released May 6, 2014:

- Good intentions lead to more confusion and mixed results

1. The release of the DFARS confirms that the responsibility of the enforcement of the regulations called out in Section 818

are limited to covered contractors.

2. The final rule also excludes small business when stating, "This rule does not apply to small entities as prime contractors."
3. However, small business is not excluded as the flow down requirements enforce the DFARS regulations are implemented at all levels of the supply chain. Fed. Reg.26099 defines, accurately, that all levels of the supply chain have the potential to introduce counterfeit or suspect-counterfeit electronic components.
4. It should be noted that as currently written, Section 818 does not cover cyber-physical or cyber regulation.

DLA Generates the Qualified Testing Supplies List (QTSL) and DNA Marking:

- Establishment of pre-qualified distributors for FSC codes 5961 (semiconductors) and 5962 (microcircuits) managed by DLA Land & Maritime.
- Pre-qualified distributors must undergo a site audit of their facility before being added to the QTSL.
- QTSL requirements are similar to the requirements called out in AS6081, and call for the distributor to have a counterfeit avoidance policy (CAP) in place, and be able to prove that they follow the protocols laid out in their CAP for parts procured from the secondary/grey market.
- Parts that pass the testing requirements per the QTSL process and procedures are then DNA marked, for purposes of establishing a chain of custody with the parts.
- DNA marking is a requirement for parts supplied through the previous established QSLD "Qualified Suppliers List of Distributors".
- Initially the DNA marking is performed by an approved third-party marker.
- Dec 2014—DLA Land & Maritime requires that all 5962 parts be marked at DLA Land and Maritime per the DLA Counterfeit Detection and Avoidance Program (CDAP).
- Apr 2015—CDAP documentation provided by distributor is amended to include "documentation of traceability or a test report prior to the shipment of parts to DLA L&M, and prohibits the contractor from shipping material until they have received written authorization from the contract administrator."
- New CDAP requirements cover material being supplied to DLA either through the QTSL program or QSLD program.

Now for the Hard Part: Implementation

So now that mandates have been issues, and regulations have been set, how has the DoD supply chain benefited from these new rules? What gaps have been created, and how has industry responded to the mandates to make the supply chain safer? This will be the topic of my next column, where I will give some first-person experience, and the importance of high-reliability supply chain professionals can begin implementing some of DoD's and Industry's best practices. **SMT**

References

1. Federal Acquisition Streamlining Act (FASA), enacted in 1994, brought the use of COTS into law.

2. SASC 2012.

3. 79 Fed. Reg. 26098.

4. 79 Fed. Reg. 26105

5. QSLD program was developed prior to the QTSL program. Per QSLD—5961/5962 D March, 2014, "The QSLD purpose of the QSLD program is to establish and maintain a list of pre-qualified sources for certain electronic components that are purchased and managed by DLA Land and Maritime. QSLD products are provided by suppliers and distributors that combine accepted commercial practices and quality assurance procedures that are consistent with industry and international quality standards, which are tailored when necessary to product-unique requirements.

6. landandmaritime.dla.mil/programs/CDAP/

Stephan Halper is the COO and principal of Secure Components. To contact the author, click here.

Automotive Electronics Driving Innovations in Test

by Stephen Las Marias
I-CONNECT007

Boon Khim Tan is the general manager of the Measurement Systems Division at Keysight Technologies Inc., which is responsible for the board test and functional test systems covering the networking computing, automotive, industrial, and consumer electronics markets. In an interview with I-Connect007's Stephen Las Marias, Tan discusses the test requirements in the automotive electronics space and the latest trends driving innovation in the sector.

Stephen Las Marias: From your perspective, how has the automotive electronics industry evolved over the past decade, and what major changes or trends have you witnessed?

Tan: The biggest change happening in the automotive electronics industry now is the increasing amount of electronic content in each automobile. For example, features such as air bags, electronic stability control and remote keyless entry, which used to be only found in luxury cars, are now making their way into entry-level models. The trends are driven by three major factors: Firstly, the move towards improving vehicle fuel efficiency and emissions, which is driven by increasingly strict regulations globally, with the aim to reduce air pollution. This is leading to the development of increasingly efficient and intelligent engine control units (ECUs) as well as hybrid electric and electric vehicles (HEVs/EVs). Secondly, the improvements to vehicular safety and reduction in the rate of accidents, which are now leading to development of driver assistance features such as collision avoidance radars and vision systems, and also the investigation into semi-autonomous and fully autonomous vehicles. Thirdly, the need for competitive differentiation among automotive makers and convenience for the users. This is leading to addition of features such as infotainment systems with navigation and remote keyless entry.

Las Marias: What are their impacts for test and measurement companies?

