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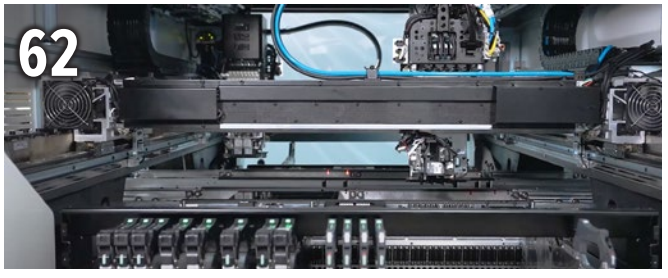

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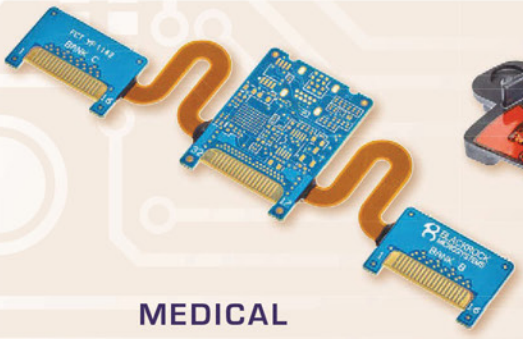

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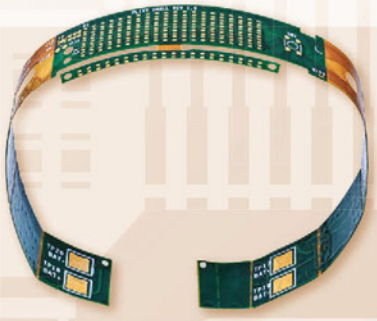

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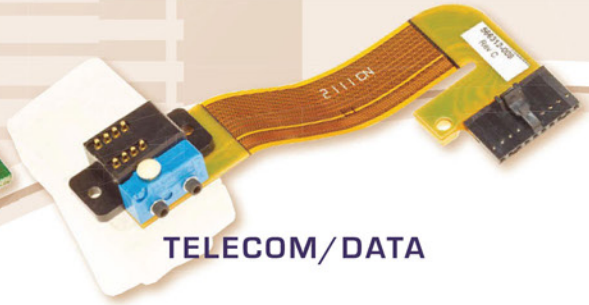

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The Cost of Rework

Nolan's Notes

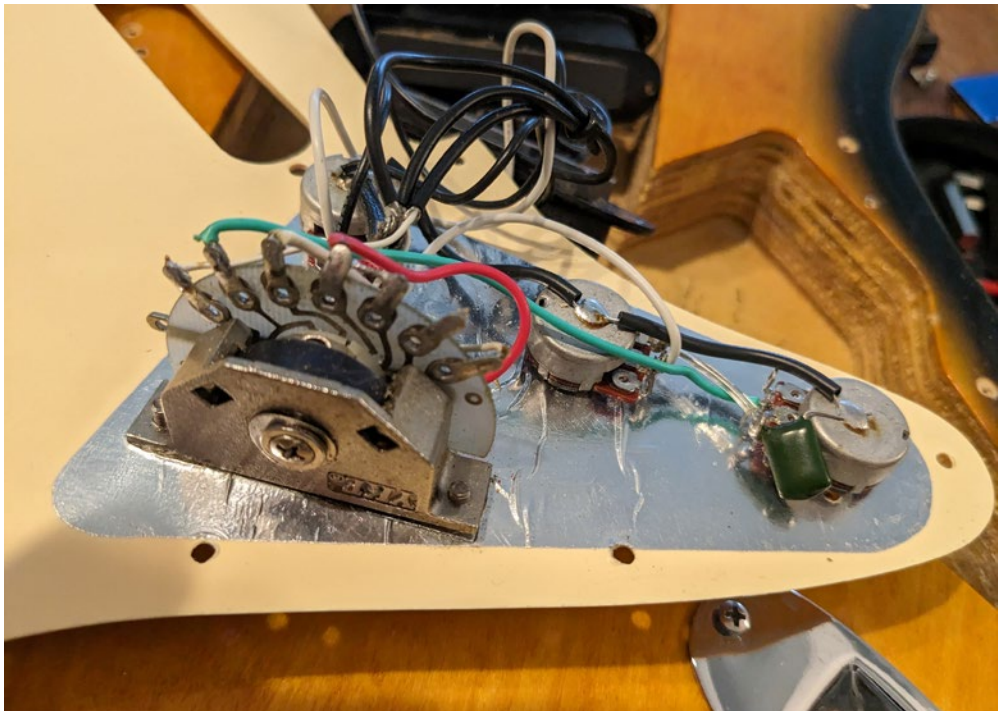
by Nolan Johnson, I-CONNECT007

I've been repairing an electric guitar—a no-name copy of the iconic Fender Stratocaster. The instrument came to me by way of my guitar teacher—full-time musician and good friend Ken Brewer—in a condition described as "functional, but unplayable." It had potential, so we decided to see if we could bring it back to life.

I'm not sure what the previous owner had in mind, but their small misadjustments in one place had to be compensated for by medium-sized misadjustments elsewhere, leading to big misadjusments that rendered the instrument mostly unusable. Nothing worked as it should.

In this issue of *SMT007 Magazine,* we visit the rework processes, arguably one of the highest-skilled, highest-pressure jobs on the manufacturing floor. What are the technical challenges? How is the rework job function being changed by new packaging technologies and increasing board densities? When faced with a staffing shortage in rework, how can we remedy the situation? How will the skill sets for rework need to evolve?

