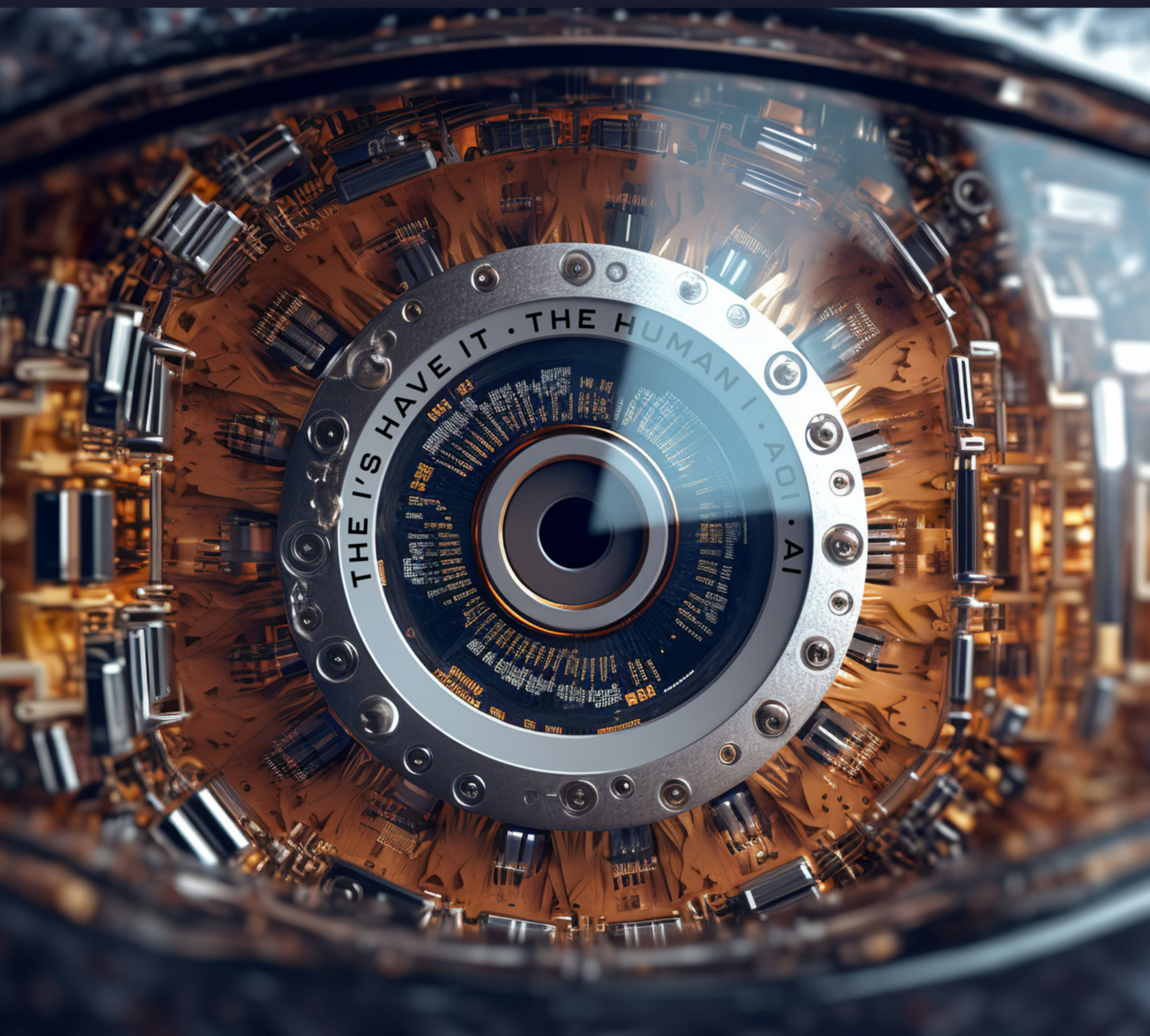
OCTOBER 2023

I-Connect007

SMT007 MAGAZINE

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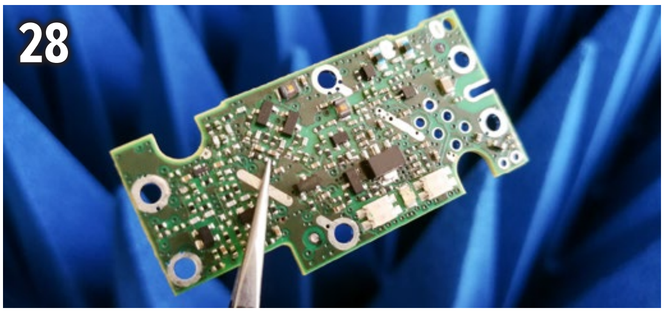
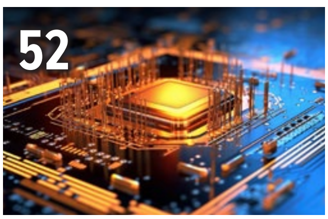
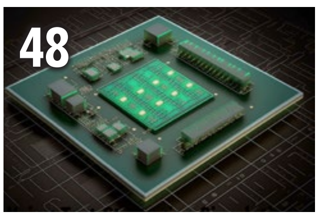
Test and Inspection

Test and inspection methods are undergoing rapid change. In this issue, we consider the influence of AOI, AI, and human eyes. How exactly are these pieces of the puzzle changing the role of test and inspection?







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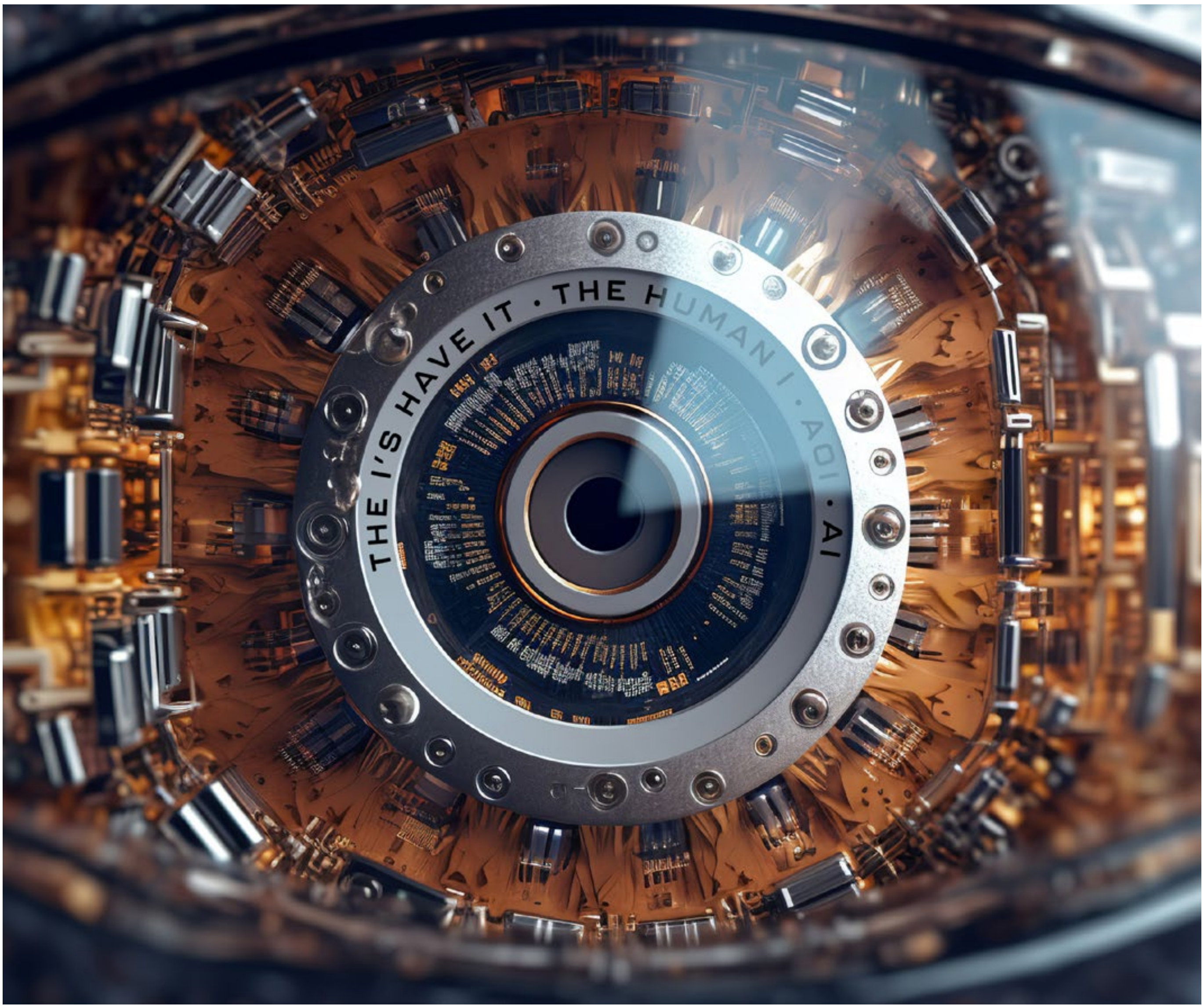
The Eyes Have It

Nolan's Notes

by Nolan Johnson, I-CONNECT007

A great example of AI's power at pattern matching images in medicine is the Google Automated Retinal Disease Assessment (ARDA) program, which turns retinopathy screening—once a test performed by an ophthalmologist—into a technician-level task. Given that only a small percentage of patients test positive for retinopathy, the AI-based assessment means that ophthalmologists now only see the patients who test positive on the app.

The computers do the data-crunching, and the expert humans do the critical analysis using that data. The result is that many more patients can be reliably checked for retinopathy than ever before. The ARDA program is extremely successful.



This medical example illustrates where imaging technology is overlapping application spaces; the fundamental image processing technology that works for medical works for industrial applications as well. The kind of data analysis built into the retinal scan is the same concept as used in automated inspection systems. Both application spaces benefit from the advances in vision and compute hardware, development database building, and predictive algorithms, such as AI engines, to provide fewer false positives, more sophisticated capabilities, and perhaps most important of all, data—both raw and analyzed—for process feedback in the automated factory.

The kind of data analysis built into the retinal scan is the same concept as used in automated inspection systems.

The test function benefits from all this data and AI as well. In this issue, we talk with experts who are on the cutting edge of what the eye can see. Bert Horner at The Test Connection paints a picture of increased test coverage and efficiencies, due in part to predictive software in setup, as well as having more data (design data, and manufacturing process data) available. The result is that Horner's team can use the data to make critical design decisions which get much closer to 100% test coverage.

ASTER Technologies' Will Webb shares how AI and digital twin concepts come together as a modeling technique to improve coverage prior to running the job: humans leveraging multiple what-if scenarios to find the most efficient. Raj Vora and Darren Carlson at VAS Engineering share how process benchmarking not only helped them increase productivity, but how it gives them an opportunity to continue improving their process optimizations, while Miles Moreau at KIC Solutions details the concept of reflow process inspection. Brent Fischthal at Koh Young shares how his company is working with academic AI research teams to continue progress into ever more capable inspection systems.

Our cadre of columnists—Mike Konrad, Jennie Hwang, Michael Ford, and Ronald C. Lasky—round out this fascinating and "eye-catching" issue. Konrad dispatches a thorough interview with three experts in the AOI space, and Dr. Hwang takes us to a conceptual viewpoint overlooking the potential of AI applications. Ford shares his thoughts on the merging of automation and custom manufacturing, and the lasting impact it will have on manufacturing processes. And Lasky, in his ongoing tutorial on process optimization based on real world examples, leaves us with a heck of a cliffhanger this month.

As I look back over all this innovation, I can't help but reminisce a bit about developing vision systems for semiconductor manufacturing 20 years ago. The black-and-white camera systems and image recognition software, limited by compute power to only processing image contrast, have given way to much more capable hardware and sophisticated software. Oh, what we could have done then with what we have now.

Look me in the eye, or rather the "I": Inspection and test. Artificial Intelligence. The human eye. Each brings a necessary component to making this system work. Enjoy! **SMT007**

Nolan Johnson is managing editor of *SMT007 Magazine.* Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing. To contact Johnson, click here.

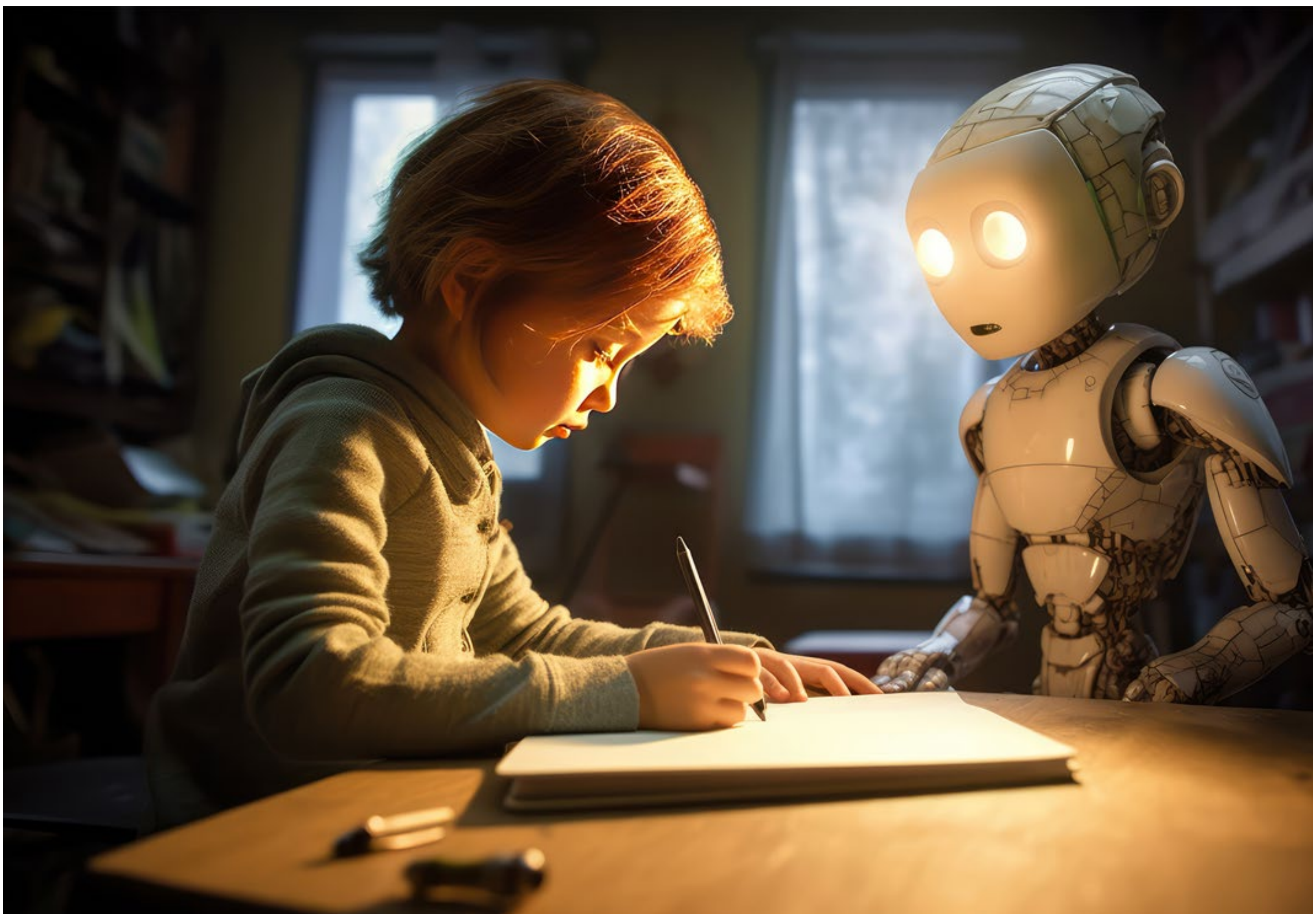
AI: A Prelude to Opportunities, Challenges, and Possibilities

SMT Perspectives and Prospects

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

It seems that artificial intelligence (AI) has become unprecedently widespread, an everyday word used by everyone. However, its reality and potential are yet to evolve. On one hand, there is sheer excitement about evolving intellectual and dexterous capabilities to improve our lives, businesses, economy, and national security; on the other, there has been trepidation about unknown and/or unintended consequences.

The explosive offerings of new AI tools and platforms are remaking our daily lives and every aspect of our workplaces, including research, engineering, design, manufacturing, operational management, and technology deployment. The ability to balance between AI's omnipotent power and its downsides is key to leveraging AI as a virtuous tool. Operations across all sectors, industry, government, and academia alike, will distinguish themselves



by how well they use the tools and how reliable and safe the respective tools can deliver.

Since November 2022, the release of ChatGPT and Generative AI (conversational AI), particularly GPT-4 large language model (released March 14, 2023), has been making the development of AI-related products, use cases, and a possible future more crucial to advancing electronics and microelectronics industry into the all-encompassing Industry 4.0—in turn, furthering the well-being of human life.

With that backdrop, I plan to write a series of columns on artificial intelligence, addressing technologies, substantive historical events, state of the art and potential case-cases, areas of attention, approaches, and human-ingenuity vs. machine intelligence.

AI Perspectives and Visions

In the broad sense of AI, it is intriguing to see that the diverse and disparate perspectives of and visions for AI are as wide as the Grand Canyon. To name a few:

- *"A little bit scared of technology such as OpenAI's ChatGPT—concerned about potential disinformation and authoritarian control of AI... the goal is to forge a new world order in which machines free people to pursue more creative work."*
  —OpenAI CEO, Sam Altman
- *"AI—the first word is right, not the second word... not intelligence, not have feelings, emotions, love... We call it intelligence, but we really do not know how the brain works... replacing humans will not happen... All things are to help humans... Can solve individual problems, humans will always be in control... Only one way to produce brain—it takes nine months."*
  —Steve Wozniak ("The engineer of engineers," Feb. 9, 2023, CNBC)
- *"This is a pivotal moment in AI development... We should carefully consider the consequences. Might they include the potential to wipe out humanity? It is not inconceivable, that is all I'll say."*
  —Geoffrey Hinton (Godfather of AI)
- *"OpenAI's GPT model is the most revolutionary advance in technology since internet, cellphones, computers."*
  —Bill Gates
- *"Dreams are kind of like generative artificial intelligence."*
  —James Cameron, Oscar-winning innovative filmmaker
- *"AI has a nonzero chance of annihilating humanity."*
  —Elon Musk

AI Technology

To map out AI technology from manifold perspectives on the current and future of AI development and deployment, the foundational components behind the AI technology, in a pragmatic sense, include machine learning (ML), deep learning (DL), neural network (NN), Internet of Things (IoT), digital twins, predictive modeling, ChatGPT-led AI boom (Generative AI), and AI with justified confidence and trustworthiness.

Each component stands on its own in terms of technological advancement, yet the useful fruition requires intricate and robust interplay among all components. Understanding and applying that interplay of all relevant components requires both broad-based knowledge and specialized expertise of the respective field.

AI: Present and Future

The future of AI is a global race. As Vladimir Putin said, *"Whoever becomes the leader in AI technology will be the ruler of the world."*

Myriad new vistas to capitalize on the sound benefits of AI are emerging and burgeoning. Among many use-cases or potential use-cases, one timely frontier related to our industry is expected to propel Industry 4.0

by leveraging AI/ML/DL/NN, in conjunction with ancillary technologies, to drive into seamlessly autonomous, intelligent cyber-physical systems effectively and reliably. To put a business case forward, the advancement of Industry 4.0:

1. Leads to the true materialization of "smart factory."
2. Shall be smart enough and consistently resilient to deliver intended efficiency and effectiveness to be globally competitive carrying a leading edge.

Take another example on national defense and security, where AI will continue to play a heightened role in the efficiency and relevancy of military operations. In large-scale missions, the speed at which data and knowledge cascade is critical to the mission's success. Holistic command and control are yet to be developed. However, for unmanned aerial vehicles (UAV) or drones, AI enables real-time access to data, which offers preemptive decision-making and simplified command and control; swarms of drones will aid each other by overcoming jamming ploys.

> "The future of AI is a global race.

While generative AI adds another dimension to semiconductor design and fabrication, chips are true differentiators to the capabilities and performance of making generative AI models in training and playing a mission-critical role in AI technology deployment. In sync with the CHIPS Act, the semiconductor could be catapulted by generative AI to a potentially phenomenal magnitude, which will create some intense dynamics.

Considering the unparalleled velocity of AI development to harvest the tangible benefits from academia, national laboratories, and industry in a timely manner, the transitioning of scientific research and technology to real-world end-uses calls for an approach that is both creative and bold.

AI Talents

It's vital to fill key roles in AI development yet demand currently exceeds supply. We must embrace AI technology and stay in the core knowledge zone to nurture the proficient and competitive engineering workforce. The broad-based general knowledge of AI technology offers a consequential opportunity to our industry.