Tan: Test and measurement companies such as Keysight need to continuously develop test solutions that are able to meet the rapidly evolving needs of the automotive companies when it comes to testing of electronic systems. Such needs include testing of new technologies in cars such as LTE and mm-wave radar systems—lowering the cost of test, which will help in lowering the cost of parts so that automotive makers can add these parts into entry-

IPC 2015 Programs

September 9–11
IPC India Pavilion at electronica India / productronica India 2015
New Delhi, India

September 15–17
PCB West
Santa Clara, CA, USA

September 26–October 1
IPC Fall Standards Development Committee Meetings
Rosemont, IL, USA
Co-located with SMTA International

September 28
IPC EMS Management Meeting
Rosemont, IL, USA

October 13
IPC Conference on Government Regulation
Essen, Germany
Discussion with international experts on regulatory issues

October 13–15
IPC Europe Forum: Innovation for Reliability
Essen, Germany
Practical applications for meeting reliability challenges like tin whiskers, with special focus on military aerospace and automotive sectors

October 26–27
IPC Technical Education
Minneapolis, MN, USA
Professional development courses for engineering staff and managers:
- DFX-Design For Excellence (DFM, DFA, DFR and more)
- Best Practices in Assembly
- Advanced PCB Troubleshooting
- SMT Problem Solving

October 28–30
IPC Flexible Circuits-HDI Conference
Minneapolis, MN, USA
Presentations will address Flex and HDI challenges in methodology, materials, and technology.

November 2–6
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November 4
PCB Carolina 2015
Raleigh, NC, USA

November 10–13
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Munich, Germany

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- Advanced PCB Troubleshooting
- SMT Problem Solving

December 2–4
International Printed Circuit and APEX South China Fair (HKPCA & IPC Show)
Shenzhen, China

December 7–11
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San Jose, CA, USA

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level models, not just into luxury cars—and speed and flexibility in deployment of test systems so as to allow customers to reuse their assets and quickly ramp up manufacturing test to meet external demand.

Additionally, there is a need for standardization of manufacturing test systems and global support since the same parts can be made in multiple locations globally, and to have a consistent process to ensure quality and reliability.

Las Marias:* *Among the many challenges today for automotive electronics manufacturers is to build reliable electronic products with increasing density, complexity and sophistication, while at the same time meeting the many automotive regulatory requirements and optimizing their investments in the choice of equipment and their feature sets. How does Keysight Technologies help your customers achieve this?

Tan: We bring 75 years of measurement expertise from our roots as Hewlett Packard, expertise and insight to automotive electronic trends, and collaboration with key market makers to help customers design and build reliable products.

The challenges facing customers as they embark on new technology areas like adaptive safety include 77–80 GHz radar development, where Keysight has deep expertise in spectrum analysis and radar simulation driven by our links to aerospace markets. In other areas, like building of high-density PCBAs in modern engine control units, Keysight-developed technologies like bead probes, high-current load switching and boundary scan can be deployed and customized for automotive applications.

Many of the automotive electronics manufacturers operate globally and we are able to leverage our global footprint to ensure customers gets the same level of strong support in any of their manufacturing sites worldwide, and we help them optimize their cost of test by providing them with standardized solutions with long lifecycles.

Boon Khim Tan, general manager, Measurement Systems Division at Keysight Technologies Inc.

Las Marias:* *The blurring lines between consumer and automotive electronics are increasingly putting manufacturers under pressure to shorten product lifecycles, drive innovation, and keep costs in check. How do you help automotive electronics companies address this challenge?

Tan: As a global test and measurement company with footprints in many industries, we have product portfolios that target different needs with different price points and value propositions. We partner with automotive electronics companies during their development cycles to understand their needs and schedules, and along with our expertise leveraged from consumer electronics industries, we are able to recommend and help drive test solutions that help them meet their goals.

Keysight has developed some of the industry's most versatile and powerful PXI-based modules that are specifically targeted at the automotive industry. For instance, our M9216A high-voltage data acquisition module allows simultaneous measurement of eight channels of positive voltages ranging from 1mV to 100V. Each channel comes with a concurrent 5V and 100V measurement ranges, with every channel capable of acquiring very low and very high voltages without the need for switching ranges.

Another solution is our new M9188A, a PXI-based, 16-channel single-slot unipolar dynamic digital/analog converter. Capable of supplying typical waveforms of up to +30V, it eliminates the need for engineers to design and develop signal conditioning circuits for applications requiring up to +30V—that's a huge saving in terms of test system application development and setup time.

***Las Marias:** From your perspective as a T&M equipment provider, what are some of your toughest challenges when it comes to providing solutions targeted at automotive electronics?*

Tan: One of the toughest challenges is being able to continuously drive cost of test lower, without compromising on the quality, reliability and coverage of the test. We are able to do this through close partnership with the automotive electronics companies, understanding exactly their test needs and developing solutions that are a right fit for them.

For example, customers testing smaller, less complex devices can make use of our TS-8989 PXI Functional Test System, a switch and load system in a box that supports up to 104 test nodes and current loads of up to 40A. We designed it to be the ideal minimalistic one box solution for the automotive industry, providing the best "Enough Test" while at the same time-saving invaluable rack and floor space.

Customers who need more test capacity can rely on our TS-5400 PXI Series, which supports up to 464 test nodes. It provides automotive manufacturers with an off-the-shelf PXI hardware and software platform with flexibility to support single or multiple DUT tests. Designed for testing electronics control modules such as power train control, complex body electronics and industrial controllers, the TS-5400 PXI Series helps manufacturers achieve higher throughput for their design validation and manufacturing functional test needs with the capacity to empower them to anticipate future functional test needs.

***Las Marias:** How do you address the increasingly strict regulatory requirements in automotive electronics manufacturing?*

Tan: Regulatory requirements differ in each region, worldwide; we have a global team that is tightly connected to the needs of each region, and to each other, so that we are able to comply to the needs of each region and to customer needs as well.