There aren't many functional pieces to an electric guitar; the bill of materials is pretty short. It's not like, say, the PCB of a cellphone. But when it comes to rework, the process is quite similar. For example, when first handed to me, it was as if that Stratocaster copy had been rejected by test. The next steps were to diagnose the problems and determine a course of action. Was it repairable? Was it—like so many of our PCBs in production—even worth repairing? Our triage suggested there was hope, and it was worth our while to try.



Stratocaster internals open for test and inspection.

So, we carefully removed the essential parts and tested them. Electrically, everything worked. The problems were, it seemed, entirely mechanical. Some of the fasteners used in

the previous work, were not as specified, leading to much of the guitar's maladjustment. Compare this to assessing a faulty assembled board. What parts need to be tested, removed, or replaced? How will reworking those parts of the board affect the performance? For my guitar, because of failures and bad repairs by the previous owner, all it needed was a second rework to put it right. Similarly, what does this look like in a test and inspection shop? Should an OEM or fabricator try to set up an in-house rework department, or is the time and money better spent just sending it straight to dedicated experts?

My guitar project, just as with blemished board assemblies, required time-intensive rework. All that triage, disassembly, error resolution, and re-assembly takes patience and skill; understanding the subtle interactions requires true expertise.

It took my own experience and Ken's many years' of expertise to fix my guitar. Similarly, a rework department requires skilled technicians, especially given the high degree of troubleshooting required to tackle cutting-edge repairs. My guitars aren't quite as technical as circuit boards, but there are a lot of interrelated mechanical parts to deliver a good tone.

Ken has been working on them since the 1960s; it's his lifelong profession. His body of knowledge is immense and soaking that up quickly helped me learn my way around. I got the reworked guitar into playable condition after a couple of hours, but it took an entire evening of Ken's wisdom to go from good to great. That human expertise can only come from direct experience.

That is where my guitar story and this issue's topic start to converge. Rework, regardless of the discipline, requires a whole lot of human expertise and dexterity. Unlike classic electric guitars, however, printed circuit board technology advances quickly. That evolution likewise constantly shifts the balance between staffing for rework, hiring it out, or not doing it at all. Doing the build right the first time is the best strategy, of course, but we can rarely be fully 100%.

In this issue, we highlight key areas across the rework discipline. We have a feature interview with Intel's Maria Mejias, who not only oversees production rework at Intel, but also contributes to rework recommendations passed down to Intel customers. The team at BEST, rework specialists, discusses the ROI dynamics in pursuing rework for your products. BEST also contributes an article on their latest part removal method, cold milling. I include a technical paper from Essemtec, published at IPC APEX EXPO 2023, on novel methods for automatic repair.

Of course, the obvious approach to rework efficiency is to have no rework at all. That's where Delvitech's AI AOI, and Hanwha's portfolio of assembly equipment come into play.

Our band of columnists pick up the rework beat as well. Michael Ford examines the current state of rework and sees a business opportunity; Mike Konrad delivers a comprehensive overview that, while valuable for all readers, should be especially helpful to readers less familiar with rework. Rounding out the band this month, we have Jennie Hwang's ongoing series on critical materials, IPC CEO John Mitchell, and Ron Lasky's latest Maggie Benson installment.

In the end, refurbishing cost me very little in parts, but it did require that I make mechanical changes to the placement of the bridge on the guitar body. Comparable, I guess, to removing a part and resoldering it with correct placement—almost all the cost of the rework was in the labor. **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.

Critical Materials: A Compelling Case, Part 3

SMT Perspectives and Prospects

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

Tumultuous forces involving geopolitical pull, along with technological and market push, have emerged since I published the first two parts of this topic in February and May 2022, respectively. Here, I will consider the impact of these new forces.

Critical materials and minerals that are the foundation for essential goods have long been sourced from areas with wars, near-wars, and some unfriendly nations; this causes high-risk concerns. When Russia invaded Ukraine on Feb. 24, 2022, for example, it elevated the uncertainty of materials and minerals. Then Hamas' attack on Oct. 7, 2023, added further peril to the availability, reliability, and security of the global supply chain. The potential hazards from these high-risk uncertainties have drawn intense attention across the national landscape.

Energy use (specifically electricity) continues to increase. This demand comes from the phenomenal growth of power-hungry data centers—some new data centers need grid connections as large as 500 megawatts—and increased deployment of potent AI tools, the need for high-performance computing, and a push for electrification. These market forces create a heightened criticality for some materials and minerals, including lithium, nickel, and some rare earth minerals.

On the national level, efforts have been made to preserve these minerals, yet a robust and integrated national strategy is needed that includes plans that are deliberate, comprehen-

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sive, and speedy. They must call for a further holistic and amalgamated approach to ensure economic prosperity and national security, as well as global competitiveness.

Critical Materials and Minerals Going Forward

The criticality of materials and minerals goes to the most crucial ingredients for indispensable products and those that the U.S. has little control over due to the lack of our domestic natural resources and sources, or those that originate from high-risk areas. Mission-critical end uses also need to be considered.

The Energy Act of 2020, defines[1]:

- A "critical material" as any non-fuel mineral, element, substance, or material that the Secretary of Energy determines: (i) has a high risk of supply chain disruption; and (ii) serves an essential function in one or more energy technologies, including technologies that produce, transmit, store, and conserve energy; or
- A "critical mineral" as any mineral, element, substance, or material designated as critical by the Secretary of the Interior, acting through the Director of the U.S. Geological Survey.

The 2023 Final Critical Materials List determined by DOE includes the following:

- Critical materials for energy: aluminum, cobalt, copper, dysprosium, electrical steel, fluorine, gallium, iridium, lithium, magnesium, natural graphite, neodymium, nickel, platinum, praseodymium, silicon, silicon carbide and terbium.
- Critical minerals that include the following 50 minerals (per the Secretary of the Interior, acting through the director of the U.S. Geological Survey, published a 2022 final list of critical minerals): Aluminum, antimony, arsenic, barite, beryllium, bismuth, cerium, cesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, iridium, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, palladium, platinum, praseodymium, rhodium, rubidium, ruthenium, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium.