To this end, I have developed a professional development course, "AI—Opportunities, Challenges, and Possibilities," with the goal of disseminating AI technology to the workforce and provide continuing education to the workforce of our industry. This short course will debut at SMTA International Conference & Exhibition on Oct. 9, offering holistic coverage of AI in its systematic hierarchy with high-level overviews, as well as specific component technologies/techniques and use-cases. The course topics include:

- Background and diverse perspectives on AI
- Current state of AI
- Justified confidence in AI
- Machine learning, deep learning, neural network, digital twin, IoT, and use cases for
- Generative AI, Edge AI, OpenAI—ChatGPT, ChatGPT-4
- How transformers work and diffusion model
- Scientific machine learning and examples in industry applications
- Use cases for modeling/simulation, and digital twin

- Deep learning NN architectures and expressive programming frameworks
- AI's uncertainty quantification
- New technologies: SNN, dynamic reasoning, continual learning (multitasking)
- Examples of global leaders and competitiveness
- Artificial general intelligence
- Brain, mind, and intelligence
- Future of AI
- Concluding thoughts

The objectives of the course are to build and to stay in the knowledge zone; to spur innovative ideas and inspire new vistas for new opportunities; to highlight what it takes to achieve AI with justified confidence/trust; to balance between AI's power and downsides; and to leverage AI as a virtuous tool to facilitate individual on-the-job efficiency and effectiveness, and enterprise business growth. SMT007

Resources

1. "The Fourth Industrial Revolution (Industry 4.0): Intelligent Manufacturing," by Jennie Hwang, *SMT007 Magazine,* July 2016.
2. "Artificial Intelligence: Super-Exciting, Ultra-Competitive," by Jennie Hwang, *SMT007 Magazine,* September 2018.
3. "Smart Factory Implementation: How Smart Is Smart Enough?" by Jennie Hwang, *SMT007 Magazine,* April 2020.

Jennie Hwang, chair of AI with Justified Confidence for DoD Command and Control study, chair of AI Committee of the National Academies, and External Review Panel of NSF National AI Institutes, brings broad-based knowledge to her writing through an integrated perspective. An International Hall of Famer of Women in Technology and a member of National Academy of Engineering, she is author and co-author of 10 internationally-used textbooks and 700+ publications/editorials; a featured speaker in innumerable international and national events; has received numerous honors and awards; served on Board of NYSE Fortune 500 companies and on various civic, government, and university boards and committees (e.g., DoD—Globalization Committee, DoD—Forecasting Future Disruptive Technologies Committee, National Materials and Manufacturing Board, Board of Army Science and Technology, and Technical Assessment Board of NIST).

Dr. Hwang has chaired the National Laboratory Assessment Board, Assessment Board of Army Research Laboratory, and Army Engineering Centers. Her formal education includes Harvard Business School Executive Program and four academic degrees (Ph.D. M.S., M.S., B.S.). She has held various senior executive positions with Lockheed Martin Corp., among others, and is CEO of International Electronic Materials Corp. She is also an invited distinguished adjunct Professor of Engineering School of Case Western Reserve University and has served on the University's Board of Trustees. To read past columns, click here.

Appearances

Dr. Jennie Hwang and Dr. George Karniadakis of Brown University/MIT will instruct a Professional Development Course titled "Artificial Intelligence—Opportunities, Challenges and Possibilities," Oct. 2, at the International Symposium on Microelectronics (IMAPS) in San Diego, and on Oct. 9, at SMTA International, Minneapolis. Dr. Hwang also will instruct a course titled "High Reliability—Role of Intermetallic Compound and Tin Whisker," Oct. 2, and a course on "Solder Joint Reliability—Principle and Practice" on Oct. 10.

Dr. George Karniadakis

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The Role of Automated Inspection Systems

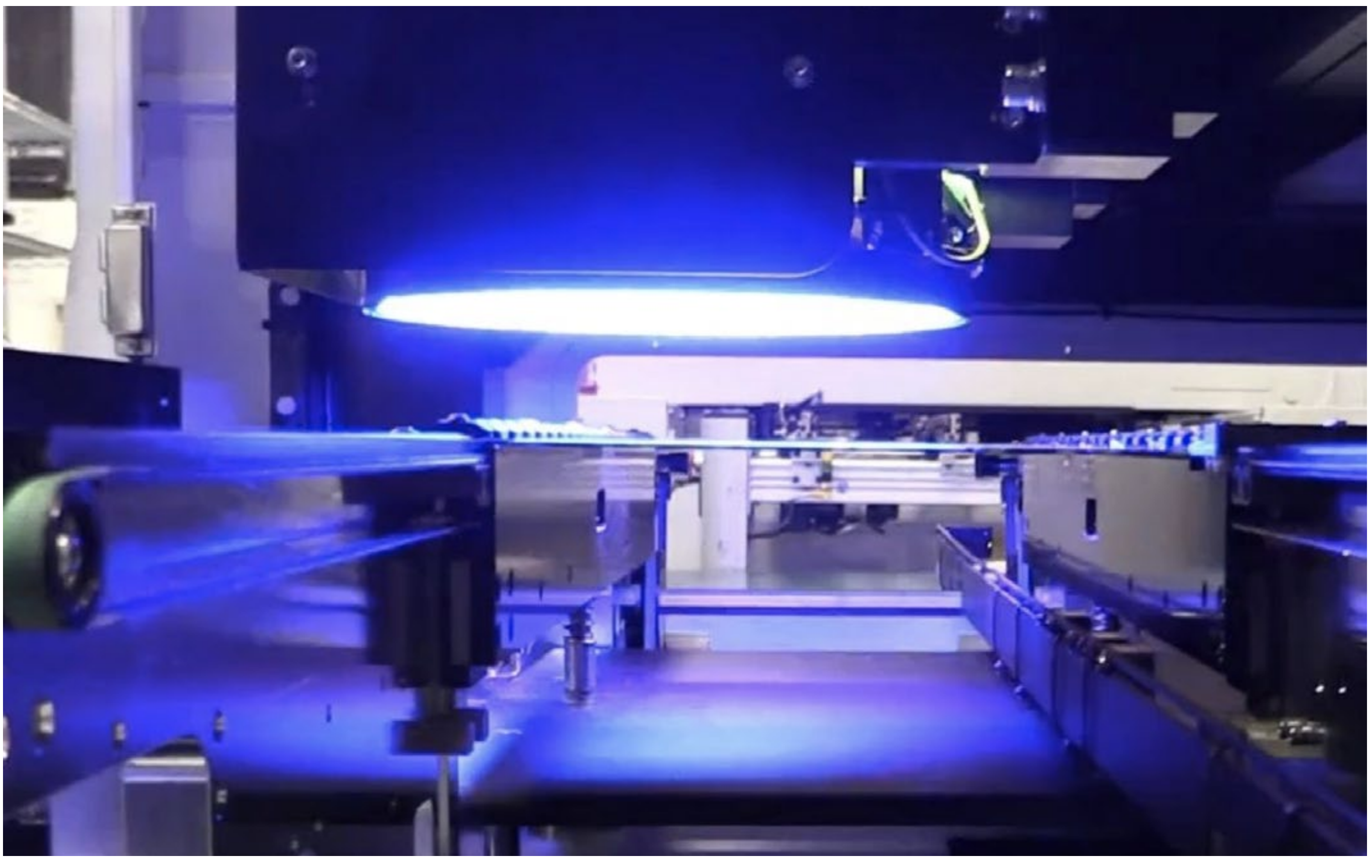
The Knowledge Base

Feature Column by Mike Konrad, SMTA

I invited three experts within the AOI space to answer 10 questions: Brian D'Amico, president of MIRTEC USA; Joel Scutchfield, general manager of SMT business operations and director of sales at Koh Young America, Inc.; and Arif Virani, COO of Darwin AI. In this insightful interview, we delve into the pivotal role of automated inspection systems in the electronics assembly industry.

In an era where technology is rapidly advancing, electronic devices have become an integral part of our daily lives, powering everything from smartphones and laptops to medical equipment and automotive systems. With this increased reliance on electronics, ensuring the quality and reliability of electronic assemblies has never been more critical.

Automated inspection systems have emerged as a game-changer in this dynamic landscape, offering a level of precision, speed, and consistency that human inspection alone simply cannot match. These systems employ advanced technologies such as machine vision, artificial intelligence, and robotics to meticulously

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scrutinize electronic components and assemblies, identifying defects and anomalies with unparalleled accuracy.

We explore the multifaceted significance of automated inspection systems in the electronics assembly industry. In this interview, we discuss their pivotal role in maintaining product quality, streamlining production processes, reducing costs, and enhancing overall efficiency. Moreover, our experts share their insights into the latest advancements in automated inspection technology and how these innovations are reshaping the electronic assembly landscape.

What are the primary objectives of implementing automatic inspection systems in electronics manufacturing?

Brian D'Amico: The primary objective of implementing automatic inspection systems is to eliminate defects within the manufacturing process. This may be accomplished not only by flagging these defects for review and rework but using the resulting inspection data to virtually eliminate the opportunity for the defect to ever occur in the first place.

Joel Scutchfield: Most think the primary reason for inspection is "defect catching" at the various typical inspection points where we inspect on a standard SMT line, including post-print, post-placement/pre-reflow, post-reflow, X-ray, or any of the various special inspection points (pin/terminal, dispensed process, THT, etc.). Although this approach provides peace of mind in terms of quality assurance and helps to ensure that escapes do not happen (do not get to the customer), the bigger benefit and value is in the use of the data provided from each of these inspection points to correct and control the assembly process, thereby preventing the defects from happening for all future builds. Taking that to the next level, we use the inspection results data to feed AI engines, which can automatically provide that control of the various processes involved, thus moving us closer to the self-healing process that is "real" Smart factory realization.

Arif Virani: Automatic inspection systems aim to improve inspection quality and consistency while reducing costs.

Please explain the key components and technologies involved in an automatic inspection system for electronics manufacturing.

D'Amico: There are a variety of different components and technologies involved in automatic inspection systems. Most systems are configured with high-resolution optics and lighting systems combined with various forms of 3D inspection technology such as moiré and laser.

Scutchfield: I'll speak to SPI and AOI, specifically. There are multiple methods (technologies) being utilized for SPI and AOI depending on whether 2D or 3D is being used. When it comes to 3D, there are two basic approaches: moiré interferometry and laser. Laser, unfortunately, has several shortcomings as it applies to the PCB inspection world for SPI and AOI, which is the reason most providers use the moiré approach to varying degrees. That's important to note, because not all 3D is created equal. Technically, a 3D image can be generated from a single moiré projector, but that image will be susceptible to back side shadows, opposite the side of the component where the moiré pattern is being projected. Thus, a minimum of two projectors are needed to eliminate the "back side shadow phenomenon." An inspection system needs to gather the right kind of data (measurement based, parametric results) using very precise subsystems for pattern generation and data gathering to gather the right amount of data from a multitude of sources for superior statistical relevancy.

Virani: AI-based inspection systems have five key components:

1. **Optics/lighting:** Taking images of the PCBA, components, and defects.
2. **Material handling:** Conveyor and logic to move PCBAs through the system.
3. **Artificial intelligence models:** Analyze PCBA images for defects and additional information.
4. **Line interface:** Interface for operator to monitor and control inspection.
5. **Engineer/quality user interface:** Interface to enable AI learning and continuous improvement of inspection performance.

What are the different types of automatic inspection systems commonly used in electronics manufacturing, and when is each type most appropriate?

D'Amico: There are many types of automated inspection systems used in electronics manufacturing, including solder paste inspection (SPI), automated optical inspection (AOI), flying probe, and X-ray. Each of these systems is used at a variety of different locations within the manufacturing process. SPI is primarily used post-solder deposition but may also be used for inspection of deposition of adhesives. AOI may be used either post-placement or post-reflow to verify the proper placement and electrical connectivity of each component on the PCB. Flying probe is used to check electrical characteristics of the finished PCB after optical inspection for manufacturing defects. X-ray may be used at virtually any phase of the manufacturing process but is primarily used to inspect solder connectivity for bottom terminated devices.

Scutchfield: SPI systems inspect the solder paste after print to confirm the position and volume of the print vs. the expected values for each. AOI can be used in various locations with different flavors, including a less complex offering (fewer projectors) for pre-reflow inspection, where we're looking to confirm that all the parts are correct, and they have been accurately placed in the right location and the correct polarity. The use of pre-reflow AOI continues to grow quickly for many valid reasons, some of which are related to the components and labor shortages that many EMS providers are still dealing with. Systems used in the pre-reflow location are typically less complex with regard to the number of projectors and camera complexity, because the inspections being performed in this location can be done effectively with such systems, which are typically also less costly. For post-reflow AOI inspection (most common location for AOI), the more complex systems are typically used due to the need to inspect solder joints and the properties that come with solder joint inspection, including hidden joints, and very reflective solder. AOI is also used for pin and terminal inspection where a high content of both is present. These systems typically require some difference in the configuration, due to the reflective nature of plated pins and terminals. Through-hole inspection can fall into this same category. Dispensed process inspection is also used where the need for conformal coating, underfill, or potting inspection is needed to confirm thickness and/or volume of each.

Virani: The types of automatic inspection systems commonly used in electronics manufacturing can be categorized as follows:

A. Visual inspection is the most flexible and versatile amongst the types of automatic inspection systems, and is appropriate at different stages of the electronics manufacturing process including:

- Parts inspection, such as the initial parts arrival stage, to check whether received parts are damaged

- Placement, to check whether components are placed properly/not missing/damaged, and whether the components are the right ones
- Solder reflow stage to ensure parts are properly soldered
- Hand load through-hole stage to ensure proper placement
- Final assembly stage to ensure that components have not moved/become missing/wrong polarity/damaged, and solder is not missing/creating bridges
- Wash stages to ensure components and solder have not been washed away/damaged

B. Non-destructive testing, such as X-ray inspection systems, is most appropriate for situations where you need to look below or within a component for damage (e.g., BGA solder paste inspection) and most appropriate at the parts arrival stage and final inspection stage.

C. Functional testing and in-circuit testing (ICT) are most appropriate at the final assembly stage to determine whether the board is producing the desired results and to electrically probe the assembled electronics to check for shorts, opens, and capacitance.

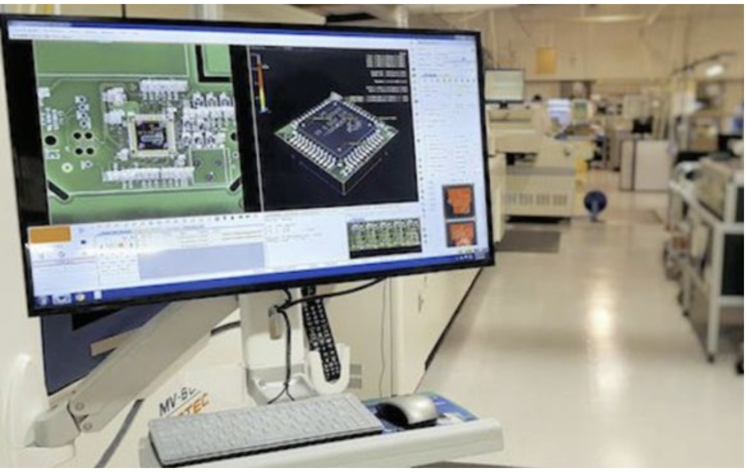
How do automatic inspection systems contribute to improving quality control and reducing defects in electronics manufacturing?
D'Amico: The whole purpose of test and inspection is to collect actionable data that may be used to reduce defects and maximize efficiency within the manufacturing line. The goal is to minimize scrap and get a really good handle on those process parameters that need to be put in place to manufacture products the right way the first time.

Scutchfield: It all starts with having the right kind of measurement-based data, and then applying it the right way, both manually and in an automated fashion where possible, to reduce the need for human intervention. The data that inspection systems provide is now thought to be the most critical and important information that can be gathered to run the SMT line properly. So, those results must be correct and very reliable. The performance and success of the line depends on it.

Virani: Automatic inspection systems offer a consistent and accurate way to identify defects. These systems are especially useful for complex printed circuit board assemblies (PCBAs) that contain thousands of components, as they can complete inspections much faster than human inspectors, thus improving cycle time.

Moreover, newer AI-based inspection systems are cost-effective and can be deployed across multiple locations within the production process. This helps to catch defects in real-time, as they occur, allowing for prompt corrective action. Additionally, the end-to-end data collected by these systems provides valuable insights into the production process, highlighting opportunities for improvement.

What are some of the common challenges or limitations associated with automatic inspection systems in electronics manufacturing, and how can they be addressed?
D'Amico: The continuing evolution toward advanced miniature packaging has led to ever-increasing PCB density and complexity. This adds an increased number of challenges and limitations for each automated inspection system within the manufacturing process. For instance, smaller discrete devices such as 01005s and 030015s, as well as micro-BGA and CSP devices, require very small solder depositions, and that adds a level of complexity for the SPI process. These smaller devices also require higher resolution optics, lighting, and



(Source: MIRTEC)

3D inspection capability for the AOI machine as well. Furthermore, as PCB density increases, the proximity decreases between taller devices and lower lying discrete components, creating a challenge with shadowing. To overcome this challenge, the AOI machine must be configured with multi-angle 3D projection technology as well as the capability to process taller devices up to 25 mm. Lastly, the increased use of bottom terminated devices increases the requirement for X-ray inspection capability for verification of proper electrical connectivity. The good news is that the technology exists to overcome each of these challenges.

Scutchfield: On the mechanical side, shiny and hidden joints can be challenging, so systems had to be created (special lighting and side camera technology) to overcome these challenges. Beyond that, management and processing of the immense amount of 3D data being generated creates additional challenges. Again, we continue to refine everything involved with doing this, as it continues to be a moving target where more and more data will be generated as we go forward.

Virani: Some common challenges associated with automatic inspection systems include:

- Long programming time for each new board type, which is amplified when components on a board change
- Poor suitability for covering a wide variety of inspection tasks at different stages of manufacturing (e.g., many systems are not suitable for final assembly inspection for inspecting a fully-populated board with components of different sizes, shapes, and height, and different types, such as SMT, through-hole, wires, etc.)
- Highly sensitive to minor acceptable variations resulting in high false positive rates

Could you describe the role of machine vision and image processing algorithms in automatic inspection systems for electronics manufacturing?

D'Amico: Most automated inspection systems use some form of machine vision. As the inspection process becomes more complex, these systems must be configured with high-speed, high-resolution optics, lighting, and 3D technology to capture multiple images of each region of interest for data processing. The most advanced systems use a combination of 2D and 3D algorithms to analyze this data to determine the integrity of each phase of the manufacturing process. For solder deposition, SPI algorithms are used to analyze the area, volume, shape, and offset of each deposition as well as bridging between depositions. AOI systems use a combination of complex algorithms to determine the length, width, height, and coplanarity for both the body and leads of each device, as well as volumetric measurement of every solder joint. X-ray systems offer computed tomography (CT) scanning with specialized algorithms for detailed cross-sectional 3D analysis of a given region of interest at multiple different angles and levels.

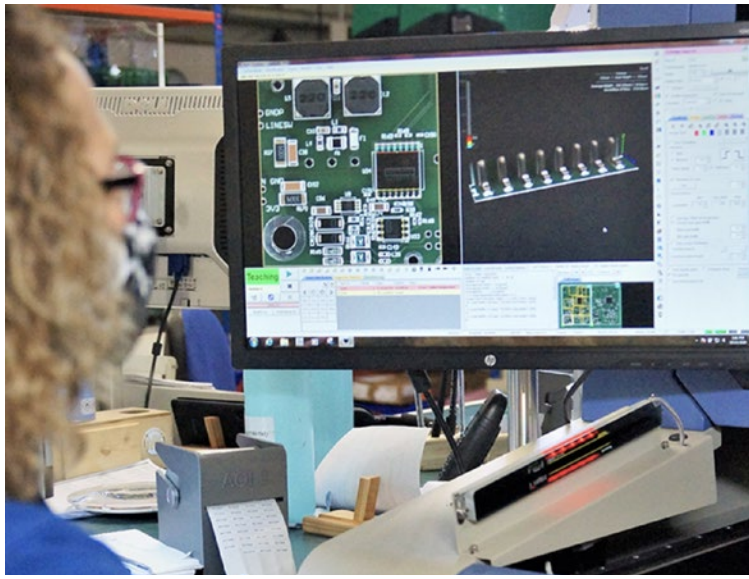
Scutchfield: This is probably the most important feature when it comes to capability, accuracy, and repeatability. Image acquisition is the first big step in the inspection process, and it must be done properly for the system to have any chance of providing a reliable, trustworthy result. The success of the inspection effort depends on a combination of the camera, optical resolution, and the number of images acquired, along with pattern creation source (digital, analog, or both). These combinations result in a data set, and size of the data set which needs to be processed and analyzed. In most cases the more data, the better the image clarity and more accurate the results the system can provide. But large data sets take longer to process, especially if many tests are being executed. To be fully capable of meeting both superior image acquisition and fast processing (fact inspection cycle times), systems must employ all features and capabilities, plus both powerful and very optimized algorithms.