We work closely with our customers to understand how critical the accuracy and repeatability of test results are to them in supporting their strict requirements. From a measurement perspective, Keysight is a leader when it comes to measurement calibration, our adherence to ISO 17025 and military Z540 standards has long been known in the industry. This coupled with our culture of quality, where we assist customers through thorough root cause analysis and investigations to understand where the failure in the measurement and test equipment are, and to identify if this has any impact to their products.

***Las Marias:** What is your outlook for the automotive electronics industry?*

Tan: The next three to five years will continue to see positive growth for the global automotive electronics market. Market analysts are citing consolidated average growth rates of more than 6%. We can expect to see growth for test and measurement equipment market trending similarly. This will be driven on the back of demands for better tests with faster speed and wider coverage to handle increasingly sophisticated ECUs for powertrain and body electronics. Beyond physical numbers, I think growth will be fueled by demands for advanced safety systems which form the building blocks of autonomous driving.

***Las Marias:** Thank you for speaking with me today.*

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

Benefits of Paralyne Conformal Coatings in Automotive Applications

by Sean Horn
DIAMOND MT

Conformal coatings are protective substrate coverings applied to circuit board technology, moving parts of strategically located components, or similar electro-mechanical assemblies; they are composed of selected chemicals or polymer films. Acrylic, epoxy, paralyne (poly-paraxylene), silicone and urethane are the major substances comprising most conformal coating used today. Although each has different properties and applications, the coatings they provide are generally between 25–75 µm thick, with coverage that accurately conforms to the contours of the substrate.

All conformal coatings exhibit some degree of physical flexibility, and protection against mechanical and thermal shock, while securing the component from exposure to corrosive elements. The substances acrylic, epoxy, silicone and urethane benefit from simple application—by dipping, flow-coating or spraying the material to the selected substrate—and relatively easy removal, repair and replacement, if necessary. In contrast, paralyne requires a specialized vapor deposition process, which is slower to enact and more costly. However, because the vapor deposition process causes the paralyne to penetrate far more completely into the substrate surface, it produces the highest levels of protection available for many automotive purposes.

Selection of coating type depends upon its function and degree of need for surface protection.

Expanded Automotive Use of Conformal Coatings

Electrically insulating, conformal coatings maintain levels of long-term surface insulation resistance (SIR) appropriate to the optimal function of the protected system. Thus, electronic circuits and operational equipment receive protection sufficiently reliable to ensure their operational integrity despite the situation within an engine, generating harsh environments that may contain moisture, humidity, electric current, chemical contaminants, or a mixture of them.

These features are particularly necessary where the protected equipment is expected to operate at high levels of reliability under conditions exemplified by persistent mechanical vibration in the presence of various combinations of aggressive chemicals, harsh liquids and vapors. For automotive purposes, the security generated by conformal coatings simultaneously protects the products and systems within the engine, while adding to the functional performance, better assuring the vehicle operates as intended.

Work where you live! The I-Connect007 team is seeking an experienced sales person to generate and manage a revenue stream for content marketing campaigns in new e-publication series and supporting online ad campaigns within our online directories and publications.

Key Responsibilities include:

- Selling sponsorships for e-publications & supporting ad campaigns
- Developing and cultivating new business
- Accurate and timely record keeping
- Following up on all leads
- Managing contract renewals
- Phone and email communications with prospects
- Occasional travel to key industry events
- Team collaboration
- Working independently in a virtual environment

Qualifications:

Successful candidates will have experience with managing and cultivating leads, projecting, tracking and reporting revenue. We are looking for positive, high-energy candidates who works well in a self-managed, team-based, virtual environment.

Requirements:

- Follow established systems and learn easily
- Maintain professional external and internal relationships reflecting the company's core values
- Establish and maintain effective working team relationships with all other departments
- 2-5 years sales experience
- Experience with Excel, Word, and able to proficiently navigate the internet
- Highly motivated and target driven with a proven track record for sales/meeting quotas
- Excellent selling, communication and negotiation skills
- Prioritizing, time management and organizational skills
- Create and deliver proposals tailored to the prospect's needs (strong writing skills mandatory!)
- Relationship management skills and openness to feedback
- Experience in the electronics industry desirable

Successful candidates should possess a BS/BA degree or equivalent and have experience with systems-based management/TQM philosophy. This is a base salary-plus-commission position. Compensation commensurate with experience.

Qualified candidates should submit resumes here.

I-Connect007
GOOD FOR THE INDUSTRY

Automotive systems have been subjected to increasing computerization, applied to virtually all of the vehicle's operational technology. Electronic sensors throughout the engine control the signal processing required to connect systems' functions for such essential vehicular systems such as:

- analytical performance measurement of automotive systems' functioning
- anti-lock brakes control
- emissions' management
- engine control unit (ECU)
- instrument pods' circuitry (IPC)
- power controls/modules for doors, mirrors, seats, sunroof, and windows
- power train/chassis operations
- passenger comfort/convenience
- tire-pressure gaskets/seals

Many additional uses of automotive electronics currently exist, and their uses will grow more numerous in the future. Since these assemblies are increasingly situated in demanding end-use environments, selection of appropriate conformal coatings for automotive applications is essential to assure efficient performance. Coatings protect circuits and sensors from aggressive automotive environments containing fluctuating mixtures of brake/transmission fluid, ethylene, engine humidity, noxious exhaust gases, fuel/oil, salt-spray, or other substances that add to the risk of degradation in performance.