Examples of Critical End-Uses

Nickel, lithium, and some rare earth elements are the most critical materials for energy yet bear the biggest supply risk.

The price of nickel (Ni), for example, has been uncharacteristically volatile during the past couple of years. It soared into an uncontrolled spike on March 8, 2022, reaching a record $100,000 a metric ton on the London Metals Exchange (LME). However, the price later pulled back, and because of this dramatic pricing volatility, the LME paused trading on

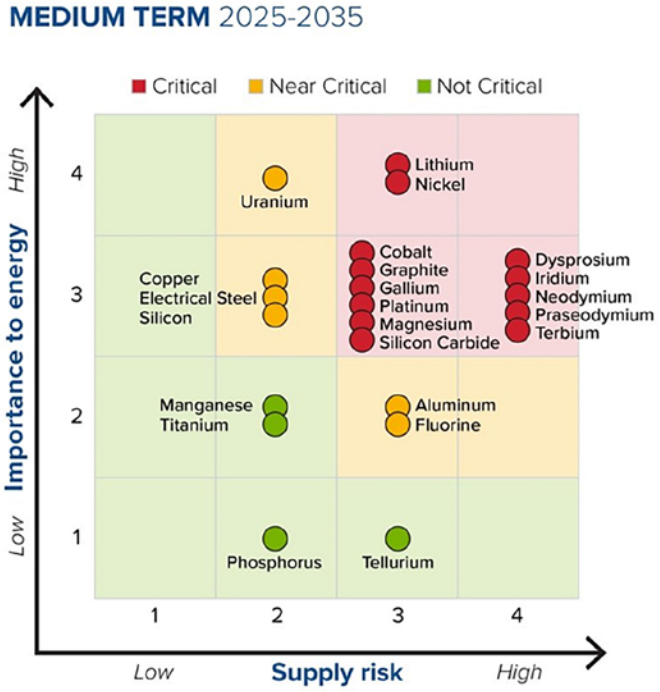

Figure 1: Levels of supply risk to the importance of energy in time horizon, 2025–35[1].

March 8, 2022, and did not resume until eight days later. It caused a review by regulators and LME, and resulted in litigation[2]. It now stands as a warning signal that pricing volatility can indicate inadequate reliability and/or is associated with undue market manipulation.

Nickel is not a fancy metal but a key ingredient for stainless steel and lithium-ion batteries that power electric vehicles (EVs). Russia and China are major suppliers of nickel, as is Indonesia. Russia also supplies oil, gas, and other essential minerals, including palladium (Pd), an essential element for catalytic converters, and semiconductor and electronics manufacturing. It is reported that about one-third of the world's palladium comes from Russia. About two-thirds of the world's lithium and cobalt, essential for electric vehicles, is processed in China.

As a key ingredient in making batteries for EVs, cellphones and laptops, lithium demand reportedly would quadruple by 2030.

According to estimates from the USGS, the U.S. has consumed an average of 8,300 metric tons of rare-earth oxides annually in recent years. The U.S. is racing to catch up with China and other countries on rare-earth supplies, as these minerals are in ever-greater demand. Some uses include EVs, offshore wind turbines, and permanent magnets.

Titanium, which is crucial for manufacturing jet airplanes and military aircraft, has been heavily sourced from Russia. A unique metal known for its high strength, light weight, and corrosion resistance, it cannot be readily substituted. Even though some materials may not risk direct exposure, indirect impact is expected to trickle down throughout the global supply chain.

According to the Critical Raw Materials Alliance, China produces 60% of the world's germanium and 80% of gallium. Both elements are essential in manufacturing electronics and semiconductors. For example, germanium is used in fiber optic products, solar products for space, and night-vision goggles, while gallium is a critical material for semiconductors to make essential gallium compounds (e.g., gallium arsenide, gallium nitride).

Role of Business and Government

In business, long-term investment requires deliberations under the spotlight of reliable and secure critical materials. Corporate boards should be addressing this through an enterprise risk management program. For instance, Exxon Mobil announced its plans to drill for lithium in Arkansas and start producing battery-grade lithium by 2027[3]. Exxon's goal by 2030 is to become a major U.S. supplier of lithium to makers of EV batteries.

Research and funding should be prioritized in government and academia, with action and implementation taken accordingly.

Furthermore, the integrated cross-agency program relevant to critical materials and minerals is duly warranted to tackle the technologies, processes, and manufacturability effectively and speedily. It is easier said than done; yet it is the time to do so.

The Role of Artificial Intelligence and Supply Chain Challenges

Critical materials and minerals will have an overarching impact on the global supply chain across all industries and sectors. Once the chain is broken, the whole system fails.

Recently, the supply chain experienced unprecedented disruptions and hurdles due to a slew of factors and root causes. Simply put, these fundamental supply chain issues can be attributed to decades of globalization, offshore manufacturing, and technological changes, in conjunction with many diverse suppliers being embedded in each product. Consequently, managing today's global supply chain is a daunting task, and securing reliable sources of materials and minerals requires an ongoing effort.

The bulk of battery manufacturing, for example, occurs in Southeast Asia, and establishing

supply chains for key materials, such as lithium-hydroxide, can take anywhere from three to seven years. As demand rises, the multiple steps—ranging from developing alternate supply sources and establishing strategic partnerships to innovating new materials and battery technologies—should be the path forward to securing a stable supply chain.