Virani: Machine vision and, in particular, machine learning, helps to overcome the limitations of traditional automated inspection systems. By automating the programming step, one can significantly increase productivity, as the system can quickly learn new boards with ease and accommodate variations in board designs and components used. Moreover, machine learning makes defect detection more robust, reducing false positive rates while maintaining high defect detection rates. Additionally, it enables us to inspect objects that were previously only possible with human operators.

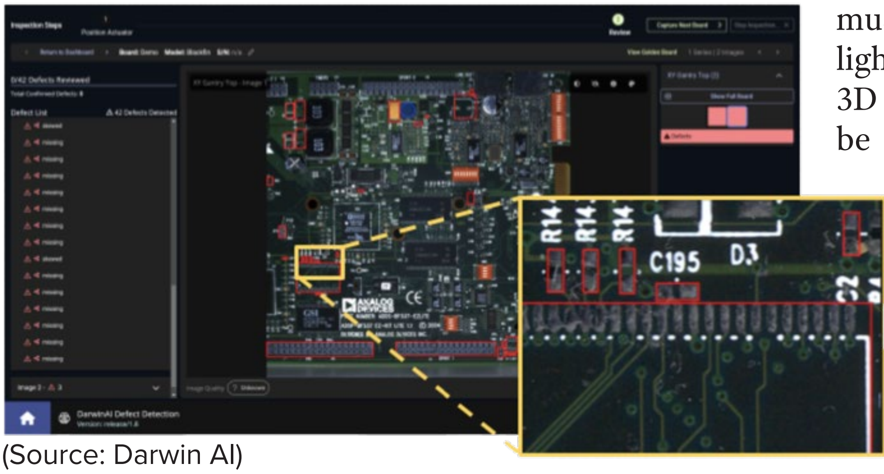
What criteria should be considered when selecting an automatic inspection system for a specific electronics manufacturing process?

D'Amico: The criteria considered for selecting any automatic inspection system is really based on the manufacturer's budgetary and production requirements. We should consider:

- What are the manufacturer's budgetary requirements?
- Is this an in-line or off-line production application?
- What is the smallest component that is currently used in the manufacturing process? What will this be in the foreseeable future?
- Is there a requirement for multiple bottom terminated devices?
- Is there a requirement for inspection of tall devices up to 25 mm?
- Is there a requirement for wafer-level devices with highly reflective surfaces?


(Source: MIRTEC)

Scutchfield: Considerations can be a bit different depending on the inspection application, but the core features and considerations center around selection of a provider/partner which can serve all current and potential future needs, and to not make the mistake of looking at the system being acquired as a one-time buy. The needs you have today are just that, and chances are good that your needs will expand over time, especially as you learn what multiple inspection points on the line can do for you. Selecting a provider that has a very proven track record with systems that serve all the various inspection functions on the SMT line, and has the strong commitment to developing the software tools to tie all systems together and truly enable Smart factory realization, is what will ensure your business will be taken to the next level. You will have the opportunity to remain state of the art and cutting edge with your SMT operation.



(Source: Darwin AI)

Virani: Criteria to be considered include:

- **Type of inspection:** Through-hole, final assembly, and cosmetic inspection require unique optics and lighting to properly identify defects.
- **Cycle time:** How fast does the inspection need to be completed?
- **Quality target:** What is the level of accuracy required at the stage of production?
- **Value (or ROI):** Cost of alternative (e.g., human inspector) or prevention of defects.

How do automatic inspection systems handle component and PCB (printed circuit board) variations, such as different shapes, sizes, and colors?

D'Amico: Once again, this really depends on whether the process is in-line or off-line. To process odd-shaped PCBs in-line, the manufacturer would have to use some sort of pallet for transport through each stage of the manufacturing process. Off-line inspection systems are more forgiving in this respect and they typically include a work fixture for processing these odd shapes.

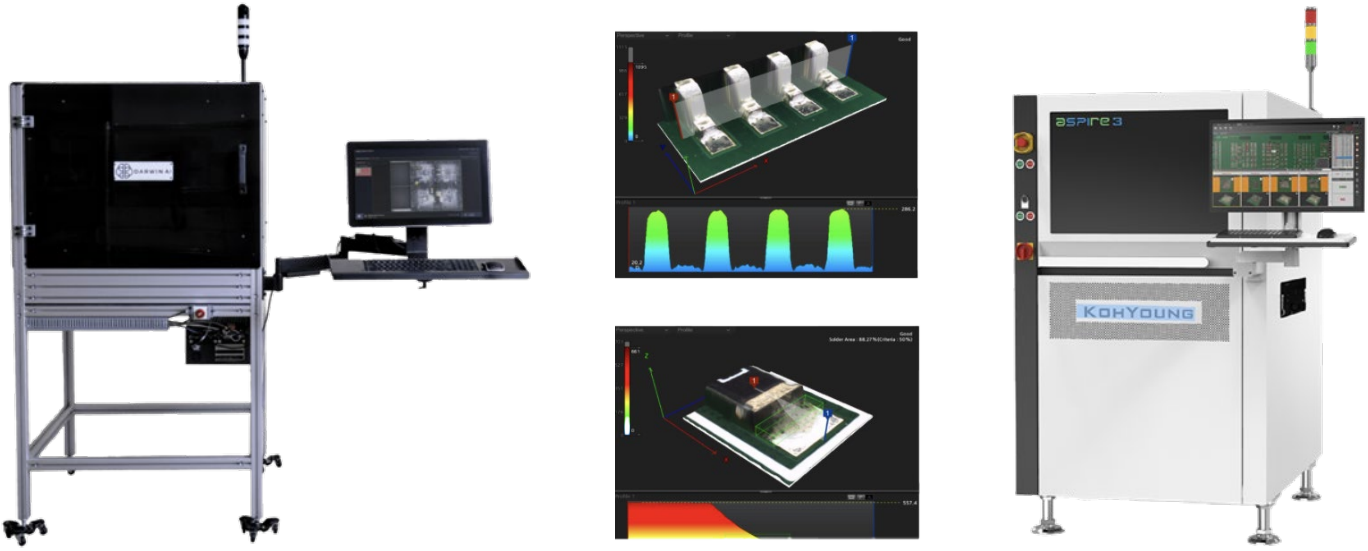
Different PCB colors such as white and red may be problematic for some inspection systems and should be addressed as an upfront requirement. Some 2D and 3D systems simply cannot handle these variations. For instance, 2D bridge inspection may be problematic for white PCBs as this may create false calls. To cope with this issue, the inspection machine must be configured with an advanced lighting system. The same is true for 3D laser inspection systems that will be more susceptible to PCB color variation than a 3D moiré system due to absorption and reflectivity of the laser light. Once again, it is imperative to address these requirements as part of the equipment evaluation process.

Scutchfield: The key here is to use a core technology and subsystems (under the hood) that are immune to color variations and can handle a wide range of component sizes and heights. Some technologies are more suitable than others when it comes to this (back to the moiré vs. laser conversation), and the number and types of acquisition methods (analog/digital, etc.) being used.

Virani: Typical automatic inspection systems require manual re-programming to handle such variations, which is a very time-consuming and tedious trial-and-error process. As mentioned previously, machine learning/AI systems can automate this process and be robust/adapt to different shapes, sizes, colors, etc.

Can you discuss the integration of automatic inspection systems with other manufacturing processes and quality control measures?

D'Amico: Industry 4.0 is a topic of much discussion within the electronics manufacturing industry. In the most simplistic of terms, Industry 4.0 is a trend toward automation and data exchange within the manufacturing process. This basically requires connectivity and communication from machine-to-machine within the manufacturing line. The challenge is to collect data from each of the systems within the line and make that data available to the rest of the machines. Without test and inspection, there is no Industry 4.0. The whole purpose



Left to right: An AOI machine (Source: Darwin AI); an image capture (Source: MIRTEC); an SPI machine (Source: Koh Young).

of test and inspection is to collect actionable data that may be used to reduce defects and maximize efficiency within the manufacturing line. The goal is to minimize scrap and get a really good handle on those process parameters that need to be put in place to manufacture products the right way the first time. For maximum efficiency, three inspection systems are required within the production line. These are solder paste inspection (SPI) post-solder deposition, automated optical inspection (AOI) post-placement, and AOI post-reflow. This requires a substantial investment, however, the combination of all three inspection machines is really the only true way to provide feedback for each stage of the manufacturing process.

Scutchfield: There is a lot of work going on to create real time communication and connectivity between inspection tools and the systems that are most likely to create defects, to allow for real time auto-adjustment, which can potentially eliminate those defects from being created. This is being done through both CFX communication protocol and the use of AI tools for both the screen printing and pick-and-place processes. This is now a daily reality and will continue to expand and grow in capability as time goes on.

Virani: With the digitization of inspection records and data, there is a promising opportunity to integrate it with other data sets. One of the most frequent demands we receive from our customers is to integrate inspection data with MES data. By integrating detailed quality data and supporting metadata (information about inspection, and production), it's possible to gain insights into drivers of yield and potential improvements.

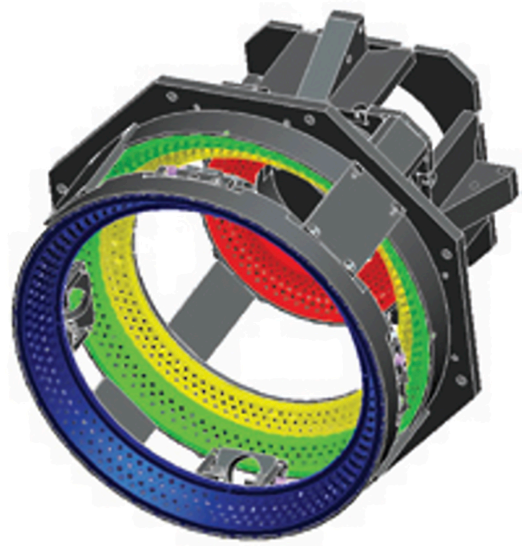
What are some recent advancements or trends in automatic inspection systems for electronics manufacturing, and how are they impacting the industry?

D'Amico: The widespread adoption of artificial intelligence (AI) is perhaps the most prolific current trend in automated inspection. In today's electronics manufacturing industry, standards for defect and quality control are stricter than ever due to advancements of electronic products and increasing safety and environmental regulations. Electronics manufacturers are forced to maximize their production efficiency by implementing Lean manufacturing initiatives and optimizing production processes. Manufacturers are relying upon AOI equipment to streamline the manufacturing process and provide real time root cause analysis of manufacturing defects. The objective is to increase profitability by improving production yields and reducing costly rework. In recent years, 3D AOI machines have developed rapidly, and many new functions have been added. While these performance improvements are welcome, they have added another level of complexity to the programming and optimization of the inspection system. 3D AOI machines require much more parameter manipulation for teaching and debugging, resulting in increased dependency on the skill of the process engineer.

This presents a host of new challenges. If a skilled employee is replaced or a new employee is introduced due to the addition of more SMT lines, productivity may be adversely affected until the skill level of the employee is improved. Such uncertainty and instability are something that electronics manufacturers must avoid to maintain quality control. This is where the need for AI is highlighted. In short, the goal of using AI is to reduce the level of operator proficiency required to maintain the highest levels of manufacturing quality and efficiency.

Scutchfield: Everything right now is revolving around Smart factory realization, where the data is applied real time to improve processes and drive toward "self-healing" initiatives. Through this, PCB assemblers are becoming less reliant on human need and intervention, and improving their yields (less rework), all of which adds up to reducing their costs. Beyond that, backend inspection is gaining a lot of traction, where we can now apply frontend concepts and technology to backend/box and module build applications. This will continue to grow significantly over the next few years.

Virani: Some advancements and trends include:

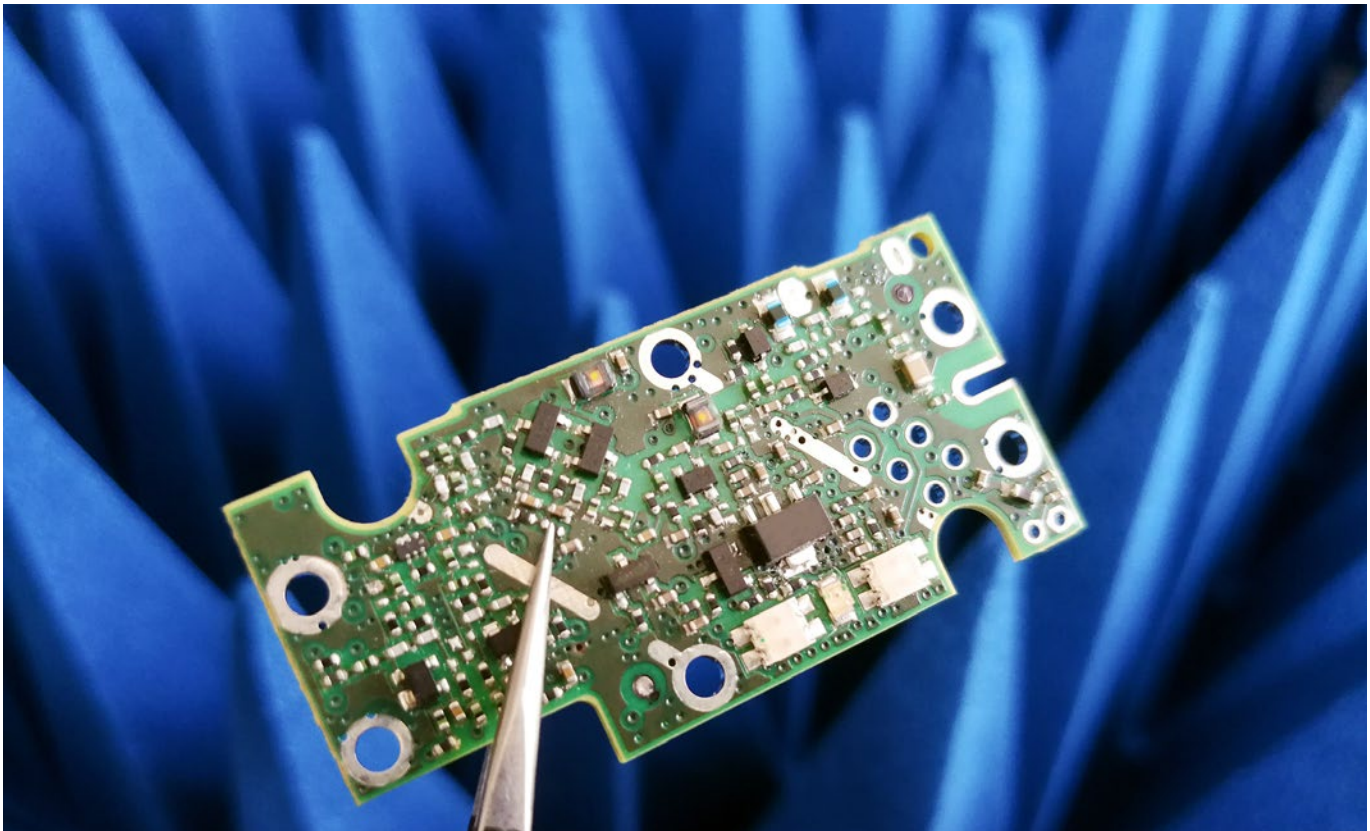


Six phase color light. (Source: MIRTEC)

- **Foundation AI models:** These are pre-trained AI models tailored to specific types of products and defects. Traditionally, manufacturers had to build in-house AI and automation teams to build AI systems for different tasks, which can take years to become production ready. Choosing an automated inspection company which has foundation models specifically for PCBA/electronics defects will reduce time-to-production for automated inspection from years to weeks.
- **Digitization:** Multiple systems (IoT, imaging systems, MES) now allow manufacturers to collect large-scale metadata. Manufacturers can use this data, including product quality data gathered from inspection systems, to identify production issues, optimize product design for efficient manufacturing, and facilitate customer-facing teams to address product defects in the field.

These advancements help electronics manufacturers reduce waste and improve quality, ultimately making them more profitable and competitive. SMT007

Mike Konrad is founder and CEO of Aqueous Technologies, and vice president of communications for SMTA. To read past columns, click here.



'Testing' a Strategy

Feature Interview by the I-Connect007 Editorial Team

To get a front-line perspective on test and inspection, we spoke with Raj Vora, manufacturing engineer, and Darren Carlson, operations manager, at San Diego-based VAS Engineering, a company that has been paying careful attention to operational efficiencies. "All roads lead to Rome," they say, so it seems any operational efficiency work ultimately leads back to data and analysis. In this conversation, Raj and Darren share how test and inspection equipment is vital to the efficiency of the entire manufacturing structure.

Nolan Johnson: When you consider your overall business operations, where does test and inspection fit, and what challenges do you see in inspection?

Raj Vora: Inspection is the bane of our existence, yet it's so crucial to the whole operation. We run in-line AOI on every single board on all three lines. If there's any add-on work—whole mechanical assembly, for example—we do a 100% final manual inspection as well.

One of the challenges is the false calls on some of our machines in SMT. We are trying to alleviate that issue by replacing all our inspection equipment.

Barry Matties: What is the strategy when you're looking at equipment? How are you looking to the future to influence the decisions you're making today?

Vora: One big piece of the puzzle we want to solve is MES software. Real-time feedback is

key. Let's say we're running a job; a reference designator sets off a couple defect conditions and, hopefully right then and there, MES-related real-time software can lock the line and correct the mistake before we start making more of that mistake. We're headed there very quickly; we're already in the RFQ process for MES software.

We have a lot of good software, but much of that data is just not wrapped into one nice suite. That's one big problem we have. The second problem was that we want better shop floor control, so we've digitized our inventory. Now our inventory management system acts like a database, and that has been a big quality improvement for many reasons.

Now we're going after quality and all the data that is tied together to understand it. Quality could have many different pieces to it. We've already built some custom in-house software, but we want to become an advanced facility.

We don't do solder paste (SPI) or pre-reflow inspection because we've haven't found the need for it. The post-reflow data tells us that our process is in good condition. We attribute that to high levels of continued maintenance and the knowledge level of our in-house staff. Almost 95% of all maintenance on equipment is done by our in-house crew.

Matties: Regarding your SPI, will the finer features coming in result in you changing your strategy?

Vora: We'll let the data tell us. We are producing boards with 01005s already. For example, we have one board that has 25-line items that are 01005 with 40–50 placements out of a total of 185 placements, just on a board the size of a dime.

Matties: Is this with stencil or jetting?

Vora: Stencil. In this case, we have a lot of tech inside the stencil. While the stencil normally costs $200, this is a $1,000 stencil with a few tricks built into it. We've been wildly successful with it.

Raj Vora

Matties: Are you looking at jetting as well?

Vora: We don't find a need to make that investment in jetting. Jet printing is not useful to us because we want to be able to run any job on any of our three lines. Stencil printing does such a great job already and we're really a production house; we have the time to make stencils. We also have a stencil house nearby that can give us a same day response if we need it.

Matties: Is your in-line AOI where you're getting your real-time feedback to control your process?

Darren Carlson: Yes. Right now, we are using the operator. Whomever is running the AOI will flag the line instead of having a software data collection system flag it. It's semi-automatic; there is still a lot of operator intervention.

Vora: We go over that data to understand the defect rates and causes. What are the reasons for the defects and how many defects are there? For example, why is this suddenly tombstoning?

Matties: So, you're using this data for real-time process control and improvement?

Vora: The MES software will wrap all this together and put out some nice big dashboards for extreme real-time feedback. That's where we gather up every piece of the process.

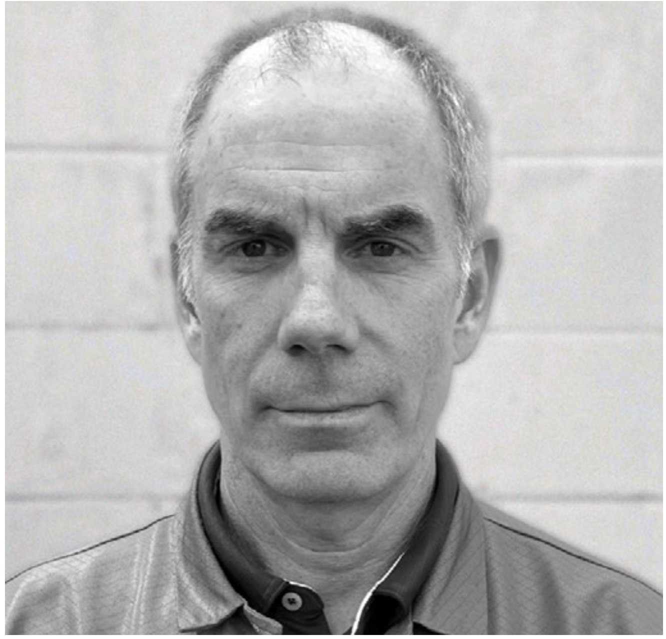
Johnson: Is your expectation that the MES software will flag the line to stop, rather than relying on operators to do it?
Vora: That's right. If you suddenly go below 99.9% defective parts per million, there are little units you can buy that control the conveyors, letting us lock a conveyor in real time. We're not sure how much we want to have automatic control of things, because then you're inviting a whole list of problems. I think it will be a slow approach, so we'll see how it goes.