Selecting the Conformal Coating Best-suited to Automotive Applications

While several choices of conformal coating materials exist for auto applications, understanding the specified end use is essential to making the appropriate selection. In the case of automotive electronics, exceptionally high-performance conformal coatings are necessary to provide adequate operational safeguards against condensation, corrosive liquids, high temperatures, humidity, and water spray. While enacting effective masking material solutions to ensure cost effectiveness with easy application and removal is a desirable objective, more expensive solutions may be necessary to generate the protection and functionality required to sustain the vehicle's systems and operation.

Thus, care must be made in selecting the coating material most appropriate to the job.

Acrylic, Epoxy, and Urethane

Fast drying acrylic conformal coatings have many product uses. Highly dielectric, acrylic conformal coatings work generally well in limited high moisture environments. They can adequately protect many types of electric circuit assemblies against moisture, dirt, dust, thermal shocks, or similar conditions that might corrode, short circuit, or otherwise damage the electric component. Acrylic is also highly flexible and provides insulation against high-voltage arcing and static discharges.

However, despite these advantages for many product uses, acrylic conformal coatings are not recommended for most automotive applications. While acrylics provide good moisture and thermal resistance in many operational environments, they are poorly suited for extensive use within the high temperatures common to automotive applications and they don't respond well to exposure to higher temperature, corrosive moisture, chemicals or petroleum residues.

Similarly, both epoxy and urethane are useful conformal coatings for many products. Epoxy possesses excellent chemical and abrasion resistance—its coatings are generally very durable, and resist the effects of moisture and solvents exceptionally well. However, epoxy conformal coatings can cause stress on components during thermal extremes. In contrast, urethane generates far greater chemical resistance than acrylic coatings, and dependable humidity resistance, as well. Although highly resistant to solvents, urethane's automotive uses are nevertheless limited by its properties.

In this respect, evidence has shown that acrylic and epoxy conformal coatings exhibit transition temperatures between 10–20°C, inducing further and excessive surface stresses during usages. Performance of automotive electronics conformally coated with these materials is frequently compromised.

Furthermore, acrylic, epoxy and polyurethane conformal coatings have a Tg of about 40–90°C. These levels are insufficient for prolonged automotive purposes, as they tend to stimulate additional undue stress during operation, generating poor performance and failure when thickness of the coating material is not carefully managed. Despite their reputation, these coatings also are moderately hygroscopic, displaying a marked tendency for moisture penetration and retention (between 0.3–1.0% of moisture left in the material). In these circumstances, they are particularly susceptible to wet weather conditions, winter road-salt, and the intrusion of corrosive industrial liquids or gases typical of automotive engines active in heavy traffic environments.

Silicone

Silicone is a better choice for automotive conformal coating. With a usable operating temperature range between -55°C to +200°C, silicone possesses the capacity to withstand prolonged exposure to higher temperatures than most other available conformal coatings. Thus, it has sufficient resistance for high humidity auto-engine environments.

At the same time, silicone also displays a very low contact angle when exposed to water and thus is very hydrophobic. Because it displays 10–20 times higher moisture permeability than acrylic, epoxy or urethane conformal coating, it cannot prevent printed circuit boards (PCBs) or other electronic components from retaining excess moisture and water. This eventuality potentially leads to corrosion and metallization of the component.

In all cases, the method of coating application represents an important consideration when factoring its use as an automotive coating. For instance, a silicone coating that has been UV-cured may lack sufficient utility for high-profile, consistently active automotive electronic components. If shadowing occurs during the application process, some of the coating may be left uncured, a factor that will necessarily compromises the reliability of the assembly.

"If shadowing occurs during the application process, some of the coating may be left uncured, a factor that will necessarily compromise the reliability of the assembly."

Paralyne's Uses as Automotive Conformal Coating

Paralyne conformal coatings, one example of which is paralyne, provide dependable protection for electrical contacts, PCBs, battery terminals and all variety of automotive electronics. In this respect, paralyne also generates stress-free protection against moisture penetration, corrosive elements, winter road-salts, water immersion, and changes in temperature.

More than this, paralyne's vapor deposition process allows for both deep penetration of the substrate and the thinnest possible effective layers of pinhole-free conformal coating, supporting its use in even the most spatially-confined segments of any automotive engine.

Parylene, in particular, offers exceptional qualities as a conformal coating for the automotive digital sensors frequently used under conditions of duress, and often at risk for diminished performance or product failure. Parylene generates chemical, dielectric, moisture and thermal protection that far surpass competitive coatings for automotive purposes. It is the conformal coating of choice for the following automotive applications:

Automotive Microelectricalmechanical Systems (MEMS)

Uniting signal processing and communication functions, MEMS automotive sensors are instrumental in the function of such electronic vehicular systems as:

- manifold air pressure (MAP)
- manifold air temperature (MAT)
- power train/chassis control
- provision and maintenance of passenger comfort/convenience

It is not unusual for automotive MEMS applications to be situated in areas of high performance activity and stress. Protection from prevailing environmental factors—caused by the combined and often overlapping presence of brake/transmission fluid, corrosive liquids, or gases like ethylene glycol, freon, gasoline, or oil, engine humidity, fluctuations in temperature, or similar conditions (either predictable or unexpected)—is necessary. Individually or in tandem, these conditions may generate product degradation or system malfunction. Products conformally coated by paralyne are far better equipped to successfully surmount these conditions and assure dependable function and performance. However, as described above, the appropriate coating material must be used to assure best-practice protection of MEMS' parts and functionality.