Is sodium-ion battery technology a viable alternative? Sodium is more abundant than lithium, less vulnerable to geopolitical challenges, and brings a substantially lower cost—the price of sodium carbonate is $286/ton vs. battery-grade lithium carbonate at $20,494/ton.

Developing and deploying AI tools that manage the supply chain in a timely way will alleviate some of the bottlenecks. One viable task is a model that combines data with artificial intelligence to predict unconventional deposits of rare earth and critical minerals.

Semiconductor "chips" are another example. High computing chips (GPU, CPU, TPU) are not only figuratively hot in terms of market demands, but literally hot in terms of temperature. AI tools to facilitate chip design and subsequent packaging and PCB assembly to facilitate thermal management are expected to boost productivity and innovative products required by the continued advances in AI technology and AI tools. AI can "reciprocally" help as an effective tool for chip design and chip manufacturing as well.

Conclusion

Securing reliable sources of materials and minerals may be challenging, but it's a must. It's a necessity to diversify sourcing routes for key materials and develop alternatives for industries that have become highly dependent on unsecured sources. New AI tools can facilitate the required outcome. **SMT007**

References

1. U.S. Department of Energy.
2. "London Metal Exchange Wins Fight on Nickel," *The Wall Street Journal,* Nov. 30, 2023.
3. "Exxon Starts Drilling for Lithium," *The Wall Street Journal,* Nov. 14, 2023.

Appearances

Dr. Jennie Hwang will deliver a Professional Development Course, "Artificial Intelligence—Opportunities, Challenges & Possibilities," and "High Reliability Electronics for Harsh Environments," April 7 and 8, respectively, at IPC APEX EXPO 2024.

Dr. Jennie S. Hwang, an international businesswoman, international speaker, and a business and technology advisor, is a pioneer and long-standing leader in SMT manufacturing since its inception, and in developing and implementing lead-free electronics technology and manufacturing.

She has served as chair of Artificial Intelligence-Justified Confidence for DoD Command and Control study, chair of AI Committee of the National Academies, and Review Panels of NSF National AI Institutes. An International Hall of Famer (Women in Technology), she has been inducted into the National Academy of Engineering, named an R&D-Stars-to-Watch, and received the YWCA Achievement Award. She has held senior executive positions with Lockheed Martin Corp., and was CEO of International Electronic Materials Corp. She is currently CEO of H-Technologies Group, providing business, technology, and manufacturing solutions.

She has served as chair of the Laboratory Assessment Board, the DoD Army Research Laboratory Assessment Board, and the Assessment Board of Army Engineering Centers. She is on the board of Fortune-500 NYSE companies and civic and university boards, Commerce Department's Export Council, National Materials and Manufacturing Board, NIST Assessment Board, various national panels/committees, and international leadership positions.

She is the author of 10 books (four as co-author) and 700+ technical/editorial publications. She is a speaker and author on trade, business, and education issues. Her formal education includes four academic degrees (Ph.D., M.S., M.A., B.S.), as well as Harvard Business School Executive Program and Columbia University Corporate Governance Program. To read previous columns, click here.

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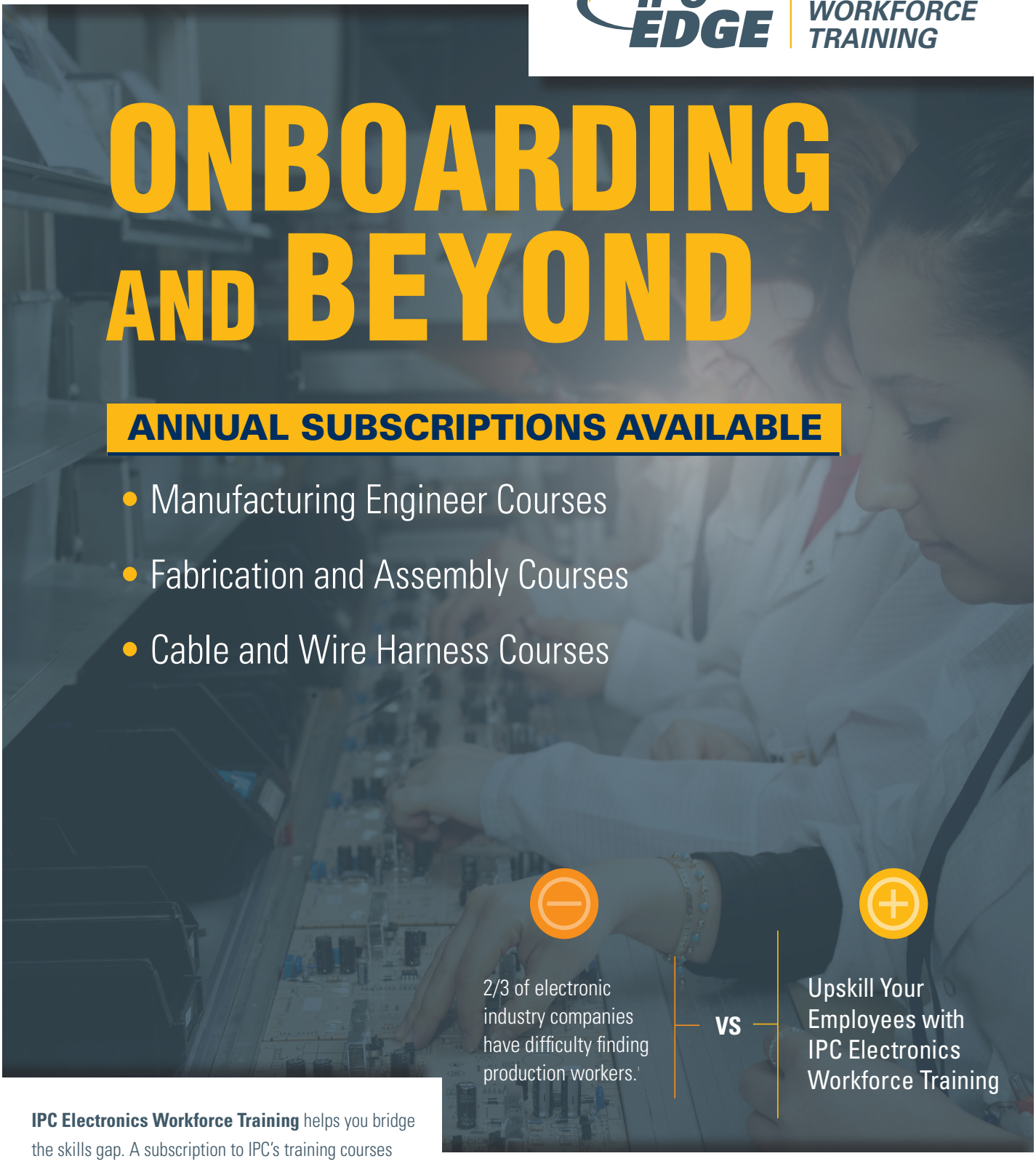