Matties: What requirements do your customers have for testing?
Vora: AOI inspection is a must for some customers. Some customers require finished article electrical tests. Some want to be here when we do the first article of the board. Typically, our big production customers have some requirements, but they're very much hands off. Whenever there are problems, we call them, and they respond very quickly.

Matties: Are you doing any flex or rigid-flex?
Vora: We're doing a lot of prototypes. We've done a few production boards; most of the production stuff has been rigid-flex, meaning we're placing parts mostly on rigid surfaces, yet there is flexible going around.

Matties: How does the test and inspection process vary with that application?
Vora: It still goes through AOI. If there are any through-holes on it, it still goes to final. We leave it panelized as long as possible. That's usually our approach. That way, we can rework and inspect it much easier; we can hold it.

Carlson: We'll have pallets made if we need to, or we'll use other ways to make it more stable during the placement process.



Darren Carlson

Matties: Now, with all the talk of ultra HDI and finer features, what impact does that have on your test and inspection processes?
Carlson: They're starting to push our boundaries a little bit.

Vora: One of our customers really pushes our boundaries, but it's good because it forces us to evolve faster. Early on, they were the ones who started using 01005s and because of that, we ended up buying new equipment and it's worked out so far.

Matties: Ultra HDI looks to become a more common job. How will what you've learned help carry you into the future?
Carlson: The biggest thing is getting equipment able to handle that stuff. I'd imagine some people who can't afford the newer generation equipment probably won't be able to do that work.

Matties: You're in a good spot as you upgrade your equipment.
Vora: We're in an interesting place in our company's life. About three years ago, we started concentrating on digitization and really understanding our processes. Once we digitized

inventory management, it jumpstarted our next generation of changes. Now we're in a growth phase. We've nailed down 60% of our processes, and we continue doing that work.

Johnson: You just alluded to finding a lot of benefit in digitizing inventory management. You're actively looking at changing inspection. Can you quantify or characterize how this improves your profitability?

Vora: Let's just look at AOI. Do we need someone sitting there, or can it be more "zone" than "man-to-man" defense? When we can make those changes, we'll see improvement. Really, though, the goal is to figure out how we can place more parts. The goal is overall equipment effectiveness (OEE).

How do we get the most efficient operation in terms of OEE? We generate revenue when the line places parts. Every single time that machine is down, we stop making revenue. That's why our goal centers around OEE. That is, except for rework, where you want the opposite. If we're super-efficient on the line, but we have a ton of rework, that's not where we want to be.

> "We have a lot of faith in our authorized suppliers.

That's where AOI will play a role in real-time factory awareness, so that boards aren't going into rework while the machine is still placing parts.

We started by making sure that material quantities were extremely accurate so that the machines could always place parts. Now that we have that wrapped up, we need AOI and MES to really be the players in terms of letting us know how the line is performing in real time. How fast can we get it on and off the line without rework?

Johnson: Are you doing inbound inspection?

Vora: Not as much. We have a lot of faith in our authorized suppliers. It's very rare they send us the wrongly unlabeled NPN with the wrong part inside the sleeve.

Carlson: It's almost zero—maybe a handful of times in 10 years.

Vora: We do inspection on first-time PCBs; we'll usually get the bare boards inspected. It works out well when you buy from authorized vendors.

Matties: When you think of test and inspection, what concerns you the most?

Vora: It's a scary moment when the first board doesn't pass that first test. The biggest fear is placing the wrong 0201 down—the one that's 100 per board—because the resistor looks exactly like the other resistor. Those are the fears we have more than whether it's going to pass test.

The first article is a very big deal. We're literally picking up every single part off the board, measuring it with some smart tweezers, and putting it back on the board. We're measuring every single reference designator. We do an initial AMI to match all the publications, all the case markings. First article inspection is where we put a lot of emphasis. Even before that, our incoming material station (IMS)—a table with a glass top that has a camera built-in underneath—is taking a picture of every single reel as it comes in; we're using the metadata off the reel to fill in our database with the data from that reel. We're trying to proactively

Inventory Management System at VAS.

ensure we don't have that problem when it gets placed on the board.

Johnson: That's where your digital factory starts.

Vora: That's right. How is any material handled as soon is it's walked in the door? How did it get labeled? Is there a verification after the labeling process? Even in the software we're looking at right now, there is a process to measure the part before it can have an approval with a unique ID in the system.

Carlson: One of our fears with AOI is false escapes; we're thinking things are fine, but something is wrong when it gets to the customer.

Vora: Sometimes the BOM from the customer is wrong. We programmed our AOI and the whole process to that BOM; getting the documentation correct saves us from thinking we're right vs. not being right.

Matties: Inspection starts at the data level.

Vora: With our current software, we have internal part numbers per customer; all parts are segregated by customer, so we don't share parts anymore. That was a decision we made to better manage the inventory.

We built software for use during the BOM introduction; it compares that BOM against all the parts we already have in our system and does any matching proactively. Every time an existing customer introduces a BOM, only 10–30% of the parts are new. We do a lot of that work up front.

We've created a few different pieces of software to help in that early entry phase. It helps because we can do that work at an expedited rate with added quality assurance.

Johnson: When a company like VAS must write its own software, it's usually because there's a functionality gap in the software from vendors that forces you to roll your own. Where are you finding gaps in the software?

Vora: Our MES search is leading us to find that about 85% of what we want is possible. Granted, it's not what we originally thought we wanted; we assumed the world was much more advanced than we're finding. Not to say we're smart, but we thought they'd already figured it out for us.

We're finding that everyone does things differently. There is not a standard way a manufacturing company operates, whether it's in equipment, process flow, or the software they're using; we're finding that no solution is perfect.

Most software now comes with usable APIs. Instead of building custom high-end software, we bought the API from our ERP. Instead of building our own database, we're enhancing our data, and the application on top of the data. That's where we find a lot of value.

As we work through our admin processes inside the ERP, we find more unsolvable process gaps than in our manufacturing process. I don't think ERPs are really built for EMS. There are a couple out there, and one of them did a clever job at solving the ERP dilemmas for electronics manufacturing services. That's where we find a lot of gaps. We have gaps in manufacturing, but we find that they're solvable through existing MES software platforms.

Matties: So, what's really giving all this optimization added horsepower is the digital factory and benchmarking your processes. That's how to get the most out of inspection these days.

Vora: Yes, workflow automation. Make the work flow through the company, rather than us having to touch all the work every time. We're headed in that direction and, eventually, we can add robotic process automation (RPA). Right now, our goal is workflow automation: How is the work finding its way to the next person rather than the person finding that next work?

Matties: Now, when you were benchmarking processes, were there any surprises?

Vora: The number one thing we learned was that when the machine was not placing parts, we weren't making money, and our facility was not functioning properly. Now, we actively look at that measure as we examine how our factory works. Our main goal is to automate that part of our operation.

The high dollar equipment is where the high dollars are. While Darren has been mentioning it for years, I started seeing and understanding it about a year and a half ago. I was building a logarithmic calculator that calculates, over time, how we should quote somebody. That's when I saw it: "If we're not placing parts, we're screwed, because that's what we're charging them for. No matter what, it costs us $30,000 just to open the door."

"Building the automated calculator to quote labor was what opened my eyes.

Building the automated calculator to quote labor was what opened my eyes. That's when we started benchmarking, and when we realized that we knew we could make changes pretty quickly as we had already solved the major problem of inventory management: unknown shortages, material locations in the building, known good material, etc. Really good data will help us do that. In taking the data and making use of it, we find value because now we have data that tells us something. Every little improvement after we do a dollar-cost average helps us to keep growing.

Matties: Benchmarking, I would think, tightens up your process windows, so your capabilities improved.

Vora: Absolutely. Darren is doing some fun things with changeovers. We're learning that when we get one of our highly skilled operators working as a changeover expert instead of an operator, we see improvements. We don't need him on the line; we need him as a floater. We thought, let's have him be our changeover guy.

Matties: Did that change your overall view of employees and how they're functioning? You're talking about upskilling and finding real value in people, and that's the greatest asset you have.

Vora: It is slowly changing our viewpoint every day.

Carlson: We've moved toward having multitasking employees. Even though we might hire them as an SMT operator, we're trying to find this cross-functioning working group that can go anywhere at any time.

> **"We've moved toward having multitasking employees."**

Johnson: What is your process for selecting new equipment?

Vora: We're big on references. We build up a form and send it to them. It should take about 10 minutes to complete the form. The form handles the typical questions, allowing us to focus on the questions that really matter.

Much of it is along the lines of how you rate the installation on a scale of one to five. How do you rate their support on a scale of one to five? If we find that referrals consistently say support is a five, we don't need to ask about it; we know what they will say. Then we hone that conversation in on the thing we need to learn the most about that equipment.

We're looking at two different manufacturers right now; one of them connected us with a company that used to have the same equipment as us. It was a very good conversation. We asked about their top three reasons for moving to a new AOI, and we found they had the same problems we had. This machine was solving those problems for them: false calls, good data, good SPC software. But even better, they'd already been integrated with a couple of the MES partners we're considering. That's a big deal.

We always ask the referral if they have an operator sitting there all the time. Did this new equipment put you in a position where you don't need an operator anymore? This is important because it means they trust the machine to do its job. If someone is always there, they don't have trust in it.

Do they have confidence that the AOI equipment is delivering the value that it's meant to deliver? Right now, we're looking at two vendors with very different technologies to interpret the board data. One of them has a unique approach on how to do AOI—laser-based plus 2D. Which technology offers a better result when it comes to that inspection?

Carlson: Our biggest challenge now is self-inflicted. We have four AOIs for three lines. They're all the same vendor, but they all have different field-of-view cameras, and two of them have different software packages. We're looking for continuity between lines; standardization with one program shared amongst machines. We're looking more at the big picture, long-term stuff to achieve that next level.


KYZEN
Where Science and Care Converge.
InstaTrak
The QUALITY of our solutions is directly related to the DEDICATION of the PEOPLE who make them.
ALLOW US TO APPLY OUR PASSION TO YOUR CLEANING CHALLENGES.

Johnson: What are the challenges on the horizon for you?

Vora: Component sizes are a big deal. I hate to keep saying this, but it will be all about the data. How well can this system integrate to make the data more aware and valuable so it can guide all these different pieces and decisions?

Planning and scheduling is a very difficult task, knowing that you can build a board on the right date at the right time. We might look at the schedule and see that these two other boards on the schedule have many common components and they're due a little bit later, so why don't we pull those up and build them all together? I think that's where AI will play a role. To do something like that, though, the data needs to be available so a "mother" can make the decisions. How many streams of data can you stitch together to understand factory awareness, and what do you do next with that data?

By buying brand-new AOI solutions, we're already thinking five years ahead. We're looking at the most advanced 3D systems, the most advanced technology; we might go down to the 7-micron level. I think we're already thinking that way, and that's why we're going for identical brand-new equipment across all lines on the same day.

To Darren's point, as soon as we start standardizing, we can hit the ground running much quicker on any next endeavor: Create a solid foundation that can handle quicker growth.

Johnson: Are you inferring that the software extensibility for your inspection equipment is very important to you? It's not so much the hardware or the specifics of the camera, but the ability to integrate to your current systems and extend them.

Vora: Yes, and that will be key. It's the thing that stitches it all together. One thing to mention is speed to program. Two companies we're looking at have two new AI engines that help speed up programming. What used to take two hours now takes 30 minutes. Things like that will be a big deal. People talk about AI, and there are a few good use cases already out there.

Matties: Any final advice for someone looking at their test strategy?

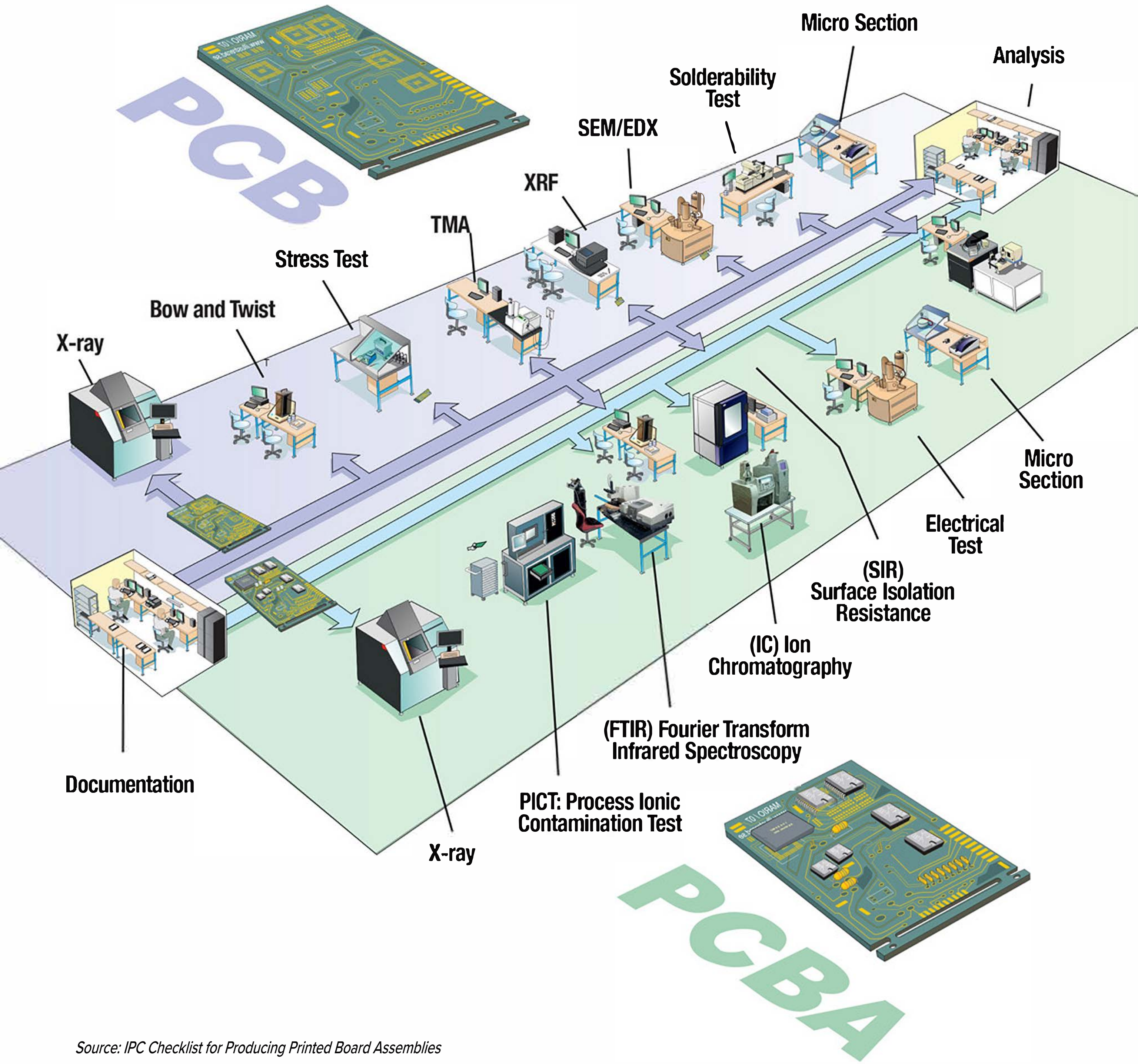
Vora: We are working on one piece of automation in our testing department. I'm sure many of the major companies have already done this, but we're high-mix, low-volume, which makes it more difficult to automate. We are working on automation, and we have an automation engineer who's good at CAD. We're building fixtures that attach to a six-axis robot with pogo pins. Those pogo pins are wired into a computer. We're automating programming and test because we do a lot of programming test day-to-day. It's an endeavor that we're really interested in. The challenge is how to do this in a high-mix, low-volume environment.

Planning and scheduling is a very difficult task, knowing that you can build a board on the right date at the right time.

Johnson: Well, thank you.

Vora: I appreciate you guys looking at us. SMT007

Anatomy of Inspection



Source: IPC Checklist for Producing Printed Board Assemblies

MilAero007 Highlights

Lockheed Martin Conducts First Flight In U-2 Avionics Tech Refresh ▸

Lockheed Martin Skunk Works, in partnership with the U.S. Air Force, completed the first flight of the U-2 Dragon Lady's Avionics Tech Refresh (ATR) program. The successful first flight tested the new advanced capabilities aboard the U-2.

Historic Wind Tunnel Facility Testing NASA's Mars Ascent Vehicle Rocket ▸

The MAV (Mars Ascent Vehicle) team recently completed wind tunnel testing at NASA's Marshall Space Flight Center in a facility that has been a critical part of NASA missions going all the way back to the Apollo program.

U.S. Government Awards GlobalFoundries New $3.1 Billion, 10-Year Contract for Secure Chip Manufacturing ▸

With an initial award of $17.3 million this month and an overall 10-year spending ceiling of $3.1 billion, the new contract provides the DoD and its contractors with access to GF's semiconductor technologies manufactured at its U.S. facilities. These GF facilities are DoD-accredited to the highest security level, Trusted Supplier Category.

Cadence to Acquire Intrinsix Corporation from CEVA ▸

Cadence Design Systems, Inc. and CEVA, Inc., a leading licensor of wireless connectivity and smart sensing technologies, announced that they have entered into a definitive agreement for Cadence to acquire Intrinsix Corporation, a wholly owned subsidiary of CEVA and a provider of design engineering solutions focused on the U.S. aerospace and defense industry. The purchase will bring Cadence a highly skilled engineering team that has expertise in advanced nodes, radio frequency, mixed-signal and security algorithms.

RAF Invests in BAE Systems' Most Advanced Fighter Pilot Helmet ▸

Developed at BAE Systems in Rochester, Kent, Striker II is one of the world's most advanced fighter helmets which uses the latest technologies to integrate its all-digital night vision system and daylight readable colour display. Striker II displays data directly onto the pilot's helmet visor, providing an augmented reality of the real world alongside mission critical information right before their eyes.

SAIC to Modernize U.S. Space Force Ground Based Radar Maintenance and Sustainment Services ▸

Science Applications International Corp. announced that it has been awarded a $574 million contract with the U.S. Space Force (USSF) to support its Ground Based Radar Maintenance and Sustainment Services (GMASS). Under SAIC's leading system integration services and expertise, GMASS provides an opportunity to augment Space Domain Awareness.

Saab Opens New UK Radar Production Site in Fareham ▸

Saab UK's Sensor Systems business will act as a Centre of Excellence developing follow-on UK Intellectual Property in the radar domain. It will also grow to maintain existing radars in-service with the UK Ministry of Defence.

Compose Yourself, Mr. Ford

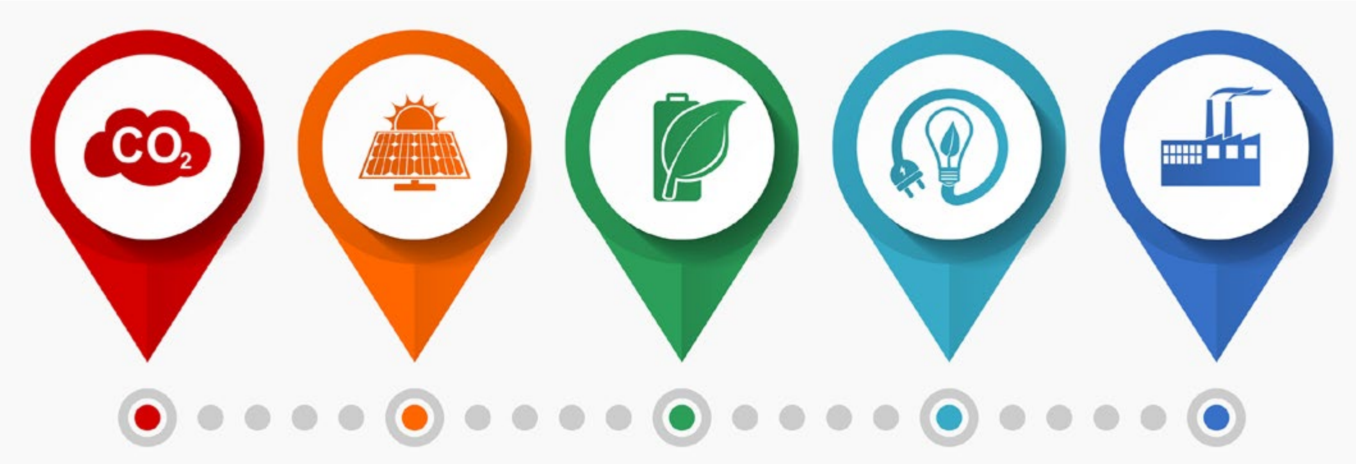
Smart Factory Insights

by Michael Ford, AEGIS SOFTWARE

In his time, my "Uncle Henry" Ford sparked an industrial revolution; efficiency in mass production enabled the manufacturing of common products that everyone could enjoy. However, this ideological approach to manufacturing has been refined to such an extent that it's no longer viable. When it comes to efficient manufacturing technology, there is a new generation in town, and it is music to my ears.