Of conformal coatings, paralyne best safeguards micro-machined circuits from the potentially deleterious effects of aggressive automotive environments. Maintaining the function of sensors and other engine assemblies through these often abrupt changes in engine conditions requires their dependable and ongoing protection, best generated by paralyne. To a lesser extent, silicone is also appropriate for some MEMS functions.

Automotive Ruggedization

Created for dependable use under extreme conditions, ruggedized automotive systems are required to function through extreme temperatures and high levels of vibration. Ruggedized automotive parts include motion controllers, a range of detection switches, door switches, limit/safety switches, tactile switches and rocker switches, among other components. These are parts and assemblies whose constant use and placement in the automobile necessitate extended protection.

Because paralyne generates superior resistance to shock, heavy vibrations, and internal disruption within the engine, it is applicable for specialized, highly refined purposes, where sensors and components need to be appropriately insulated. Its other capabilities include:

- Withstanding the impact of the effects on efficient functioning of dirt, hazardous chemicals, heat, moisture and a variety of additional potential contaminants
- Exceptional dielectric strength
- Reliable physical/mechanical properties
- Sufficient environmental protection during operation to minimize degradation of performance factors usually caused by humidity within the unit, or contamination from debris or other sources

Other Automotive Products Benefiting from Paralyne Conformal Coating

Automotive sensors, controls, and polymer/elastomer seals are normally confronted by harsh operating conditions. Dependable performance, even ruggedization of components, results in functional upgrades and enhanced operational efficiencies. Paralyne conformal coatings significantly diminish the likelihood of malfunction or breakdown in automotive environments characterized by changing thermal conditions and exposure to a variety of potentially corrosive engine liquids. They also provide superb component protection for automotive computers.

They are especially valuable protecting components for high-mileage vehicles requiring reliable GPS communications; voice/data communications (Wi-Fi/Bluetooth); and vehicle telemetry also benefit from automotive conformal coating. Rapidly evolving products for automotive information technology (IT), electrical systems, engine components and sensors increasingly depend on parylene and silicone coatings to assure ongoing performance through all conditions. In addition, automotive LED lights, essential to safe driving, benefit from conformal coating protection, which extend the functional life of the LED light itself, while enhancing its performance.

Conclusion

Automotive conformal coatings are fundamental to sustaining robust engine performance. Further improvement of the capabilities of conformal coatings is expected in the future, with the resolution of present developmental/manufacturing issues. A wider range of smart assemblies, components and sensors will add to the performance of current automotive systems.

Although some of these applications already exist, evolution of such enhanced systems as accelerometers for airbag deployment, angular rate sensors, and communication devices that connect the vehicle to the outside world will rely on new conformal coatings safeguarding the operation of an enhanced digital automobile. For instance, improved MEMS technology is expected to soon become commonplace for many more automotive functions.

Popular conformal coatings such as those provided by acrylic or epoxy are less suited for automotive purposes—moisture can still migrate underneath the circuit board, causing such corrosive and degrading conditions as expansion of the supposedly protected area and subsequent peeling of the protective coating layer from the component. Since they are not hydrophobic, acrylic, epoxy and polyurethane conformal coatings cannot generate adequate protection for effective use within these heavy moisture environments, typical of automotive systems.

Silicone conformal coatings are more widely used in high temperature environments. This attribute has made them a primary choice for many under-hood automotive applications. Unlike acrylics and urethanes, silicones do not vaporize with the application of heat. They further exhibit the capacity of operating effectively as more thickly-layered coatings, generating reliable dampening/isolation of excessive engine vibration. This capacity helps the component function with improved efficiency in a high vibration automotive ecosystem.

At the same time, it should not be forgotten that, while hydrophobic to water, silicone conformal coatings can allow high moisture penetration far in excess of even acrylic coatings. Thus, they frequently are rather susceptible to the negative impact of moisture, and associated corrosive elements within the engine.

> “Regardless of where the protected part is situated, the objective for all conformal coatings will continue to include using environmentally compliant, low-outgassing, solvent-free materials that generate optimal protection and functionality for automotive systems.”

Paralyne coatings offer manufacturers an exceptional range of properties that support ruggedization for numerous products, providing added durability and enhanced performance. They are recommended for any products where reliable, dedicated protection is essential to the performance of electrical components and associated automotive ecosystems. For instance, PCBs and similar components benefit from parylene conformal coatings during operation. For example, parylene pinhole-free coatings conform precisely to the contours of assemblies and components, while improving component protection and performance.

Regardless of where the protected part is situated, the objective for all conformal coatings will continue to include using environmentally compliant, low-outgassing, solvent-free materials that generate optimal protection and functionality for automotive systems.