2/3 of electronic industry companies have difficulty finding production workers.[1]

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


Roberto Gatti

A New Generation of AI AOI

Feature Interview by Barry Matties
I-CONNECT007

Roberto Gatti is CEO of Delvitech, a Swiss company that has launched a new generation of AOI utilizing an AI neural network. As Roberto explains, their approach was not to bring another AOI machine to the market; instead, they focused on bringing a new technology to an AOI system.

Barry Matties: As you enter the crowded AOI market space with a new system, I am curious what inspired you to do this.

Roberto Gatti: To start, we did a complete study and assessment of the AOI market around the world, and we found areas that were not addressed by our competitors. Basically, we had two choices. We could enter the market with a machine and strategy like what was already out there and try to compete on price, or we could do something completely different. We chose to be different, with a new generation of AOI driven by AI. With that, we invested 30–40 million euro and developed a totally different system.

We are offering a single system with two different concepts. One has an optical head that is fixed and the board moving. The other is with

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an optical head that is moving, and the board is fixed. We developed a proprietary optical head for both machines that can be used for all processes: plated through-hole, SMT, SPI, and mechanical objects, as it can be used to identify whatever is available on a board.

Is this optical head something that you developed in-house?

Yes, totally in-house, together with some universities in Switzerland. It's a project that took almost three years. It has several patents. Our system is the only one on the market with six cameras, all fully integrated with FPGA and Thunderbolt interface. The telecentric lens is another customized system with two arms. On one arm you get the polarized camera; on the other, you get a 12- or 25-megapixel top camera. The reason for such a complex optical head is the fact that we need to acquire a lot of information from the board because we do an inspection that is the opposite of everything our competitors are doing.

Our competitors—extremely good companies—are looking at what is wrong inside the window with a mathematical algorithm or an image comparison. We, on the contrary, check everything that is happening in each window, even what is good and why it is good. We apply AI to everything, but not an algorithm. The machine is AI-based, so whatever you touch in the machine has an impact on different neural networks that are doing different jobs. You can train the machine to inspect new components and new technologies. You take the component and tell the machine to learn it. The machine learns the component, and while it learns, it already understands the best way to inspect it.

This system is web-based and is totally available on the cloud which provides a big advantage, especially for those international customers who need to have different types of systems in their production line—SPI, pre-reflow, and post-reflow. With Delvitech, they don't need to buy different machines, they can buy one

model of machine and place it wherever they want in the line. The completed neural network training happens locally in the line, or if you have a large or a major account, everything happens on the cloud. If you have a plant in Germany, for example, with 20 of these machines on 10 different lines, the neural network is learning a lot of information and bringing detectability to the highest possible level. Then, say you decided to open a plant in India. You simply take the information from the neural network in Germany and apply it to the machine in India, which will instantly behave the same way it did in Germany.

When customers come to you to learn about your equipment, what are their greatest concerns?

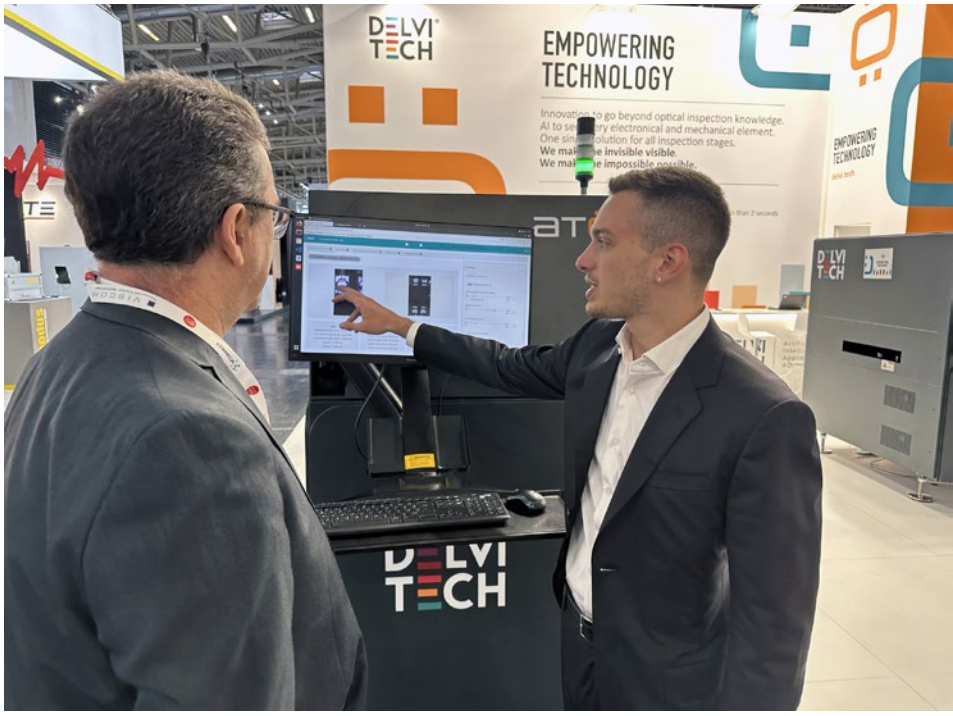
That it's a new technology. If you go back to when Tesla arrived in the market with a new-concept electric car, everybody asked, "Will it work? Can we use it?" It was very difficult for Tesla to enter the market with this new-generation car. Then a lot of others decided to put their electric cars on the market. However, they simply took a very good gasoline or diesel car, removed the engine, put in an electric engine, and said, "Okay, this is an electric car."