A Look Back on Mass Production

The evolution from mass production into flexible mass production configuration was built on a flawed premise. At the time, the intent was that each black Model T shuddered off the production line like clockwork, each car representing an immediate sale. The mass production principle requires that the final assembly line runs continuously, not stopping



for any reason. This is great as long as there is a continuous demand, sufficient quality, and on-time delivery in the supply network. Yet this practice spawned a series of compromises, hidden under the guise of "doing business," which became an accepted and unwanted part of the mass production business model.

For mass production, sales organizations have been under pressure to maintain the smooth flow of demand. Large OEM companies found that they could link advertising campaign expenses to customer demand influence. It was just a cost of doing business. Unfortunately, competitors used the same tools, disrupting carefully-crafted demand patterns, which resulted in the need for another marketing tool—and discounted another cost of business. Of course, competitors were doing the same, all generating a spiraling, cost-driven sales strategy.

As this was unsustainable in terms of profitability, pressure turned toward designers to create unique and compelling technology that could be used to differentiate new products against competitors. The race for novel technologies was expensive (but newsworthy) as products became smaller, lighter, less power hungry, and smarter—ironically also becoming larger, heavier, and more power hungry. As technology innovation became too expensive to sustain, the need for interoperability and commonization of technologies greatly weakened this approach.

The principle of mass production itself, therefore, in many cases has come under threat. Lines that ought to have been performing continuously were stopped, as the significance of excess inventory cost in the distribution network was included in the overall calculations. Product changeovers on assembly lines were even more necessary, which increased product mix, and reduced lot quantity. Again, this came at a high and hidden cost. Not only were key machines not adding value for much of the time—a fact that most companies somehow kept hidden from their business management—but ironically, more goods inventory was needed to cope with batch production, and to meet the increasingly volatile demand from the distribution network.

The automotive industry could not survive under such conditions, opting instead to build mass production lines that included the ability to work with variation on the final assembly line, at least to an extent. The final glory of the automotive mass production line now looks quite different than the original Model T line in that there is now a wide variety of colors and models, and performance, comfort, and indulgent options. Sophisticated sequencing systems manage the creation of each individual product with surgical precision. Millions of different combinations can be supported by just one continuous line.

What Are the Trade-offs?

This flexibility has come with significant (and mostly hidden) costs. Though the final production line works smoothly, the pain and cost of variation is passed upstream to suppliers, who receive a high variation in demand, together with the need for perfection in quality, as well as just-in-time delivery. Suppliers, in turn, had difficulties with their suppliers to whom they could not commit to an accurate demand forecast for materials or components. Supply-network issues and increased risk, as compared to other industries, quickly became very damaging, as we saw with post-COVID supply network issues.

Another symptom in this accumulation of problems, particularly in the car industry (even pre-COVID) was the lead-time from the date an order was placed to when it was delivered. Sometimes it was even a half-year before the order was fulfilled, which deterred many customers. At the same time, more basic "filler" specifications were inserted into the schedule to keep the line running, which could be sold through dealers or online third parties. We have seen bizarre inventory holding practices, with unsold cars kept in fields because they required significant discounts to resolve.

"The economies of Henry Ford's mass production only worked because he was the first.

These costs and losses mean an extreme amount of waste. The economies of Henry Ford's mass production only worked because he was the first. This evolution of endemic waste has led the industry toward the next industrial revolution—Industry 4.0—which for most of manufacturing remains an enigma. This is partly because Industry 4.0 takes us backward, rather than forward. Before Henry, products were made to order, tailored to a customer's requirements. For much of manufacturing, the market has either reverted to this or is on the way there. The throwaway culture is being replaced, whether we like it or not, with one based on value and sustainability. Manufacturing, therefore, must come up with a new take on this old challenge.

We have quite sophisticated technologies at our disposal that were not available in Henry's time. From the hardware perspective, automation is now quite adaptable and, based on its programming, able to handle varied requirements. Such program data, as well as instructions for manual assembly, can be tailored to each production lot. Simply by reading the incoming production unit ID, the appropriate set of instructions for setup and assembly are presented, which may even be bespoke to each individual article. The role of the modern MES is to ensure that the individuality of each operation is automatically managed and executed, with full visibility of progress, completion, and material management.

For many, the instinct is to shy away from this principle. Lean cell production, for example, though it has proven successful at matching the effective levels of mass production, is considered rather too extreme because of the complexity of stations and operator training for most manufacturing applications. The state of the art has become the idea that real-world manufacturing can neither be supported by a mass production derived model, nor by Lean cell production. Both approaches represent ideals in which the business must compromise.

Positive contributions to the business from sales, marketing, and the distribution network have always trumped priorities from the manufacturing floor, which has been expected simply to be the engine in which products are made. Companies find it difficult to invest in manufacturing and have been quite happy in many cases to see the responsibility of such placed with a third party in a location on the other side of the planet. Not the greatest way to form the state of the art.

A Modern Approach

Composable manufacturing is a more modern approach. Rather than fighting and resisting patterns of customer demand, composable manufacturing embraces them. Driven by digitalization, it hits the sweet spot between mass production and Lean cells. Composability allows work to be freely assigned across capable production stations, exactly as needed, including high volumes, mixed lots, and even individual tailored products. Composable work instructions are derived directly from design data, following composed user interface and machine program templates. Based on a product-centric data model, flexibility to choose the best production configuration can be done quickly and easily without engineering burden. Both operators and machines simply follow the individual set of tasks. During execution, traceability information is continually gathered, with confirmations of each completed step, ensuring that no mistakes or omissions are made.

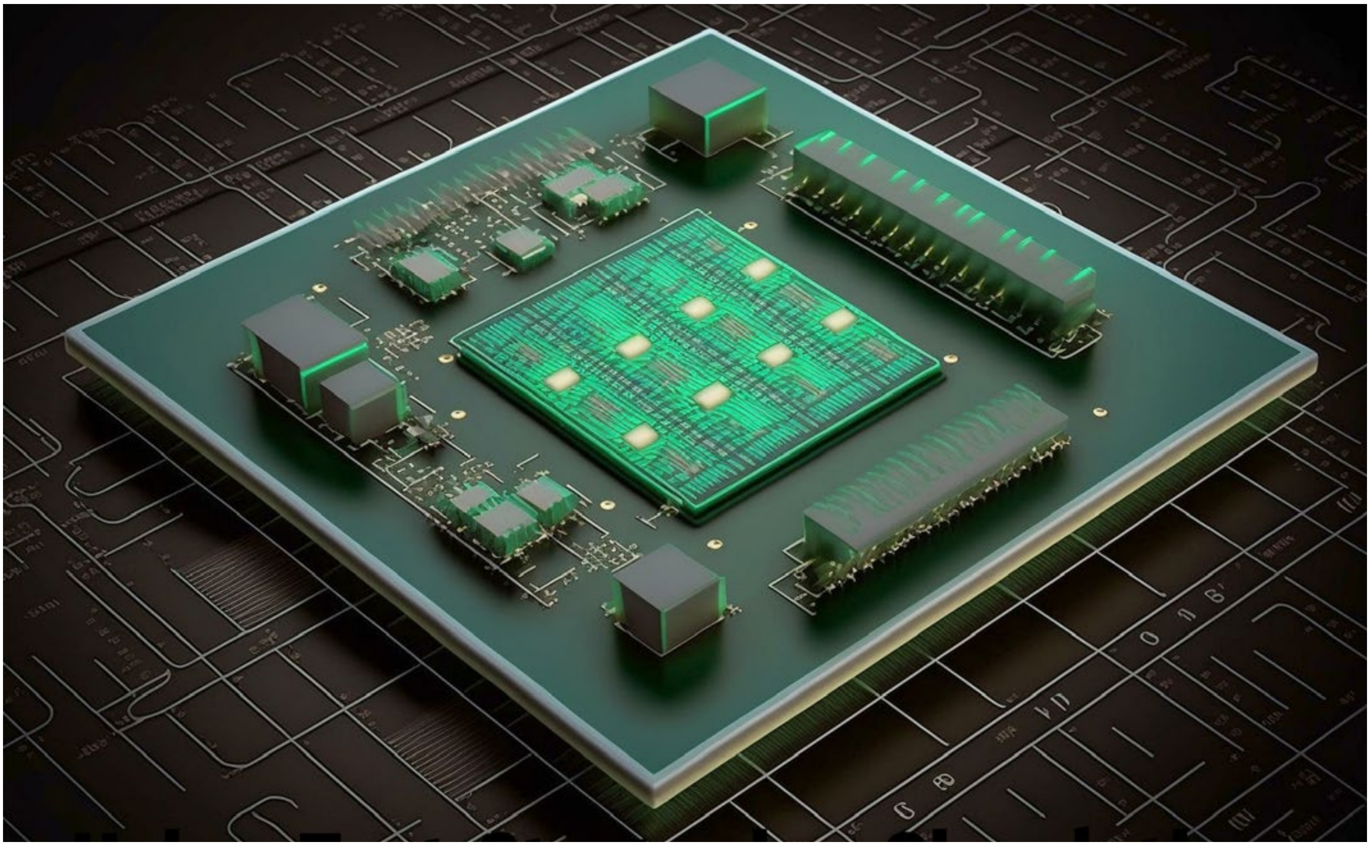
> Composable manufacturing is a more modern approach.

Traceability information, in the form of data collection from both manual and automated operations, brings visibility and control when composing the flow and distribution of work allocation, and materials on an internal just-in-time basis. Adaptive planning ensures that the entire hierarchy of manufacturing assemblies and final products exactly meets shipping requirements without the need for a stock of excess finished goods and with an almost eliminated risk of delivery delays. This is the core principle driving Industry 4.0, addressed precisely and uniquely by composable manufacturing.

A factory based on composability can make any product efficiently, in any quantity and configuration, whenever it is needed. The potential effect on the business is significant. Sales and marketing are no longer compromised by the need to sell out excess stock of near obsolete products stuck in the distribution chain. Factories can take advantage of competitor weaknesses throughout the product lifecycle. Using new or updated technologies can be introduced far more rapidly. Composable manufacturing enables locating manufacturing back to the target market, eliminating multiple hidden wastes in the distribution chain. Composability is the natural choice for industries that need to be close to their customers by eliminating distribution cost wastes and being both agile and efficient.

The modern MES solution does not simply automate what is already there. It does not just gather data and leave the customer to decide how to use it. Modern MES drives the best new manufacturing practices that meet the evolving customer demand patterns, and that emphasize quality, availability, value, and cost performance—in contrast to the environmentally challenging, cheapest, and discardable products. Composable manufacturing is for the factory of the current, as well as the factory of the future. SMT007

Michael Ford is the senior director of emerging industry strategy for Aegis Software.
To read past columns, click here.



Using Test Strategies Simulation in Test and Inspection Workflow

Feature Article by Will Webb
ASTER TECHNOLOGIES

Applying test strategies simulation to the test and inspection workflow should be top of mind in the digital age, yet we notice that many engineers are still not applying this critical piece to get the test and inspection workflow optimized.

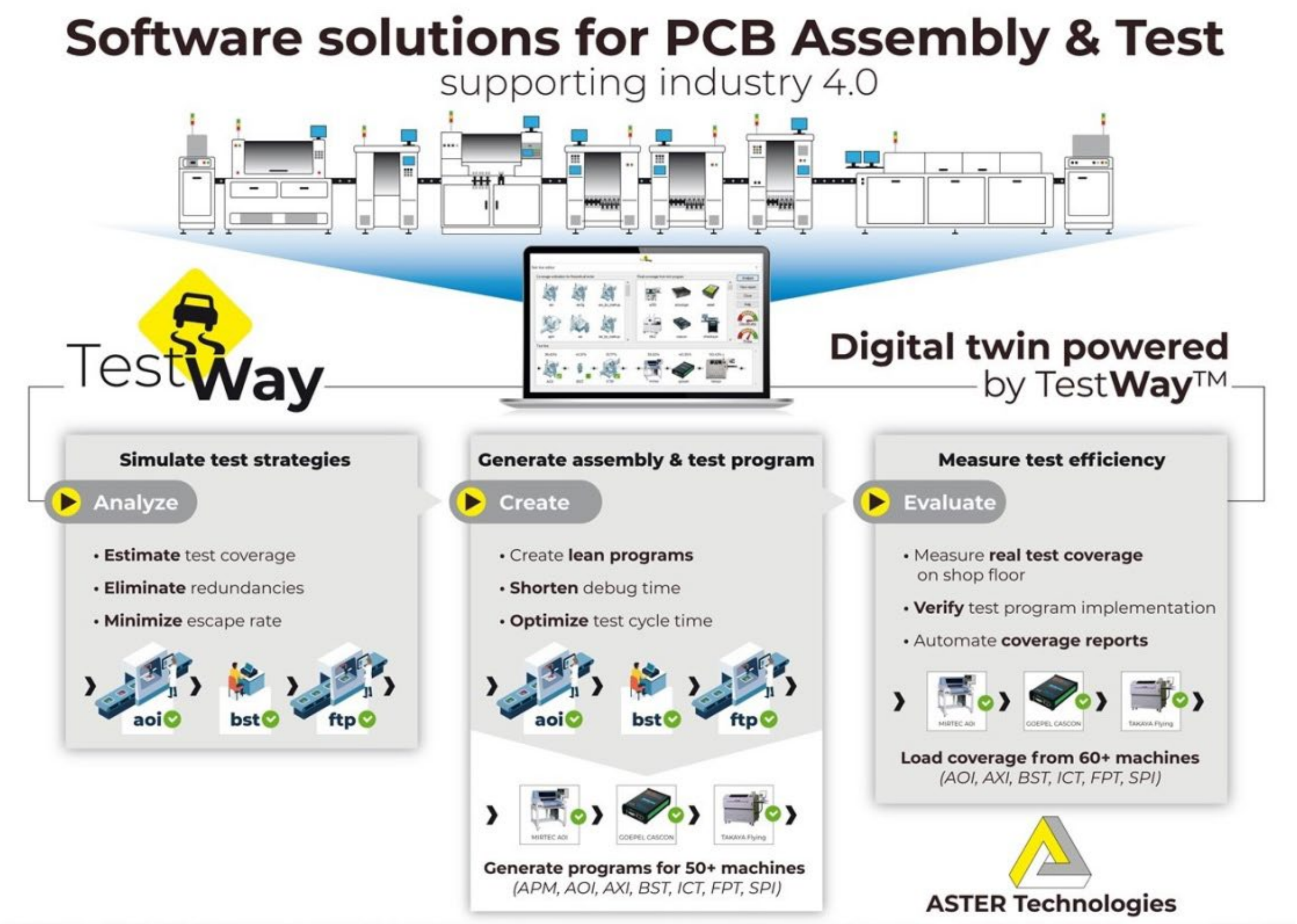
In the past, test engineers tended to focus on one piece of the test and inspection workflow: AOI, boundary scan, ICT, flying probe, functional test, and the like. In their focus on one strategy, they generally ignored the other test and inspection tests, and had little idea of what was and was not covered by these other strategies. Essentially, applying the maximum coverage from their area of focus or assuming what pieces may be covered from other strategies is like taking a shot in the dark because you don't really know the facts.

The key to designing a good test and inspection process is to model that process before starting to produce test programs and then see the coverage results reflected. The concept is to build a digital twin of the test and inspection process to get the visibility that's needed to make important decisions.

Digital twin relates to the test and inspection workflow by using data analytics or AI-driven simulation technology to create predictive models which have been tuned and can continuously be tuned based on real test results. Simulation models allow the user to determine the effectiveness of the test and inspection steps. Where are coverage duplications that are not needed? What components still have missing coverage or low coverage from the process that need supplementation or more creative solutions to achieve the desired test coverage?

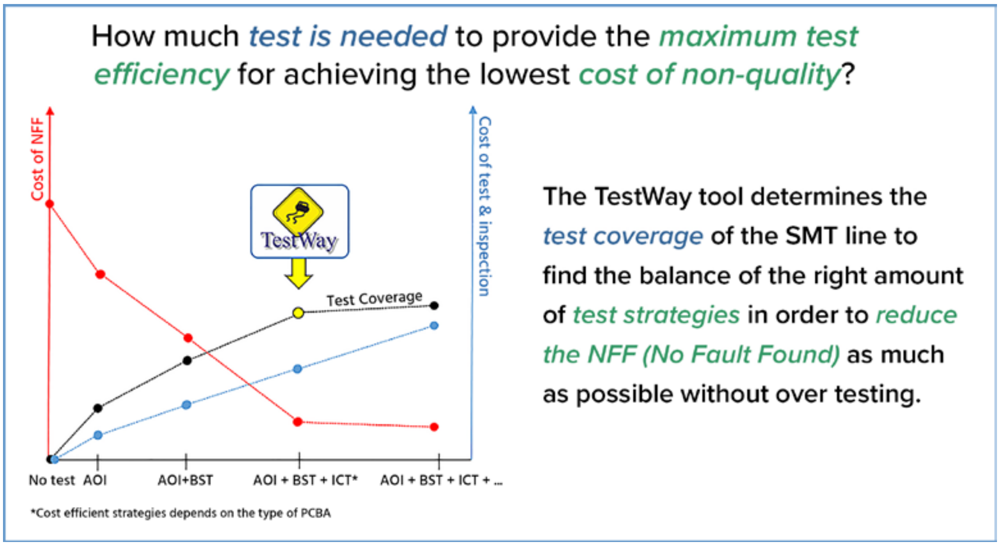
A good predictive model of a test strategy will allow a comprehensive report to be generated about the coverage as it applies to the board being examined. The simulation model for each test strategy needs to know the strategy's capabilities. For example, if we're looking at AOI, what type of machine will be used—2D or 3D? Will it have good camera resolution, or laser capability for planarity and tombstoned components? With what effectiveness can solder joints be examined? The model can then be tuned to reflect the machine to be used and predict the test coverage offered by the machine on the board. The same idea can be applied with other test strategies, such as X-ray, ICT, flying probe, etc. Depending on the machine to be used, the model needs to understand the capabilities, accessibility of the board, and the way some programming features will be used to, again, produce a report of comprehensive test coverage.

All the planned or intended strategies need to be summed up together to look at overall coverage of the test and inspection process. These simulation results then need to be analyzed for duplicate and missing coverage. Duplication of coverage between test steps can be optimized to remove redundancies that result in less test time and development expense. In some cases, the results may show that a particular strategy or test and inspection step is not needed at all. An understanding of the results will also show where the lack of coverage is; what compo-



nents are missing coverage or have low coverage that results in test escapes.

A long-standing question that layout engineers have asked of test engineers is whether accessibility can be improved and where the layout engineer should concentrate on adding the test access. Are there some accesses that will be more beneficial than others? Yes, of course, but we need to understand where the most likely test escapes are. Predictive coverage simulation will show where the most benefit will be to add missing access, if possible.



One of the concepts being applied with the simulation of structural test strategies is the idea of "pushing test left." If good results can be achieved with the structural test strategies, then perhaps functional test can be reduced.

Functional test has two significant issues that lead to difficulties: The cost of implementation of functional test can be high for complex boards, and the diagnostic resolution from functional test can be difficult, which requires advanced training for technicians and can lead to bone piles of boards that can't be diagnosed or fixed. If most of the coverage can be pushed "left" to the structural test where diagnostic resolution is better, then functional test can concentrate on only the areas where coverage just can't be achieved with structural test. This will result in quicker functional test times, and fewer functional testers to be deployed. Also, the predictive coverage simulation will show which components are not able to be tested in structural testing, giving the technicians the knowledge of where to look for defects on the functionally failing boards.

From these ideas, you can see that if predictive models of the test strategies are performed, and continually tuned with available data, you can gain a thorough understanding of the coverage on the board prior to implementation and development of the test programs.

Instead of driving for as much coverage as possible at each test strategy, a more intelligent method can be used which places the right coverage at the right strategy, substantially reducing wasted duplication and therefore providing cost savings. We can then apply this idea to the CAD conversion process for producing the test programs, performing real coverage measurement to evaluate the results, and check that the results match the simulation.