Coatings' value is safeguarding systems' efficient operation under conditions of duress that might otherwise engender diminished performance or product failure. Continual development and refinement of the capabilities of paralyne and other conformal coatings is inevitable. It should unite effectively with the ongoing evolution of automotive digital technology, as well. Doing so will improve the function and security of systems benefiting from conformal coating. **SMT**

Sean Horn is the VP and CFO at Diamond MT, a premier conformal coating services provider for key industry leaders in the electronics/MEMS, life sciences, industrial, automotive, aerospace and defense markets.

SMT QUICK TIPS

Selecting a Reflow Oven, Part 2

by Robert Voigt
DDM NOVASTAR

In this follow-up to Part 1, which focused on selecting and evaluating a basic reflow oven configuration for a circuit board assembly environment, we'll address heating technologies, methods of board transportation, and inerting systems.

Heating Technologies

Regardless of the technology used for heating boards, the primary objective is to control the thermal profile to prevent undesirable conditions, such as:

- Tombstoning: a condition that causes the component to stand up due to micro-explosions in the solder
- Delamination of the substrate (a partial separation of the layers of circuit board material, similar to blisters)
- Poor adhesion/contact: caused by over-heating and under-heating

Typically, there are three main methods used for reflow oven heating. They are:

1. Vapor phase
2. Infrared
3. Convection

Vapor Phase

Vapor phase is a simple and very reliable method of soldering. Complex components and assemblies can be done in a small process window, but this comes at a cost, so understand the process and what is involved before making a purchase decision.

Vapor phase heating is performed in a batch process using a special liquid with a very particular vaporization temperature of 240°F, ensuring that materials are never overheated and damaged. Parts are placed in a single chamber above a liquid bath, which is then heated to create a vapor at the perfect melting point of solder. The board is enveloped in the vapor to accomplish the soak and reflow over time, and the chamber temperature is reduced to condense the vapor back into the liquid bath. The parts are then removed and replaced with a new board (or set of boards).

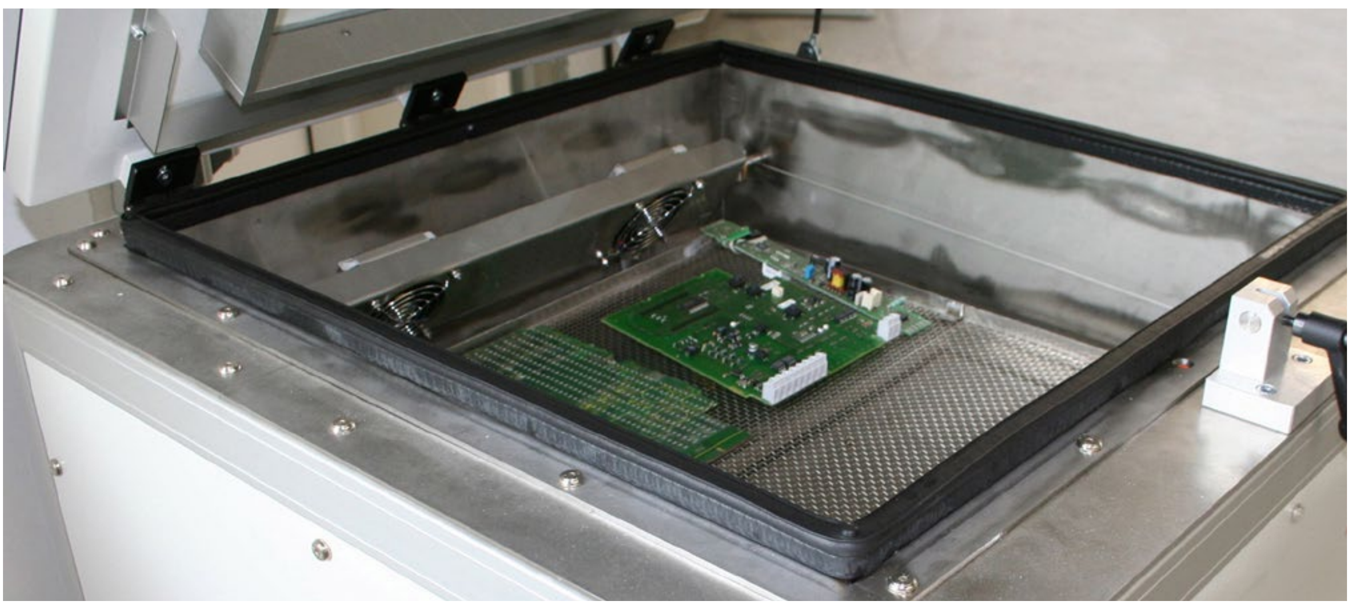

Figure 1: Vapor phase reflow oven showing board suspended above heat transfer fluid bed.

SELECTING A REFLOW OVEN, PART 2 *continues*

Galden®, a proprietary heat transfer liquid from Solvay, is the most popular material typically used in these processes, and is quite expensive, although most of the material condenses back into the bath at the end of a heating cycle, so it can last quite a while. Vapor phase is a very predictable method of heating, but because it is a very expensive system, it is more appropriate for extremely high-end precision applications such as MIL-spec electronics.