What's happening in the market now is something similar. We have not created a machine, but a concept, a new technology that is totally AI-based and matched with a very particular camera head to simplify the work of our customers. Some of our competitors understood that we were creating a different generation of AOI, so in some cases they have decided to bring AI inside one or two algorithms, data analysis, or data management, but it's not like having a real AI-based machine. It's not enough to do software. You also need to structure the computer hardware of the machine to support this huge amount of data flying in and out, providing a real-time result. We need to simplify the concept of the systems, and the concept of this technology, to let customers understand what's going on without using the difficult terms of AI—because AI is complex.

Bringing a new product to market can be slow and painful because people go back to what they know. What will motivate them to take that step?

There are different reasons to take a new generation system like this. The first one is the return on investment. You can imagine a company with 80–100 different devices in its manufacturing plant or 80–100 identical AOI machines. With identical AOI, you train people on one machine, one software, one maintenance system. You train them on having stock of spare parts for that one model of machine. The cost savings is huge.

The second advantage is you are not talking anymore about one machine; you're talking about a technology. The machine becomes a part of the complete optical inspection system that can be used at your manufacturing plant. A small customer can gain an advan-



tage because the machine is very simple to be programmed with embedded performance. A large fabricator also benefits because the experience of all the plants goes into the same neural networks. The experience you're doing in India will be available for the team in Germany. The experience you're doing in Mexico will be available for the team in India. The complete system gives much better detectability at a much lower cost.

This is translated to a very short return on investment. Having total AI, you do not have a limit on what you want to inspect. If you get the board with some mechanical parts and nothing to do with electronic parts, you can learn and detect them easily. If you get the screws, mechanical items, glue, whatever you have—you teach and it learns and inspects, and you get the results.

Can this system be adopted to be an inline system in that it will control your prior processes and adjust to prevent ongoing defects?

Yes, the machine is designed for line production, and it's designed to have predictive capabilities in the very near future. Our end solution is not to be the best one in detection. Once you detect, you already have an error and it's too late. We work opposite of the others. We do not analyze the window to discover the error; we analyze the window to understand the whole process and its characteristics. We do not simply analyze the 3D information or X-Y-Z information, we analyze everything. Is this solder joint perfect? Yes, it's perfect. But based on the characteristics of what we see, it's not the nicest solder joint. It's a perfect shape, but it's a cold solder joint. Or perhaps the solder joint is perfect but it's slightly different from the same solder joint of the previous board. Of course, if this happens once, twice, or three times these deviations will become an error at the end of the life. You get to step back and say, "The joint has a problem. What is the problem?"

This is the advantage of neural networks. The system knows what's going on and that everything changing is related to a specific problem. It's becoming the first sustainable AI technology in the market because, rather than arriving with 10 errors at the end of the line on a board, there will be only one or two. Eight fewer errors mean more good boards. It means less CO_2 and less power wasted. It means fewer components wasted, and so on. This is a huge cost savings. We have done the calculation for some customers. The return on investment on a machine like this could be in the range of 10 to 20 days.

Let's talk about service contracts. That's obviously something that people must take into consideration as a cost of ownership. Where are you in that space?

We can offer very different service contracts. This is a machine that, in terms of hardware, has been designed to be high-end quality. So, we are not worried about the real maintenance of the machine, which is reduced to very few things. The filters and the machine must be

cleaned, but little else. The most important part of this machine is the software. Basically, these machines can all be remotely driven. Customers can give us access to do continuous upgrades, or they can give us access to their server to receive the software and then they do the upgrade inside. Once you buy the machine, everything is done on software, so it is the software that, for example, automatically calibrates everything. The only thing you need to do is clean the machine occasionally for filters or lenses.

Where's the reference data for the components coming from initially?

We have built the whole library internally and we give it to the customer; it's a very complete library. What could be missing are very particular odd-shaped components, or very particular new, high-end technology components. We give you a training manager tool, so if you have your secret or specific components, you do not need to share this information with us. You have the tool and the machine, you learn the component, and put it back in your library. Typically, if you learn something new, the neural network will forget what it learned in the past. What we created is a very particular software, very high end that allows you to learn something new without forgetting the past. You can take whatever is in the past and keep on adding new information which will not overwrite what was available before, so you have that history.