This all means a nice feedback loop in the process that allows tuning of the simulation models and the actual test process, so improvement is always being made. What better way to use the concept of the digital twin than to achieve real benefit in the test and inspection world where the results will be quickly evident? **SMT007**

Will Webb is technical director at ASTER Technologies.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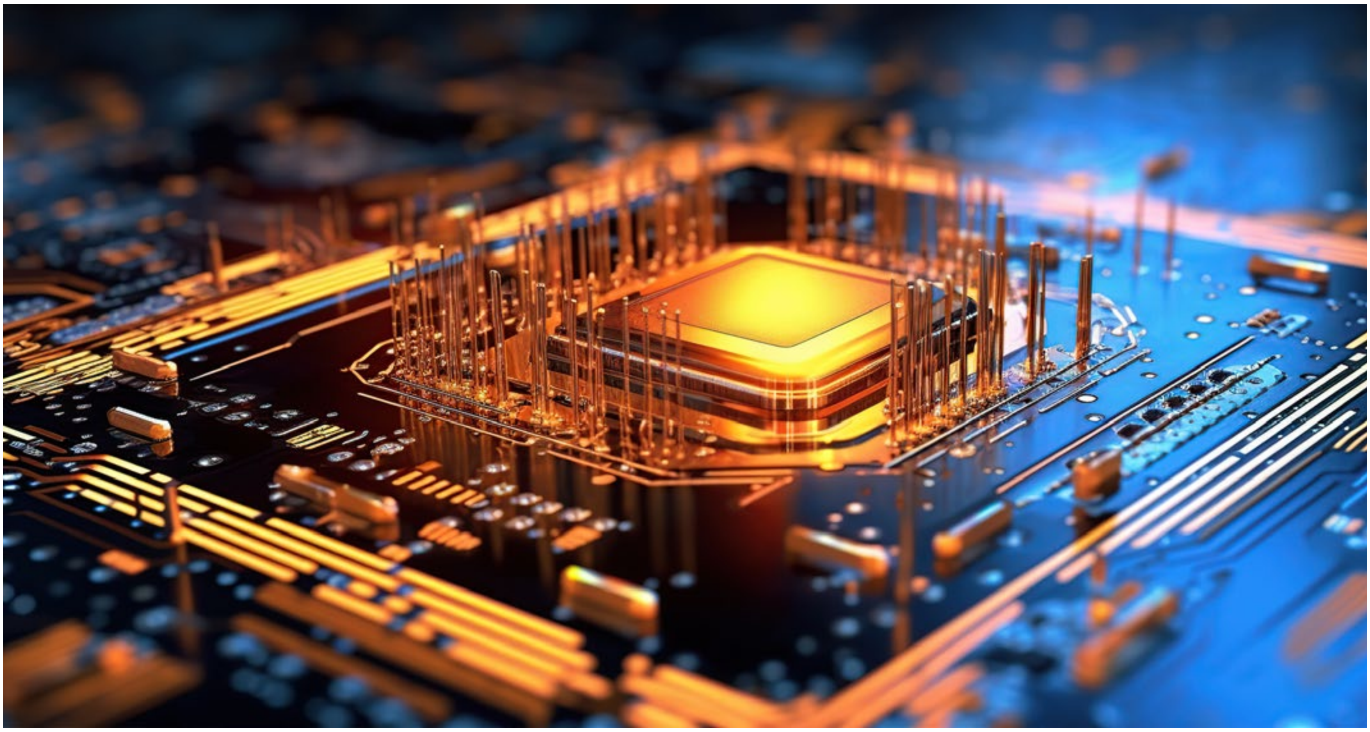

Smarter Design Means Smarter Test and Results

Feature Interview by Nolan Johnson
I-CONNECT007

Nolan Johnson speaks with The Test Connection Inc.'s Bert Horner about the pragmatic realities of life as a contract test company. To no one's surprise, data is at the center of the business. As the conversation proceeds, however, Bert shares insight on how the data's use is shifting inside his test services and with his OEM customers.

From your point of view as a test services provider, which new equipment developments are most valuable to you right now?

It would be the software tools for processing board level data for test development. Making that more user friendly allows test engineers who are not software developers to process information in a friendlier format.

Tools which allow limited access testing while still allowing a successful test on an assembly are another advancement we are seeing in the automated test. We relied on basic boundary scan because that was all we had. With high-speed digital, we can allow access. The big guys have all jumped on board with it, and now you're seeing some camaraderie or sharing of tools: A Corelis or XJTAG will work with a Teradyne or Keysight and an in-system programmer will work with a Seica or Takaya. We have more tools in the tool chest to work with.

So, it's very important to have the ability to interconnect devices through data protocols like CFX, JTAG, etc.?
Speaking as a test service, yes, the collaboration of the different test equipment manufacturers to help identify our challenges is key to see how their tools can help our jobs not only get easier but get better coverage.


Bert Horner

Let's talk about that interoperability. What does a day in the life of a test service look like? How does that integration give you better results and efficiencies, or a competitive advantage?
I characterize it in three or four different ways. As a test service, you're "the expert," and they lean on you to serpentine through the test process to give them the best bang for the buck. You're utilizing the tools for better testing, and that helps us as a test service.

Instead of trying to over-engineer something, if the tool is built into the test solution, and the customer and you both have that tool, you can reduce the number of pins.

Third-party companies, like ASTER Technologies, have tools to help test applications change how we test product, so you can now fit it on a smaller machine because now you will utilize tools, like boundary scan, and you can remove some of the pins from traditional ICT. You're able to make things fit into a smaller tester, if you will, with the combination of the different testers.

Finally, there's speed of test. You can couple those different test strategies. For example, Seica has a tool called FNode that can do a characteristic type of testing instead of doing point-to-point testing all over the place, which takes time. That adds value to us, because now if the board is passing, we can use a quicker test. It's when you have a failed board and you do the traditional shorts and opens on the flying prober that give you a quicker turnaround. Production is happy we can turn product quicker. It's a win-win for both the customer and us.

That seems like that would be very efficient: Triage, then a detailed diagnosis.
Right. As you get more experienced with these tools, you start looking at trends and seeing where certain failure characteristics happen. Now your test engineer and test operator become more familiar with a product.

At any given moment, we have a five-year window with a tool. Brand A is better at this process today, but three or four years down, maybe there's another vendor with a tool that's just a little bit quicker, more thorough, and a better fit for your tool chest. Every three to five years we evaluate the technology.

We saw it with the flying probe vendors. At one time they were all horizontal; now they're vertical. Some of the vendors, like Digitaltest, are partnering with companies like Feasa Enterprises, a supplier of LED testing tools for color and intensity, and SMH Technologies, which makes a programming pod to get even more functionality. SMH is working with many of the test vendors and embedding the programmer into the machine, which saves us cost on the application. The in-circuit testers, like Keysight and Teradyne, have a similar track with creating new software test tools to allow your existing (but current) hardware to stay relevant for testing the newer technologies that have been introduced.

There's an obligation—and discipline required—on the part of the OEM design teams to set you up to succeed at that as well. What can your customers do to make their experience better when using a test service?

The newer designs have access to all the data. The key is disseminating that data to the test service. We still see many long-life boards that are five, 10, 15, 20 years old. Just the bare minimum of the data is there. Avionics is a good example of that, where you'll see a system that was designed 10 or 15 years ago, and they will still be building it for the next 10 or 15 years. Data and documentation are the challenges. Maybe we don't have an updated schematic, or it's been scanned three times from paper and it's hard to read.

Has current test equipment made the older legacy work better or easier for you?

We can reverse engineer a board today. I can take a raw PCB and create Gerber files. We can create ASCII CAD. One must ask, "Do you want your test guys to re-engineer your board to come out with the design files, or is it cheaper to go back to a designer and get updated data?" We process Gerbers all the time here, but at the same time, it's a manual or semi-manual step.

> "We can reverse engineer a board today. I can take a raw PCB and create Gerber files.

You're suggesting that for some long-life designs, it's time to bring them into the 21st century?

Yes, we still see stuff that is 1980s technology that needs to be built and tested. There are other times you must break free and say, "Look, we need to update that design data."

Let's talk about the user interface improvements you mentioned. What's going on there, and how does user interface development help?

We don't have to use the native tester software to do everything. We use the software to process certain BOMs and CAD files. With these interchangeable solutions, they have all made it more automated, reducing the chance of human error, even from a newer developer of tests. Now the challenge becomes ensuring that the data supplied is current and correct.

Can you quantify that? In 2018, for example, what it was like to set up and test a brand-new job? Compare the effort involved then to what you're doing now. How has that changed?

The tools are more automated in handling certain known factors and setting up format of data is more flexible. They're building more intelligence into the parsing tools. Back then, we had to describe things a little bit more in the parsing algorithm. Now it's built in with its own level of intelligence. When we pull in a new BOM, it's intuitive: It will see certain measurements and description files, and it recognizes the data type.

Would you characterize it as predictive?

I would say it is predictive to a certain level. If it predicts wrong, it's a lot easier to clean up one or two errors than to describe the whole board to the tester. That process is a lot smoother than to go through the development cycle by brute force. That's what test engineers had to do back then.

How long would a setup process take?

In 2016 to 2018, a 300-node test job took a full day just bringing in the data. Now, it's probably 20–25% more efficient, and it seems to be getting better each time we talk to our partners; we're pretty active in the dialogue with all the ATP in the tester manufacturers. They'll say, "By the way, it came out last week." The big guys are very much leading the way. They're listening, and they keep my tester relevant.

Is it fair to say that the differentiator with test equipment now is in the software more than the hardware?
It's still 50/50. Software can make it more user friendly and can automate some stuff that you wouldn't normally see.

Mirtec is an example on the inspection side. When you're bringing different devices into the library for storage and reuse, reallocation and such, the tool is tremendous. We're breezing through that part of the process. I know all the inspection tools have some flavor of that software but it's amazing to see it in action.

What do you think is currently missing from test equipment, and what's on your wish list?
I would say what's missing is a good synergy. When you talk to Keysight, Mirtec, or Teradyne, they have great coverage analysis; they're all different, yet they're trying to speak the same language. ASTER is a third-party tool, and it's bringing in different formats, putting it into its own language. A software developer at these companies will see the report differently than will our people on the floor. Something does get lost in translation.

So, they're headed in the right direction. They need to just keep doing more of the same.
I'll tell you the truth: More mil/aero, medical, and automotive customers want that drill-down data. Our customers want us to do data dumps back into their systems. They harvest that information using their quality systems.

The whole idea of a closed feedback loop, or even all the way up to the designers, is just on the verge, isn't it?
I have medical, aerospace, and industry control customers. As soon as we finish a program, they're asking us to give feedback to their designer. They're already looking at what to improve in the next rev. They'll say, "Why couldn't The Test Connection test this?" I respond, "You didn't give us access to this enable pin, or you didn't have this pull up; you didn't have that pull down. You didn't give us access to this pin." When we pass that information back and they're able to put it in, you're addressing their test coverage.

What you're describing is the vision we've had for quite some time in DFX. Are we on the threshold of that vision?
I really think we are with OEM tools from Keysight and Teradyne, as well as third-party tools like those from ASTER Technologies and Mentor Graphics. There will always be some disconnect as OEMs outsource to contract houses and third-party design groups, but if the data is there, and people are willing to share that data to the OEM or give the designer that feedback, they will know what to do "better" in the next design.

Fantastic. Bert, thank you so much.
Always a pleasure. **SMT007**

Collaborating to Develop AI-powered Smart Assembly Processes

Feature Article by Brent A. Fischthal
KOH YOUNG TECHNOLOGY

In electronics manufacturing, automated production has undeniably revolutionized the industry, enabling the creation of high-quality products at an unprecedented scale. However, it comes with its own set of challenges, particularly the potential for specific failures that need human intervention. The rapid advancements in technology, such as the Industrial Internet of Things (IIoT), big data analysis, cloud computing, and artificial intelligence (AI), have ushered in the era of Industry 4.0 and promise more intelligent manufacturing processes.

Smart manufacturing, a pivotal part of this transformation, relies on real-time decision-making based on operational and inspectional data, seamlessly integrating the entire manufacturing process into a unified framework. This digital transformation of cyber-physical systems enables proactive responses to uncertain situations while ensuring heightened efficiency.

In the context of printed circuit board assembly (PCBA) with surface mount technology (SMT) lines, IIoT technology accelerates data collection on equipment status and production quality. Data-driven solutions powered by AI and machine learning algorithms can diagnose abnormal defects, as well as adjust machine parameters on the fly in response to unexpected changes during production. Collaborating with various SMT industry partners, researchers at the State University of New York at Binghamton (Binghamton University) have developed a groundbreaking framework based

Professor Daryl Santos (left), Systems Science and Industrial Engineering, in the lab with a research student at Binghamton University. (Source: binghamton.edu)

on AI-based closed-loop feedback control and parameter optimization. This innovation promises to implement a smart manufacturing solution in the PCB assembly, with a focus on improving yield and throughput. This AI-based framework holds the potential to pave the way for data-driven process control in SMA.

Binghamton University Collaboration

Since 2016, Koh Young Technology and the Smart Electronics Manufacturing Laboratory (SEMLab) at Binghamton University's Integrated Electronics Engineering Center (IEEC) have been collaborating on several key research initiatives to improve the assembly process in electronics manufacturing using AI integration. The aim of the SEMLab is to develop smart electronics manufacturing solutions using data science and AI principles to manufacture sophisticated printed circuit board assemblies with a focus on advanced robotics to revolutionize the electronics manufacturing process with improved yield and productivity. With automatic optimization, real-time intelligence techniques, and the implementation of advanced analytical approaches to the data collected from the equipment, the smart systems can deliver fewer defects, higher productivity, and increased reliability with cost-efficient results.

> "In PCBA, each step significantly affects the final quality and throughput of the PCB product."

The team from Binghamton University, including Dr. Seungbae Park, Dr. Daehan Won, Dr. Sangwon Yoon, and Benson Chan, have helped deliver several beneficial studies that drive Koh Young to further refine and deliver AI-based solutions. The research involves developing closed-loop control and optimization modules using self-optimization and AI-based diagnostics for process enhancement in the printed circuit board assembly. This research is clearly advancing PCBA with innovative artificial intelligence and machine learning techniques.

Machine Intelligence in PCBA

In PCBA, each step significantly affects the final quality and throughput of the PCB product. The solder printing process, for instance, is a critical operation that causes nearly 80% of PCBA soldering defects. Printing faults, characterized by an inadequate volume of solder paste on PCB pads, can lead to board failures and substantial rework costs. The component mounting process, encompassing expensive machine investments and extended production times, is another high-cost procedure. Meanwhile, in the reflow process, the quality and reliability of solder joints are contingent upon reflow oven temperature and related settings. Consequently, inspection machines, such as solder paste inspection (SPI) and automated optical inspection (AOI), can enhance PCBA.

Specifically, including two independently-linked AOIs in the PCBA line before and after reflow can detect component defects.

As electronic components shrink (e.g., 0201M components), PCBA-related failures increase. The SEMLab has the tools in place to help find solutions: solder paste printers, component mounters, and a reflow oven, as well as Koh Young SPI and AOI machines. Extensive testing on over 8,000 PCBs revealed that numerical methods based on physical properties may have practical limitations in explaining the behavior of small-scale components. This is often due to unknown environmental factors—temperature, humidity, machine calibration, measurement inaccuracies, and

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vibrations—which can influence PCBA quality. Research demonstrates that AI-based methods can enhance product quality by up to 35% and reduce scrap rates compared to traditional approaches. This suggests data-driven intelligent process control can advance PCBA significantly.

Intelligent Inspection Modules

The goal of smart PCBA is to maintain optimized settings both offline and online. AI and data analytics solutions can optimize PCBA process parameters before production (offline control) and during production (online control). A printing advisor module uses sophisticated data-driven methodologies to improve the printed circuit board quality and increase process robustness. Reinforcement learning approaches developed a printing optimization module to achieve intelligent control of printing parameters. Also, a printing diagnosis module will reduce the operational costs and potential failures by identifying and preventing the root causes.

Using deep learning models like convolutional neural network and recurrent neural network, we can detect a potential anomaly in the PCBA to ensure high operation reliability and smart process control. Yet, beyond print process advancements, collaboration is helping drive component mounting improvements. Testing is underway on modules designed to identify optimal component placement positions by predicting post-reflow positions based on data collected by SPI, pre-AOI, and post-AOI machines, as well as offering adaptive placement adjustments during production. Preliminary results show an 18% reduction in misalignments compared to conventional placement methods. Moreover, the module uses operational and AOI inspection data to trace the root causes of mounter defects and prevent future failures, achieving an 84.5% accuracy in finding known root causes. These efforts not only save time and labor but also enhance the automated PCBA process. The innovative electronic manufacturing solutions from this project will promote the sustainable success of the electronics manufacturing and improve the competitive advantage with efficient manufacturing decision making, improved product quality, and increased profitability, while advancing Industry 4.0 development for PCBA.

Summary and Conclusion

The increasing complexity of PCBA, driven by the demand for small-scale electronics products, requires innovative solutions. With AI and big data harnessed from various inspection operations, PCBA can become intelligent and adaptable in response to dynamic environmental conditions. By maintaining the ideal process parameters throughout the processes, AI-powered tools can help manufacturers improve quality and yield without sacrificing production speed. Automated, smart systems open the door to the next level of electronics manufacturing by utilizing data from end-users to facilitate customized product manufacturing with enhanced efficiency for high-mix/low-volume production. This not only expands the possibilities for design variations but also accelerates delivery times, ushering in a new era for electronics manufacturing. **SMT007**

Brent A. Fischthal is head of global marketing at Koh Young Technology.

Additional Resources

The Printed Circuit Assembler's Guide to... SMT Inspection: Today, Tomorrow, and Beyond

The Companion Guide to... SMT Inspection: Today, Tomorrow, and Beyond

The Big Reveal

Maggie Benson's Journey

by Dr. Ronald C. Lasky, INDIUM CORPORATION

Editor's note: Indium Corporation's Ron Lasky continues this series of columns about Maggie Benson, a fictional character, to demonstrate continuous improvement and education in SMT assembly.

Professor Patty Coleman looked in the mirror and she could definitely see it. She had gained 15 pounds. Actually, it had been 17 pounds, but she had lost two pounds in the past two weeks after she stopped eating ice cream. She was a victim of the gelato and ice cream shops that had opened in Ivy University's hometown of Hanover, New Hampshire. She found coconut gelato and peach ice cream irresistible. However, she knew she had to stop after the day she had one of each. To make matters worse, she hadn't been exercising as regularly because she was so busy with several research proposals and helping her twin sons in the adventure of applying to colleges. It was still hard for her to believe that they were seniors in high school.

In no time at all, Patty was heading out of the door for the 30-minute trip to Ivy U. She was excited to see how Paul LaCroix made out in developing his "profitability potential" analysis. However, she was a bit concerned about Hal Lindsay, the Excel salesperson.

As Maggie Benson pulled into the parking lot of the engineering school, she felt a bit sentimental. Could it already be 10 years ago that she had graduated? She saw a few students and was shocked at how young they looked. Oh well, time marches on. Maggie was excited to see how Paul had done his cost of ownership analysis. Hal was sure persuasive in his pitch that his component placement machines had the lowest cost of ownership.

Patty had arranged for a large conference room as there was quite a crowd to review the proposals from Hal and Paul. Maggie, the executive from Benson Electronics (BE), would be there, as would Andy Connors and Sue March. Several students and some BE process technicians were also in attendance. Patty asked Maggie to kick off the meeting.

"I would like to thank everyone for coming, Maggie began. "Now, let's get down to business. BE needs to install a new assembly line as our business is booming. Obviously, we would like to minimize the cost of the new line, but we want it to have the capacity to meet the growing needs of our customers. I have asked Hal Lindsey to be the first to share with us his perspective on how Excel component placement machines (CPMs) are the best solution. Then, student Paul LaCroix will present his analysis comparing Excel to Pinnacle. Hal, the floor is yours."

"Thank you, Dr. Benson," Hal said. "I performed a cost of ownership analysis between Excel and Pinnacle CPMs as seen in this spreadsheet. The price of the Excel is $599,000 and the Pinnacle is $999,000. I assumed a five-year amortization. I calculated the electrical power consumed at $0.20 per Kwh. In addition to rent, I added in utilities other than electricity. For repairs, I used 6% of the CPM's sale price. Note that the Excel's cost of ownership is $167,600 per year and the Pinnacle's is $266,000 per year. So, clearly the Excels are the best buy."

Upon looking at the spreadsheet, Sue, Andy, and many of the others were surprised by how amateurish it looked (Figure 1).

There was murmuring in the audience, until Patty interjected.

"Paul, do you agree with Mr. Lindsay's conclusions?"