Pros: precise temperature control; eliminates the need for a profile based on product mass or size; less overall programming required since a single recipe fits all

Cons: extremely high cost, up to $100,000 versus a comparable convection oven at $15,000; material very expensive; typically batch process only with slow cycle times (10–20 min/cycle versus 4–5 minutes for convection)

Infrared (IR)

IR systems were widely used throughout the 1990s because they were relatively inexpensive to buy and operate. IR heating can be used in either batch or continuous conveyorized units. While still available for specialized applications, IR heating is affected by the color of the target components, so different colored components absorb heat at different rates and can produce different heating profiles, not entirely desirable.

Today, IR heating is often used for special applications where heat ramp rates need to go quickly with very little soak time. The direct heating technique of IR makes modulation and control very difficult. Factors that can be used to vary the heating profile include distance, speed and heat intensity. For these reasons, IR is not often used in low- to medium-volume production environments which need to accommodate a wide range of board configurations and heat profiles.

Pros: appropriate for specific applications requiring direct heating, but no longer widely used in circuit board assembly

Cons: very unforgiving heat; boards may be easily damaged by overheating, delaminating, tombstoning, etc.; heat profiles difficult to set based on material type and color; trials are usually necessary, making it impractical for short runs

Convection

Convection heating is the most widely used method for reflowing circuit boards today. In this system, air is circulated throughout one or more chambers (or zones), either vertically or horizontally, to surround the entire board assembly with even, uniform heat. Each zone in a multi-zone oven retains its own heat profile very reliably. Both the vertical and horizontal methods of heat distribution share the same end result—even heat around the boards.

A plenum heat distribution system typically directs air vertically from above and below toward the board surfaces. They often require preheating plenums to condition the air temperature before heating the board, but directing airflow from two different directions (top and bottom) allows the user to adjust heat settings independently and with good control to create a very precise profile. This type of system is usually more complicated to build and thus more expensive than a horizontal convection type.

Pros: even heat distribution; individual zone temperatures are extremely close to product board temperatures, making it easier to profile than IR; less trial and error testing needed

Cons: certain methods of air circulation may not be as effective or easy to manage as horizontal convection

In a horizontal convection chamber, heat is uniformly distributed throughout the entire chamber, resulting in even heat distribution around the board itself. The length of each zone and the conveyor speed determine the amount of time a board resides in a particular heating environment, ensuring very reliable and repeatable processing quality. As opposed to air circulation moving vertically above and below the board, in horizontal reflows the air is circulated in one direction across the top of the board, and in the opposite direction beneath the board. This is a key benefit that prevents hot spots, and allows the parallel airstream 'angle of attack' to infiltrate the spaces beneath the components.

Pros: Even heat distribution, as the top and bottom of the board receive the air from the outside to the center, which counters the com-

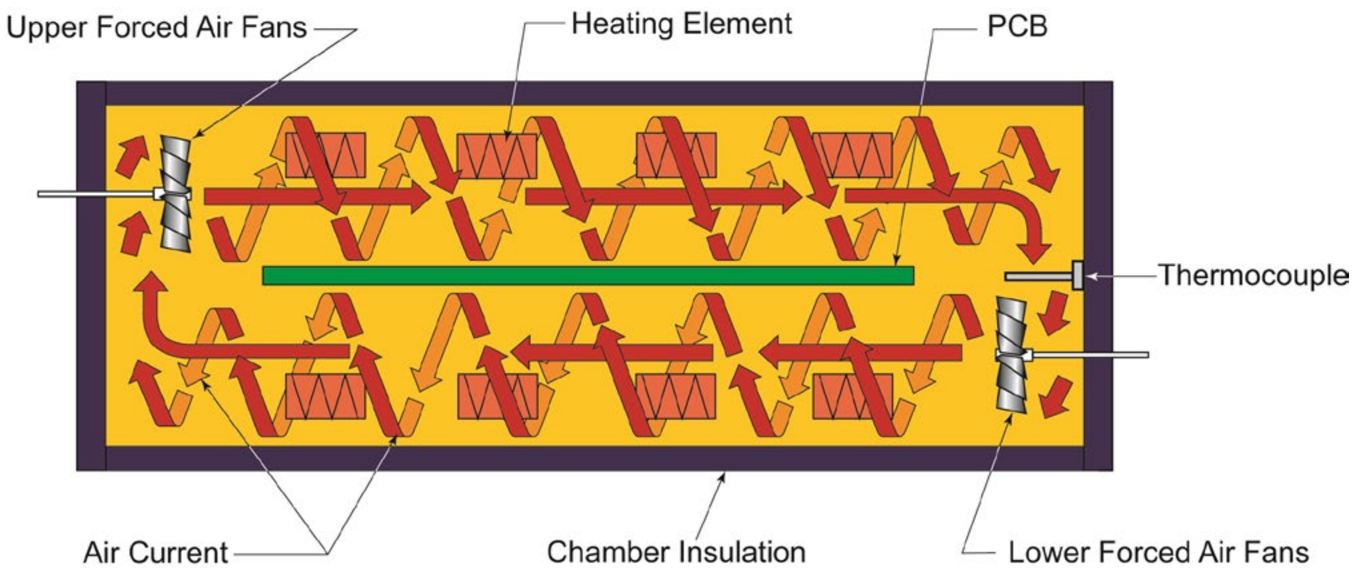

Figure 2: Airflow pattern in a horizontal convection conveyorized oven.

mon 'center hot spotting' sometimes present in traditional reflow ovens; individual zone temperatures are extremely close to product board temperatures, making it easier to profile; lower overall equipment cost, since a plenum is not required

Methods of Board Transportation

There are two common techniques used for conveying boards through a multi-zone oven:

1. Belt conveyor
2. Edge or pin conveyor

A conveyorized mesh belt, typically stainless steel or other non-corrosive alloy, is the most common method. Air is able to flow through the belt for even heating on the top and bottom of the board.