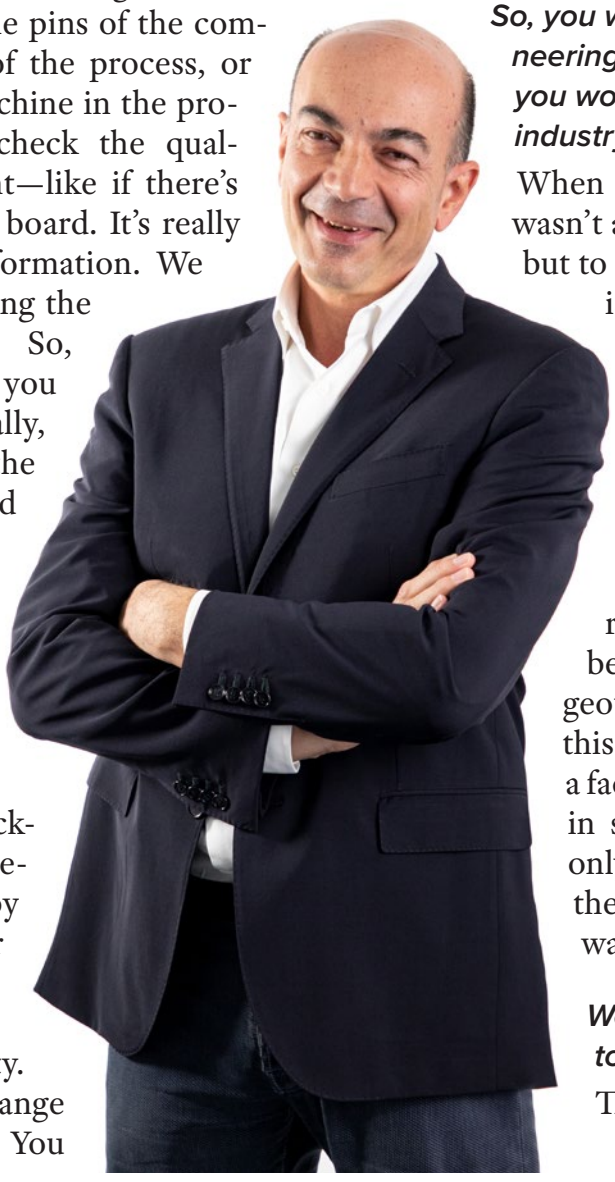
Process benchmarking is important, and it sounds like this tool will be very helpful in benchmarking processes and creating a digital factory as we move into the digital factory era.

Yes, and we are not even talking about Industry 4.0. We are far beyond that. You get a machine that has all the information about your process. You simply need to understand the information you want to use.

That will be the challenge because it's an overwhelming amount of data.

Absolutely. It's a huge amount of data, but we have created a totally open system. We do not want it to become a problem for the customer, who has the option to understand and select whatever they want. They can use the quality management tool internally to understand that you can analyze every single point of the board, every single component.

AI gives you huge advantages. You can check the quality of the pins of the components, the quality of the process, or the quality of each machine in the process. You can even check the quality of the environment—like if there's too much dust on the board. It's really a huge amount of information. We have succeeded in giving the customer everything. So, it depends on where you want to focus. Typically, you try to understand the number of errors and say, "Today we got 2,000 errors; what is the most recurrent one? Okay, the most recurrent error is this one. What caused this error?" You can go backward and say that a specific error was caused by this particular supplier who supplied me with these components that are low in quality. Then you decide to change or talk to the supplier. You can really learn and continuously improve your quality process.



It won't be just limited to components. It will be the amount of flux on the board or solder paste or whatever.

It can also be related to the fact that you're not maintaining your oven, for example. If you inspect the board and suddenly start to see drops of flux, you might ask why it's happening so frequently in these shifts or this amount of time. Perhaps rather than doing maintenance to the oven every month, you must do maintenance every 20 days. You can really detect everything. It's a process diagnostic tool, a preventive process diagnostic tool.

So, you wind up with predictive engineering. Are there any final thoughts you would like to share with the industry about this?

When we created this company it wasn't about creating a new machine but to create a new technology. This is a new generation of AOI, a new concept of inspection. I cannot say if it's better than others because this is a decision made by the customer, but for sure, this is a system that opens the future of quality management inside factories. It is a step that needs to be taken. We need to be courageous and take this step because this will change the future. This is a fact. If we want to be sustainable in such a market, we must not only catch errors, we must avoid them in the first place. The only way is to become predictive.

Well, thank you for your time today.

Thank you. **SMT007**

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Mastering the Art of Reworking Circuit Assemblies

The Knowledge Base

Feature Column by Mike Konrad, SMTA

In the dynamic realm of electronics manufacturing, the need for reworking circuit assemblies is an inevitable reality. Whether it's correcting defects, upgrading components, or adapting to design changes, the process of rework plays a crucial role in ensuring the functionality and reliability of electronic devices. In this column, we'll delve into the challenges, best practices, types, and reasons for reworking circuit assemblies, and shed light on the intricate world of electronic assembly modification.