"Yes, Professor Patty," Paul said. "Excel, clearly has the lowest cost of ownership."

The murmuring increased.

At this, Hal was ecstatic. Maybe Professor Patty Coleman wasn't so bad after all. She was certainly teaching these young kids, like Paul, how to be successful engineers.

Hal opened his briefcase, reached in, and felt the purchase order he had filled out for Maggie

	Liine with Excel	Line with Pinnicle
Machine Amortization (5 year)	$120,000	200,000
Power per Year	$24,000	$30,000
Rent + Utilities Per Year	$20,000	$30,000
Machine Repairs (6% per year)	$3,600	$6,000
Total	$167,600	$ 266,000

Figure 1: Hal Lindsay's cost of ownership calculations. Some of the students were surprised at the "bare bones" appearance and typos on the spreadsheet.

Benson to sign. It was going to be a good day, indeed.

Initially, Patty was disappointed in Paul. Clearly, she thought, he did not do a thorough job. That was, until Paul continued to speak.

"Yes, Excel's cost of ownership is lower, but when profitability potential is considered, Pinnacle's potential is much greater," Paul elaborated.

At this, the murmuring increased to an unsettling point. Hal started to fume.

What will Paul's profitability potential reveal? Will Hal stay calm? Stay tuned to find out. **SMT007**

Ronald C. Lasky is an instructional professor of engineering for the Thayer School of Engineering at Dartmouth College, and senior technologist at Indium Corporation. To read past columns, click here.

Cutting-edge Inspection Challenges

Koh Young's Brent Fischthal explains how UHDI and advanced packaging are challenging inspection systems.

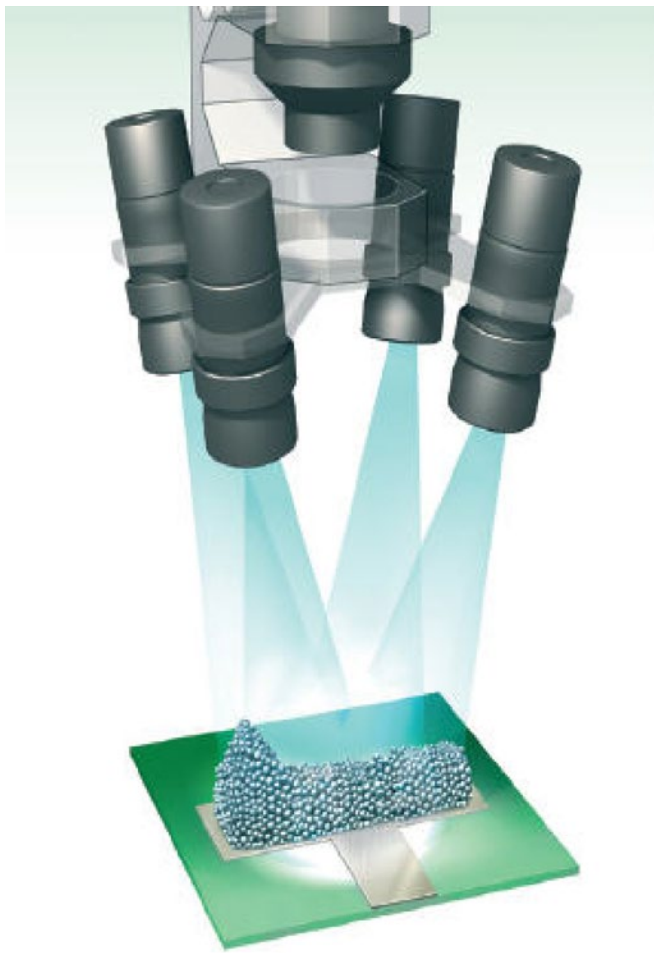
Advanced packaging seems to be accelerating the trend toward larger component packages. What are the new demands/challenges these packages put on inspection?

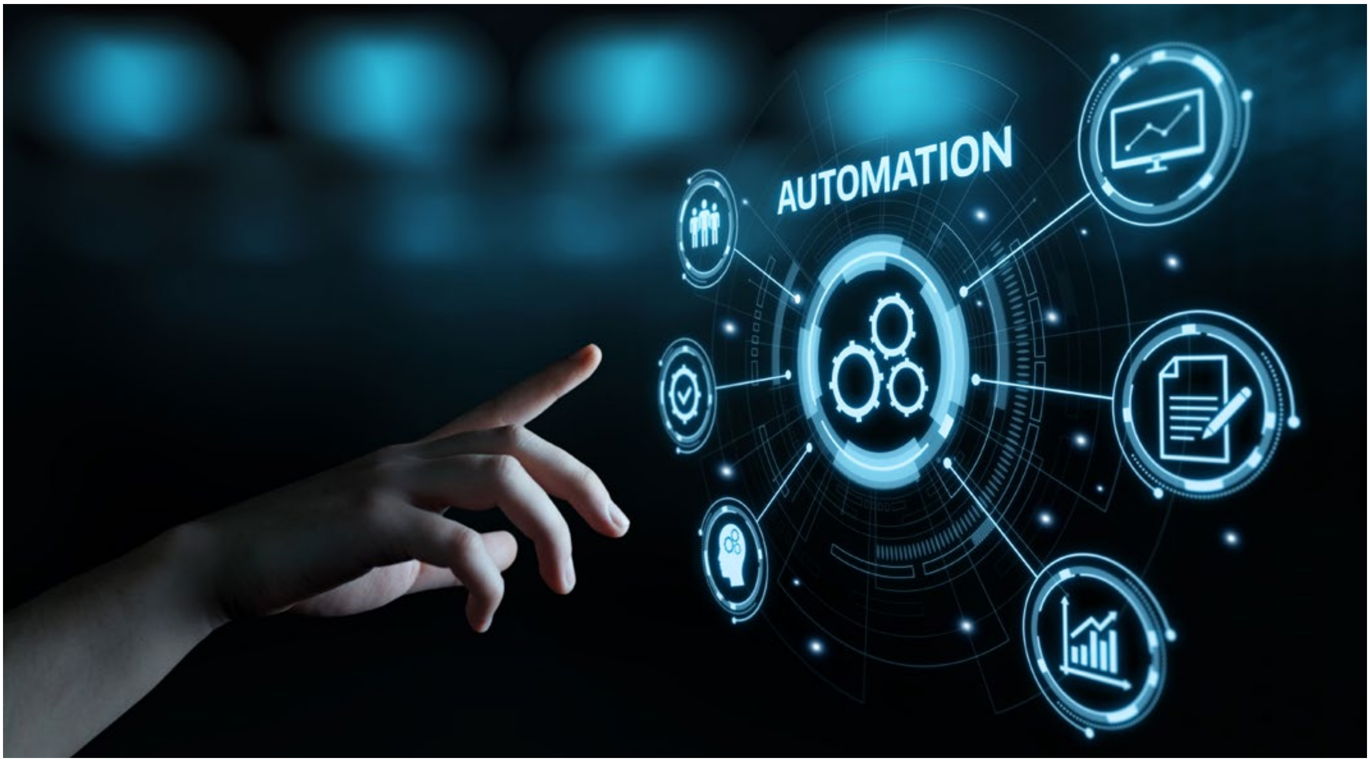
Brent Fischthal: The shift toward larger components and advanced packaging brings a host of challenges that impact the industry. These challenges include complexity, density, package diversity, and inspection methodologies, all of which necessitate a more innovative approach.

First, the increased complexity associated with advanced packaging techniques introduces more intricate board designs with multiple chip types and miniaturized components. Furthermore, the drive toward higher density and smaller pitch, facilitated by advanced packaging solutions such as 2.5D and 3D packaging, places significant demands on inspection machines. For instance, inspection systems must reliably address challenges like 10 mm thin solder deposits, 50 mm component spacing, and highly-reflective components within densely populated areas, even where access might be limited.

Moreover, the proliferation of diverse advanced packaging methods, including fan-out wafer-level packaging (FOWLP), system-in-package (SiP), and chiplets, requires inspection machines to accommodate a wider variety of package types and configurations. In addition, the variation in component heights, a common characteristic in advanced packaging due to designs like stacked die and heterogeneous packaging, requires the inspection system to overcome the shadowing created by these height differences in order to make consistent and reliable measurements.

To continue reading, click here.





Closing the Inspection Gap:

Enhancing Electronics Manufacturing Quality With Reflow Process Inspection

Article by Miles Moreau
KIC

Introduction

In the world of electronics manufacturing, inspection and quality control are paramount. Manufacturing engineers, process engineers, and managers in the electronics industry are constantly seeking innovative ways to improve the reliability and performance of SMT lines, and OEM auditors want assurances of complete process control and traceability of production for their product builds. Real-time inline inspection steps are necessary to maintain consistent quality and ensure the highest level of process control and traceability. This article sheds light on the critical role of reflow process inspection (RPI) that ensures the quality and reliability of PCBAs during reflow soldering, and briefly touches on exciting new sensing technology developed by KIC, an industry leader.

The Challenge of Reflow Soldering Inspection

Reflow soldering is a unique step in PCB assembly because it involves no added material. Instead, it relies on the precise application of heat to properly solder the assembly and cre-

ate reliable solder joints. Unlike other stages where technologies like solder paste inspection (SPI) and automated optical inspection (AOI) use high-resolution cameras to inspect the print of solder paste and placement of components, reflow soldering inspection presents a different technological challenge. Employing similar camera-based inspection methods during the reflow process is cost-prohibitive and technically challenging. While AOI can inspect solder joints after the reflow oven, it does not directly inspect the reflow process and confirm that the proper reflow profile was achieved.

The Role of Temperature Profiling

To ensure the integrity of the reflow soldering process, the industry relies on temperature profiling. This involves measuring and recording the temperature profile that the PCB, solder paste, and components experience as they pass through the reflow oven. This temperature profile directly impacts the quality of solder joints and the overall reliability of the PCBA.

Traditionally, temperature profiling has been a manual operation that requires human intervention and production line downtime. Engineers use temperature dataloggers and thermocouples attached to a test board to measure the temperature profile. This data helps configure and verify the oven's settings for the correct temperature profile and proper soldering. But unlike SPI and AOI, it is a static, manual methodology that only gives an infrequent spot check and is error prone. Let's first discuss the value of SPI and AOI, and then how that translates to the value of reflow process inspection.

The Vital Role of SPI and AOI

SPI and AOI systems are not only essential for inspecting and ensuring the quality of PCBAs but also play a significant role in closed-loop feedback and control mechanisms that enhance the accuracy and efficiency of the manufacturing process.

Solder Paste Inspection (SPI)

SPI systems employ advanced optical technologies to inspect the solder paste printing process, providing real-time feedback and con-

trol capabilities for screen printers. Key technologies include:

- **3D SPI:** This technology uses 3D measurement techniques to precisely capture the height and volume of solder paste deposits.
- **Machine learning and artificial intelligence (AI):** Some SPI systems incorporate machine learning algorithms and AI to analyze historical data, identify trends, and make proactive adjustments to the printing process.

Automated Optical Inspection (AOI)

AOI systems are crucial for verifying component placement, solder joint quality, and overall PCBA integrity. Key technologies in AOI include:

- **Advanced vision systems:** AOI systems use high-resolution cameras, advanced optics, and lighting techniques to capture detailed images of PCBAs. These images are then analyzed using sophisticated algorithms to identify defects and deviations from quality standards.
- **Machine learning and pattern recognition:** Some AOI systems employ machine learning and pattern recognition algorithms to continually improve their defect detection capabilities, adapting to new product designs and variations.

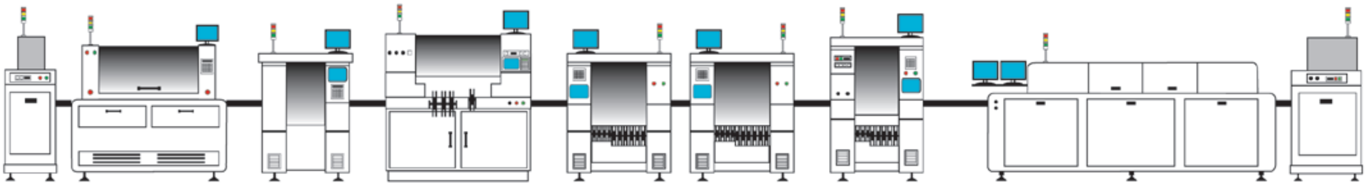
The Vital Role of Reflow Process Inspection (RPI)

To bring reflow up to the level of automation and precision seen in SPI and AOI, an approach has emerged called reflow process inspection (RPI). These embedded inspection systems for thermal processes were originally invented and developed by KIC, an industry leader in thermal process solutions for electronics manufacturing. Most available systems today are based on KIC technology.

Reflow Process Inspection (RPI)

An RPI system consists of an array of embedded thermocouple sensors along the process path within the reflow oven tunnel. These sensors measure temperature, track the conveyor speed, and monitor each PCBA as it enters the oven. By continuously and automatically tracking and calculating the temperature profile for every production PCBA, RPI eliminates the need for manual interventions and downtime required for manual profiling methods. Programming an RPI system is as straightforward as using a datalogging profiler device. Engineers run a baseline temperature profile of the PCBA, allowing the system to learn and adapt to the specific requirements of the assembly. Once programmed, the RPI inspection brings automation and real-time process control to the reflow soldering process, ensuring consistency and quality in every PCB.

- **Machine learning and artificial intelligence (AI):** A true RPI system like KIC's has predictive learning capabilities to recommend oven recipe settings with just the PCB dimensions and weight. Furthermore, the on-the-fly AI in the RPI system actively tracks process Cpk, provides temperature profile data for each assembly, and has connectivity capabilities to include critical real-time reflow profile data in the decision feedback loop. It operates with CFX, Hermes, and other standards as well as API connectivity to any MES system.
- **New sensing technology from KIC:** Until recently, there has only been indirect detection of convection changes through monitoring the production temperature profile or possibly monitoring fans. But by measuring the production boards' temperatures directly, KIC reflow process inspection systems will have the ability to know how the oven convection changes over time. KIC has new sensing technology to measure every production board



temperature directly at the beginning and end of the heated section of the reflow process, determining both temperature and convection changes in the process, and the potential impact on the quality of the reflow profile. This is an industry first and a revolutionary step in reflow process inspection technology.

Filling the Gap: SPI, RPI, AOI

A comprehensive inspection implementation should always include the reflow process. With SPI, RPI, and AOI, the inspection flow is complete across the entire SMT line. This creates a huge value-add with the ability to monitor process fluctuations at each stage and then correlate the combinations of process changes over time to determine what contributes to defects and how to auto-adjust to improve quality and production efficiency.

The Journey Toward Full Factory Integration

The integration of inspection systems like SPI, RPI, and AOI holds immense promise for electronics manufacturers, especially those operating in industries where high reliability is non-negotiable, such as automotive, medical, military, and aerospace.

- **Production traceability and process audits:** Traceability is a cornerstone of quality control. Integrated inspection systems, including RPI, provide a comprehensive record of each PCBA's journey through the manufacturing process. This traceability allows manufacturers to pinpoint the source of defects, make process improvements, and provide end-to-end documentation for compliance and quality assurance—a key requirement for automotive, medical, military, and aerospace products.
- **Real-time decision-making:** The integration of these systems creates a closed-loop feedback mechanism. SPI data can be used to adjust the printer in real-time, ensuring precise solder paste application. Similarly, AOI data can trigger adjustments in component placement, further reducing the risk of defects. RPI data plays a pivotal role in this real-time environment, ensuring that the temperature profile during reflow is consistently optimal and recommending adjustments when necessary.

Conclusion

Reflow soldering is a critical step in electronics manufacturing and ensuring the quality of solder joints is paramount. Systems for reflow process inspection (RPI) address the inspection gap by seamlessly integrating sensors into the reflow oven, automating temperature profiling, and providing real-time process control. By adopting RPI technology, as demonstrated by KIC Solutions, manufacturers enhance their quality control measures, improve efficiency, and make data-driven decisions, ultimately delivering reliable and high-quality PCBAs to the market. Now, with KIC's new sensing technology, the capabilities and value are even higher. As the electronics manufacturing industry evolves, RPI is a vital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tool for staying ahead of the curve and meeting the demands of an increasingly competitive market.

Moreover, the integration of SPI, AOI, and RPI paves the way for a new era of manufacturing where quality is assured, traceability is guaranteed, and real-time adjustments are the norm. For industries demanding high reliability, such as automotive, medical, military, and aerospace, this integrated approach is not just a competitive advantage, it's a necessity to meet the rigorous standards and ensure the safety and performance of electronic components. The journey toward full factory integration is an exciting one, promising a future where electronics manufacturing reaches new heights of efficiency, reliability, and precision. **SMT007**

Miles Moreau is general manager at KIC, a solution provider for SMT assembly and advanced packaging thermal processes and inspection and profiling systems. He can be contacted at mmoreau@kicmail.com or on LinkedIn at www.linkedin.com/in/milesmoreau. Visit our YouTube Channel @kicthermal.

Two Events Spotlight Electronics Industry in India

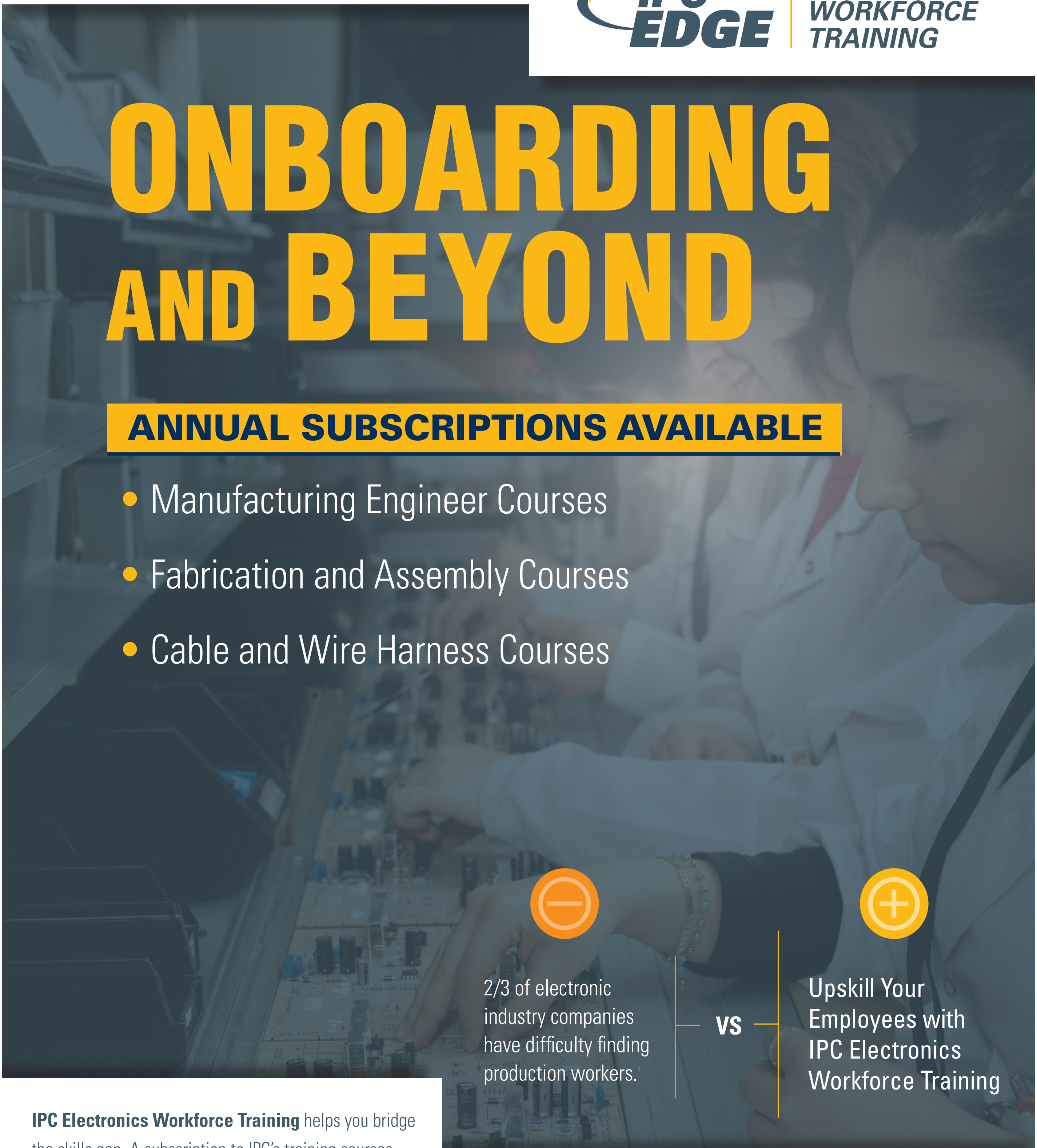
This year's Electronica India and Productronica India concluded on a successful note on Sept. 15. More than 600 companies from 24 countries showcased innovative products and solutions at the expo. The trade fairs attracted 39,133 visitors. The events, which took place at the Bangalore International Exhibition Centre (BIEC), was a major success for the Indian electronics industry, providing a platform for businesses to connect, collaborate, and drive innovation.