The pin or edge-type conveyor carries the board by the edges in a continuous line, allowing unobstructed airflow around the board. This method can be integrated within a modular inline system with other assembly machines.

Either method works equally well for single- or double-sided boards. Edge conveyors can add some cost that may not be necessary. For integration with other in-line systems, consult the Surface Mount Equipment Manufacturers Association (SMEMA), which writes connection standards for modular circuit board assembly integration.

Inerting Systems

If an inerting system is advised for a specific product application, nitrogen is the most common gas used for reducing or eliminating oxidation during reflow. However, in most low- to medium-volume assembly environments, inerting is typically not needed. When specified, an inerting system can add approximately 10% more to the cost of a basic reflow oven, and most manufacturers offer it.

In the next column, Reflow Ovens, Part 3, I will address the following:

1. Software and controls
2. Onboard PLC profiling
3. PC-driven profiling
4. Third-party profiling and validation
5. Power management **SMT**

Robert Voigt is VP of global sales at DDM Novastar Inc. To reach Voigt, click here.

TOP TEN

Recent Highlights from SMT007

1 Meeting High-Speed Demand with Optical Circuits

In an interview with I-Connect007's Barry Matties, Felix Betschon of vario-optics discusses the advancements in optical circuit boards, and explains the core advantage of this technology and what circuit designers must do to add optical circuits into their design disciplines.

2 Mechatronics Innovations and Applications

Edward Neff, President of SMAC Moving Coil Actuators, discusses with I-Connect007's Stephen Las Marias some of the latest mechatronics innovations happening in his company, and how these developments are being applied in different industries including electronics assembly and robotics.

3 Fairlight: An Iconic Name in Digital Audio

Fairlight Instruments became one of the biggest names in the recording industry with its digital sampling technology in 1975. Forty years later, the company is still leading with a full line of products that their technologists design, engineer in house, and produce with a network of EMS companies. Fairlight's Emilijo Mihatov shares insights and strategies for succeeding by thinking differently.

4 Pad Cratering Susceptibility Testing with Acoustic Emission

This article presents the results of pad cratering susceptibility of laminates using the acoustic emission method under four-point bend and compares the AE results to the pad-solder level testing results.

5 EMI-caused EOS Sources in Automated Equipment

Electrical overstress causes damage to sensitive components, including latent damage. A significant source of EOS is high-frequency noise in automated manufacturing equipment. This article analyses sources of such noise, how it affects components and how to mitigate this problem.

6 Localized Contamination Can Cause Big Problems

In today's electronics manufacturing environment, assemblers continue to overlook areas of localized contamination that are capable of causing product failures. This article talks about a case study involving a visible white residue and dendritic growth in a connector area, and the analysis done to determine its cause and implications.

7 Acceptance Testing Of Low-Ag Reflow Solder Alloys

The electronics industry has seen an expansion of available low-silver Pb-free alloys for wave soldering, miniwave rework, BGA and CSP solder balls, and, more recently, solder pastes for mass reflow. This article discusses test protocols that can be used for assessing new Sn-Ag-Cu, Sn-Ag, and Sn-Cu alloys for general use in electronics.

8 Flextronics is Now Flex

EMS firm Flextronics has officially changed its name to Flex, with a promise to help the world live smarter.

9 2Q 2015 Saw Six Completed EMS M&As

There were six completed mergers and acquisitions (M&As) in the EMS industry during the second quarter of the year, up from four in the previous quarter but down from nine transactions reported in the same period last year.

10 Newbury Electronics Powers Racing Yachts

Sailors in high performance racing yachts are the latest to benefit from advancements in electronics, which allow them to monitor every aspect of their vessel's performance and the prevailing conditions.

EVENTS

For the 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.

electronica India
September 9-11, 2015
New Delhi, India

productronica India
September 9-11, 2015
New Delhi, India

PCB West
September 15-17, 2015
Santa Clara, California, USA

Medical Electronics Symposium 2015
September 16-17, 2015
Portland, Oregon, USA

SMTA International 2015
September 27-October 1, 2015
Rosemont, Illinois, USA

IPC Conference on Government Regulation
October 13, 2015
Essen, Germany

IPC Europe Forum: Innovation for Reliability
October 13-15, 2015
Essen, Germany

Long Island SMTA Expo and Technical Forum
October 14, 2015
Islandia, New York

TPCA Show 2015
October 21-23, 2015
Taipei, Taiwan

2015 International Printed Circuit & APEX South China Fair
December 2-4, 2015
Shenzhen, China

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

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OCTOBER:
Cycle Time Reduction

NOVEMBER:
The DATA Factor(y): Looking at Industrial Internet