In a time when cross-industry collaborations are pivotal to business innovation and growth, IPC's recent endorsement of MMI's Electronica India and Productronica India as the "supporting association" is particularly noteworthy. With enthusiasm and dedication at the event, IPC reinforced its dedication to the ever-changing demands of the industry.

IPC Executive Director Mr. Gaurab Majumdar interacted with member companies, discussing collaborative efforts and aligning IPC's offerings with the industry's needs, both within India and on the global stage. Shedding light on IPC's skill training and certification programs, Majumdar noted the growing need for upskilling and ensuring that professionals are well-equipped with the latest knowledge and techniques.

On the second day of the event, IPC spearheaded a technical session, "The Significance of Standards in PCB Manufacturing," which catered to both novices and experts in the field. A highlight at ELCINA's India PCB Tech Conference, this session reflected the importance of maintaining quality and consistency in today's rapidly evolving electronics landscape and underscored the commitment of Electronica India and Productronica India to provide not just a platform for product showcases, but also a knowledge-sharing hub for the electronics community.

IPC EDGE | ELECTRONICS WORKFORCE TRAINING



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2/3 of electronic industry companies have difficulty finding production workers.[1]

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IPC Electronics Workforce Training helps you bridge the skills gap. A subscription to IPC's training courses makes it easier than ever to build career pathways for your employees and deliver effective training in the most efficient way. Email sales@ipc.org to learn more.

See our current course listing on IPC EDGE.

Courses can be offered directly to employees or integrated into your training programs.

[1] IPC. (2017). Findings on the Skills Gap in U.S. Electronics Manufacturing.

TOP TEN

EDITOR'S PICKS

Bob Duke

Global Sourcing Spotlight: Why We Need Global Sourcing

There are still too many people who are wary of global sourcing. It's as though they feel using global sourcing means they are cheating in some way, that they're being disloyal to domestic suppliers. Honestly, I can see why some people feel that way, but it just doesn't make any sense.

CHIPS Act, One Year On

Fresh off his annual meeting with the Printed Circuit Board Association of America (PCBAA), Travis Kelly, CEO at Isola Group and chairman of the PCBAA, gave us an update on government legislation in the United States that directly and indirectly affects the printed circuit board industry. Travis was candid in his remarks about funding from the CHIPS Act, what the PCB industry needs to do, and how a bill reintroduced into Congress this year might be just the ticket we need.

Manufacturing Isn't Linear; Stop Planning That Way

In the last couple of years, exacerbated by the chaos of the COVID-19 pandemic, the uncomfortable reality is that many manufacturers are not well prepared to properly deal with and respond to last minute changes in the supply chain, worker availability, or major swings in customer demand. Many of you likely have a painful story or two about scrambling to address unexpected changes in the production plan and schedule over the last few years.

SMTA 'Members of Distinction' Awards Announced

The SMTA is proud to honor the 2023 "Members of Distinction" award recipients who have shown exceptional dedication to the association and the electronics manufacturing industry.

BTU International Adds Manufacturing for Reflow Ovens in Mexico

BTU International, Inc., a leading supplier of advanced thermal processing equipment for the electronics manufacturing market, announced today the capability to manufacture reflow ovens in Mexico.

North American EMS Industry Up 3.4 Percent in July

IPC announced the July 2023 findings from its North American Electronics Manufacturing Services (EMS) Statistical Program. The book-to-bill ratio stands at 1.27. Total North American EMS shipments in July 2023 were up 3.4 percent compared to the same month last year. Compared to the preceding month, June shipments decreased 0.7 percent.

Emerald EMS Redefines Prototyping Capabilities with Second State-of-the-Art NPI Center

Emerald EMS, an innovative solutions provider, has inaugurated its second New Product Introduction (NPI) Center, this time in San Jose, California. Situated within the heart of Silicon Valley, alongside its existing NPI Center in Salem, New Hampshire, the San Jose facility is strategically positioned to foster rapid innovation and collaboration with tech companies in the region.

KIC Revolutionizes Electronics Manufacturing with Innovative Solutions for Soldering and Curing Processes

KIC, a renowned pioneer in thermal process and temperature measurement solutions for electronics manufacturing, is thrilled to announce its participation in the upcoming SMTA Guadalajara Expo & Tech Forum. The event is scheduled to take place on Oct. 25-26, 2023, at the esteemed Expo Guadalajara in Jalisco, Mexico. Miguel Carbajal, KIC's dedicated Mexico sales manager, and Miles Moreau, general manager, will be in Booth 1101 to engage with industry experts and engineering professionals and discuss the latest developments and innovations.

Towards a Silicon to Systems Industrial Strategy

Semiconductors do not function in isolation. They gain functionality through electronic interconnection with other components on printed circuit boards (PCBs). These electronics systems feature prominently in key sectors like defence, aerospace, space, automotive, medical, and high-performance computing, but electronics are vital to every industry.

CHIPS Act Priorities

The U.S. Department of Commerce is actively administering the $53 billion of funding in the CHIPS Act. IPC Vice President and Chief Technology Officer Matt Kelly offered a printed circuit board and system-wide perspective to the IAC, part of the ongoing advocacy efforts being undertaken by IPC and other organizations.

For the latest news and information, visit **SMT007.com**

Career Opportunities

Senior Sales Representative

Ventec Central Europe

Location: Kirchheimbolanden, Germany/Remote

We are looking for a self-motivated Senior Sales Representative—Ventec Central Europe, ideally with experience in the PCB industry. This position requires significant selling experience (15+ years) in the electronics and PCB industries. Candidates must possess a proven & consistent history of proactive sales growth with OEM customers. Most notably, they must be able to connect with OEM contacts that have decision-making capabilities.

Key Responsibilities

- Promote, sell, and close business for all Ventec product lines with focus on key OEM and PCB manufacturing customers.
- Track projects and submit monthly updates to management.
- Coordinate cross-functional resources when applicable.
- Assist in coordination and set-up of relevant trade show events.
- Assist in strategic planning initiatives.
- Assist in market and customer intelligence gathering.
- Recommend pricing strategies.

Job Requirements

- Entrepreneurial spirit, positive, high energy, and desire to win.
- Proactive and self-motivated work strategy to develop and win business for all business units.
- Excellent written and oral communication skills in German and English
- Excellent computer skills (Microsoft Office, especially Excel).
- Proven track record securing new business at OEM accounts.

Please apply in the strictest confidence, enclosing your CV, to: accountingde@ventec-europe.com

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Technical Support Engineer

USA Region

ViTrox aims to be the world's most trusted technology company in providing innovative, advanced, and cost-effective automated Machine Vision Inspection Solutions for the semiconductor and electronics packaging industries. Located in Hayward, California, ViTrox Americas Inc. is actively looking for talent to join our expanding team.

Key Responsibilities:

- Delivering excellent and creative problem-solving skills for servicing, maintaining, machine buy-off, and troubleshooting advanced vision inspection machines at customer sites. Providing remote customer support to minimize machine downtime.
- Cultivating strong customer relationships and ensuring comprehensive customer service to drive repeat orders and support business development in machine evaluation.
- Proactively understanding customer needs and feedback to drive continuous improvement in existing technologies and new product development.

Qualifications & Requirements:

- A recognized diploma/advanced diploma/ degree in Science and Engineering, preferably in Electrical & Electronics/Computer Science/ Computer Studies or equivalent.
- 3+ years of relevant experience in servicing automated inspection equipment (SPI, AOI, and AXI).
- Strong communication and troubleshooting skills.
- Willingness to travel extensively across the USA.
- Positive attitude and flexibility to accommodate conference calls with headquarters.
- Applicants from the USA and Canada are welcome to apply.
- Training will be provided at our headquarters in Penang, Malaysia.

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Career Opportunities

The Test Connection, Inc.

Rewarding Careers

Take advantage of the opportunities we are offering for careers with a growing test engineering firm. We currently have several openings at every stage of our operation.

The Test Connection, Inc. is a test engineering firm. We are family owned and operated with solid growth goals and strategies. We have an established workforce with seasoned professionals who are committed to meeting the demands of high-quality, low-cost and fast delivery.

TTCI is an Equal Opportunity Employer. We offer careers that include skills-based compensation. We are always looking for talented, experienced test engineers, test technicians, quote technicians, electronics interns, and front office staff to further our customer-oriented mission.

Associate Electronics Technician/ Engineer (ATE-MD)

TTCI is adding electronics technician/engineer to our team for production test support.

- Candidates would operate the test systems and inspect circuit card assemblies (CCA) and will work under the direction of engineering staff, following established procedures to accomplish assigned tasks.
- Test, troubleshoot, repair, and modify developmental and production electronics.
- Working knowledge of theories of electronics, electrical circuitry, engineering mathematics, electronic and electrical testing desired.
- Advancement opportunities available.
- Must be a US citizen or resident.

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Europe Technical Sales Engineer

Taiyo is the world leader in solder mask products and inkjet technology, offering specialty dielectric inks and via filling inks for use with microvia and build-up technologies, as well as thermal-cure and UV-cure solder masks and inkjet and packaging inks.

PRIMARY FUNCTION:

1. To promote, demonstrate, sell, and service Taiyo's products
2. Assist colleagues with quotes for new customers from a technical perspective
3. Serve as primary technical point of contact to customers providing both pre- and post-sales advice
4. Interact regularly with other Taiyo team members, such as: Product design, development, production, purchasing, quality, and senior company managers from Taiyo group of companies

ESSENTIAL DUTIES:

1. Maintain existing business and pursue new business to meet the sales goals
2. Build strong relationships with existing and new customers
3. Troubleshoot customer problems
4. Provide consultative sales solutions to customer's technical issues
5. Write monthly reports
6. Conduct technical audits
7. Conduct product evaluations

QUALIFICATIONS / SKILLS:

1. College degree preferred, with solid knowledge of chemistry
2. Five years' technical sales experience, preferably in the PCB industry
3. Computer knowledge
4. Sales skills
5. Good interpersonal relationship skills
6. Bilingual (German/English) preferred

To apply, email: BobW@Taiyo-america.com with a subject line of "Application for Technical Sales Engineer".

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Career Opportunities

BLACKFOX
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IPC Instructor

Longmont, CO

This position is responsible for delivering effective electronics manufacturing training, including IPC certification, to adult students from the electronics manufacturing industry. IPC Instructors primarily train and certify operators, inspectors, engineers, and other trainers to one of six IPC certification programs: IPC-A-600, IPC-A-610, IPC/WHMA-A-620, IPC J-STD-001, IPC 7711/7721, and IPC-6012.

IPC instructors will primarily conduct training at our public training center in Longmont, Colo., or will travel directly to the customer's facility. It is highly preferred that the candidate be willing to travel 25–50% of the time. Several IPC certification courses can be taught remotely and require no travel or in-person training.

Required: A minimum of 5 years' experience in electronics manufacturing and familiarity with IPC standards. Candidate with current IPC CIS or CIT Trainer Specialist certifications are highly preferred.

Salary: Starting at $30 per hour depending on experience

Benefits:

- 401k and 401k matching
- Dental and Vision Insurance
- Employee Assistance Program
- Flexible Spending Account
- Health Insurance
- Health Savings Account
- Life Insurance
- Paid Time Off

Schedule: Monday thru Friday, 8–5

Experience: Electronics Manufacturing: 5+ years (Required)

License/Certification: IPC Certification–Preferred, Not Required

Willingness to travel: 25% (Required)

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Prototron Circuits

Sales Representatives

Prototron Circuits, a market-leading, quick-turn PCB manufacturer located in Tucson, AZ, is looking for sales representatives for the Utah/Colorado, and Northern California territories. With 35+ years of experience, our PCB manufacturing capabilities reach far beyond that of your typical fabricator.

Reasons you should work with Prototron:

- Solid reputation for on-time delivery (98+% on-time)
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- MIL-PRF- 31032
- ITAR
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- Completely customer focused team

Interested? Please contact Russ Adams at (206) 351-0281 or russa@prototron.com.

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Career Opportunities

KYZEN
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Regional Manager

Southwest Region

General Summary: Manages sales of the company's products and services, Electronics and Industrial, within the Southwest Region. Reports directly to Americas Manager. Collaborates with the Americas Manager to ensure consistent, profitable growth in sales revenues through positive planning, deploy-ment and management of sales reps. Identifies objectives, strategies and action plans to improve short- and long-term sales and earnings for all product lines.

DETAILS OF FUNCTION:

- Develops and maintains strategic partner relationships
- Manages and develops sales reps:
  - Reviews progress of sales performance
  - Provides quarterly results assessments of sales reps' performance
  - Works with sales reps to identify and contact decision-makers
  - Setting growth targets for sales reps
  - Educates sales reps by conducting programs/ seminars in the needed areas of knowledge
- Collects customer feedback and market research (products and competitors)
- Coordinates with other company departments to provide superior customer service

QUALIFICATIONS:

- 5-7+ years of related experience in the manufacturing sector or equivalent combination of formal education and experience
- Excellent oral and written communication skills
- Business-to-business sales experience a plus
- Good working knowledge of Microsoft Office Suite and common smart phone apps
- Valid driver's license
- 75-80% regional travel required

To apply, please submit a COVER LETTER and RESUME to: Fernando Rueda, Americas Manager

fernando_rueda@kyzen.com

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EMA Design Automation®

Technical Marketing Engineer

EMA Design Automation, a leader in product development solutions, is in search of a detail-oriented individual who can apply their knowledge of electrical design and CAD software to assist marketing in the creation of videos, training materials, blog posts, and more. This Technical Marketing Engineer role is ideal for analytical problem-solvers who enjoy educating and teaching others.

Requirements:

- Bachelor's degree in electrical engineering or related field with a basic understanding of engineering theories and terminology required
- Basic knowledge of schematic design, PCB design, and simulation with experience in OrCAD or Allegro preferred
- Candidates must possess excellent writing skills with an understanding of sentence structure and grammar
- Basic knowledge of video editing and experience using Camtasia or Adobe Premiere Pro is preferred but not required
- Must be able to collaborate well with others and have excellent written and verbal communication skills for this remote position

EMA Design Automation is a small, family-owned company that fosters a flexible, collaborative environment and promotes professional growth.

Send Resumes to: resumes@ema-eda.com

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Career Opportunities

pluritec®
MACHINES FOR PRINTED CIRCUIT BOARDS

Field Service Engineer

Location: West Coast, Midwest

Pluritec North America, ltd., an innovative leader in drilling, routing, and automated inspection in the printed circuit board industry, is seeking a full-time field service engineer.

This individual will support service for North America in printed circuit board drill/routing and x-ray inspection equipment.

Duties included: Installation, training, maintenance, and repair. Must be able to troubleshoot electrical and mechanical issues in the field as well as calibrate products, perform modifications and retrofits. Diagnose effectively with customer via telephone support. Assist in optimization of machine operations.

A technical degree is preferred, along with strong verbal and written communication skills. Read and interpret schematics, collect data, write technical reports.

Valid driver's license is required, as well as a passport for travel.

Must be able to travel extensively.

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KOH YOUNG AMERICA

Technical Service & Applications Engineer

Full-Time — Flexible Location

Koh Young Technology, founded in 2002 in Seoul, South Korea, is the world leader in 3D measurement-based inspection technology for electronics manufacturing. Located in Duluth, GA, Koh Young America has been serving its partners since 2010 and is expanding the team with an Applications Engineer to provide helpdesk support by delivering guidance on operation, maintenance, and programming remotely or on-site.

Responsibilities

- Provide support, preventive and corrective maintenance, process audits, and related services
- Train users on proper operation, maintenance, programming, and best practices
- Recommend and oversee operational, process, or other performance improvements
- Effectively troubleshoot and resolve machine, system, and process issues

Skills and Qualifications

- Bachelor's in a technical discipline, relevant Associate's, or equivalent vocational or military training
- Knowledge of electronics manufacturing, robotics, PCB assembly, and/or AI; 2-4 years of experience
- SPI/AOI programming, operation, and maintenance experience preferred
- 75% domestic and international travel (valid U.S. or Canadian passport, required)
- Able to work effectively and independently with minimal supervision
- Able to readily understand and interpret detailed documents, drawings, and specifications

Benefits

- Health/Dental/Vision/Life Insurance with no employee premium (including dependent coverage)
- 401K retirement plan
- Generous PTO and paid holidays

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Career Opportunities

ARLON ELECTRONIC MATERIALS

Arlon EMD, located in Rancho Cucamonga, California, is currently interviewing candidates for open positions in:

- Engineering
- Quality
- Various Manufacturing

All interested candidates should contact Arlon's HR department at 909-987-9533 or email resumes to careers.ranch@arlonemd.com.

Arlon is a major manufacturer of specialty high-performance laminate and prepreg materials for use in a wide variety of printed circuit board applications. Arlon specializes in thermoset resin technology, including polyimide, high Tg multifunctional epoxy, and low loss thermoset laminate and prepreg systems. These resin systems are available on a variety of substrates, including woven glass and non-woven aramid. Typical applications for these materials include advanced commercial and military electronics such as avionics, semiconductor testing, heat sink bonding, High Density Interconnect (HDI) and microvia PCBs (i.e. in mobile communication products).

Our facility employs state of the art production equipment engineered to provide cost-effective and flexible manufacturing capacity allowing us to respond quickly to customer requirements while meeting the most stringent quality and tolerance demands. Our manufacturing site is ISO 9001: 2015 registered, and through rigorous quality control practices and commitment to continual improvement, we are dedicated to meeting and exceeding our customers' requirements.

For additional information please visit our website at www.arlonemd.com

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INSULECTRO

Are You Our Next Superstar?!

Insulectro, the largest national distributor of printed circuit board materials, is looking to add superstars to our dynamic technical and sales teams. We are always looking for good talent to enhance our service level to our customers and drive our purpose to enable our customers to build better boards faster. Our nationwide network provides many opportunities for a rewarding career within our company.

We are looking for talent with solid background in the PCB or PE industry and proven sales experience with a drive and attitude that match our company culture. This is a great opportunity to join an industry leader in the PCB and PE world and work with a terrific team driven to be vital in the design and manufacture of future circuits.

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Career Opportunities

Career Opportunities

Educational Resources

ON DEMAND! Free 12-part Webinar Series

Smarter Manufacturing Enabled with Inspection Data

with expert Ivan Aduna

A smart factory is created from many parts, and inspection systems will play a critical role for process optimization in the next industrial revolution. Accurate, reliable 3D measurement-based data is essential, and a key element for a true smart factory. In this 12-part webinar series, viewers will learn about secure data collection, AI-powered solutions to manage and analyze data, and how to leverage the IPC CFX-QPL to succeed in the transformation to Industry 4.0.

I-007eBooks

Process Control

by Chris Hunt and Graham K. Naisbitt, GEN3

In this book, the authors examine the role of SEC test and how it is used in maintaining process control and support for objective evidence (OE.) Issues, including solution choices, solution sensitivities, and test duration are explored.

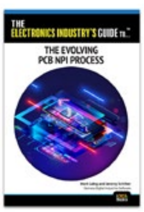
The Companion Guide to... SMT Inspection: Today, Tomorrow, and Beyond

Advances in artificial intelligence have been limited exclusively to the human world until now, but there are far-reaching applications within the manufacturing sector, too. In this guide book, learn how equipment providers like Koh Young are enabling the Smart Factory of the Future by adopting AI to generate "knowledge" from "experience."

Solder Defects

by Christopher Nash and Dr. Ronald C. Lasky, Indium Corporation

This book is specifically dedicated to educating the printed circuit board assembly sector and serves as a valuable resource for people seeking the most relevant information available.



The Evolving PCB NPI Process

by Mark Laing and Jeremy Schitter, Siemens Digital Industries Software

In this book, the authors look at how market changes in the past 15 years, plus the slowdown of production and delivery of materials and components in recent years, have affected the process for new product introduction (NPI) in the global marketplace. As a result, we feel that PCB production companies need to adapt and take a new direction to navigate and thrive in an uncertain and rapidly evolving future.

PODCAST! *On the Line with...*

...is available now on Spotify. In this podcast, we speak with industry experts to get the latest insights and perspectives on the most relevant topics in the electronics industry today. The first series of *On the Line with...* features conversations on sustainability.

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COVER IMAGE: ADOBE STOCK © 0.0

SMT007 MAGAZINE

SMT007 MAGAZINE®
is published by IPC Publishing Group, Inc.,
3000 Lakeside Dr., Suite 105N, Bannockburn, IL 60015

October 2023, Volume 38, Number 10
SMT007 MAGAZINE is published monthly,
by IPC Publishing Group, Inc., dba I-Connect007.

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