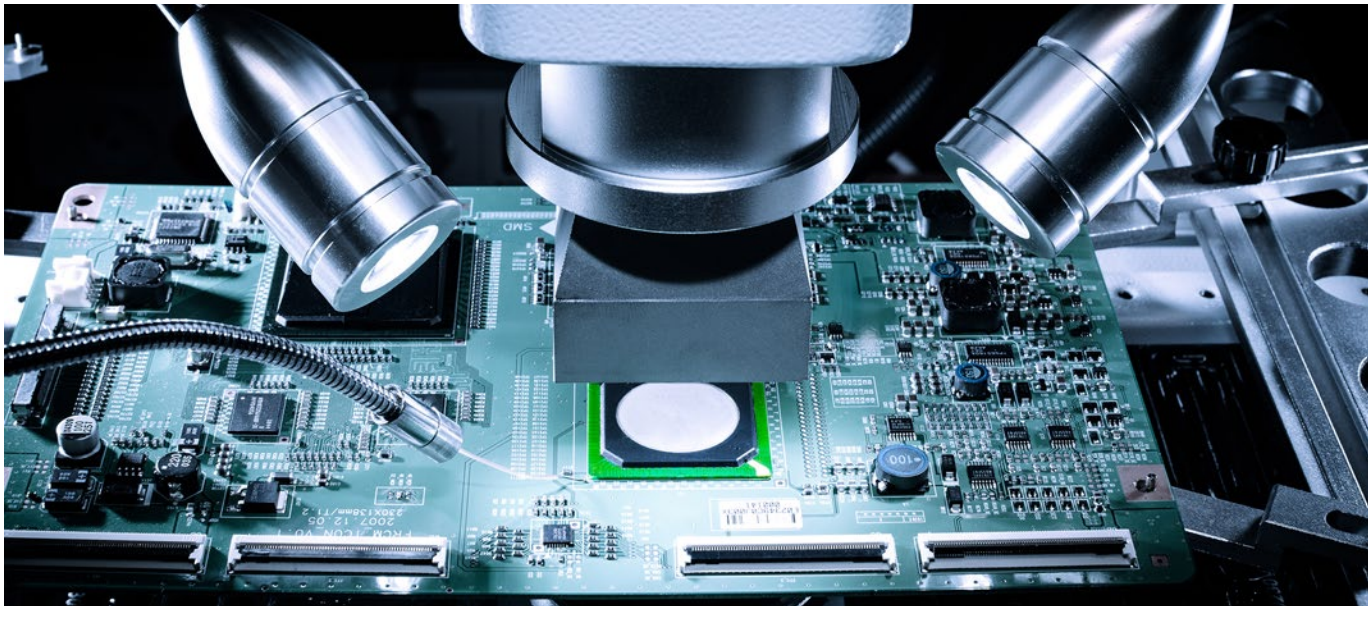
Challenges of Reworking Circuit Assemblies

Reworking circuit assemblies presents a unique set of challenges that demand precision, expertise, and careful consideration. One of the primary challenges is the risk of damaging delicate components during the rework process. Soldering and desoldering components can expose them to excessive heat, potentially compromising their functionality or longevity.

Another challenge is the potential for introducing new defects during the rework process. Misalignments, solder bridges, or inadequate heat control can lead to unintended consequences and cause more harm than good. Moreover, as electronic devices become more compact and densely populated with components, navigating the intricate pathways of modern circuit boards requires a steady hand and keen attention to detail.

Best Practices for Reworking Circuit Assemblies

To overcome the challenges associated with reworking circuit assemblies, it's essential to



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adhere to best practices. First, a comprehensive understanding of the specific assembly and its components is crucial. This includes knowledge of materials, thermal profiles, and the potential impact of rework on adjacent components.

Investing in high-quality tools and equipment is equally important. Precision soldering stations, hot air rework systems, and specialized tools for component removal contribute to successfully executing rework tasks. Additionally, utilizing soldering techniques such as drag soldering, hot tweezers, and vacuum desoldering can enhance accuracy and minimize the risk of damage.

> "Temperature control is a critical factor in rework success."

Temperature control is a critical factor in rework success. Monitoring and controlling the temperature during soldering and de-soldering processes helps prevent thermal stress on components and the circuit board. This is particularly important when dealing with sensitive components such as microprocessors and integrated circuits.

Thorough documentation of the rework process is often overlooked but can be a lifesaver in troubleshooting and quality control. Detailed records of replaced components, soldering temperatures, and any modifications contribute to traceability and aid in future diagnostics.

Types of Rework

Reworking circuit assemblies can take various forms, depending on the nature of the modifications required. Here are some common types of rework:

- **Component replacement:** This involves the removal and replacement of faulty or outdated components, such as resistors, capacitors, or integrated circuits.
- **Solder joint repair:** Repairing solder joints with defects, such as solder bridges, cold joints, or insufficient solder, is a common form of rework. This ensures proper electrical connections and reliability.
- **Modification and upgrades:** Circuit designs may evolve due to changes in specifications or the introduction of new technologies. Reworking allows for modifications and upgrades to keep pace with advancements.
- **Quality improvement:** Rework is sometimes performed to enhance the overall quality of the circuit assembly. This can involve reinforcing weak connections, improving thermal management, or implementing design changes to address reliability issues.

Reasons for Rework

Understanding the motivations behind reworking circuit assemblies is crucial for both manufacturers and engineers. Several factors contribute to the need for rework:

- **Design changes:** As product designs evolve or specifications are updated, rework becomes necessary to incorporate these changes into existing circuit assemblies.
- **Defects and failures:** Manufacturing defects or failures identified during testing and quality control may require rework to rectify issues and ensure the final product meets quality standards.
- **Component availability:** Changes in component availability or the introduction of newer, more efficient components may prompt rework to improve the overall performance of the assembly.
- **Customer feedback:** Feedback from end-users or customers can highlight areas for

improvement. Rework allows manufacturers to address issues and enhance the user experience.

- **Cost reduction:** Rework can be driven by the need to reduce manufacturing costs. For example, it could mean replacing a costly component with a more affordable alternative without compromising performance.

Hand Soldering

In the realm of reworking circuit assemblies, the application of industry hand soldering standards is paramount. These standards provide a comprehensive framework for ensuring precision, reliability, and consistency in manual soldering processes. Adherence to these standards not only enhances the quality of rework but also contributes to the long-term durability and performance of electronic devices.

1. IPC-A-610 *Acceptability of Electronic Assemblies*

IPC-A-610 is widely regarded as the industry standard for the acceptability of electronic assemblies. This comprehensive document defines the criteria for soldering, component placement, and other aspects of electronic assemblies, including those subjected to rework. When it comes to hand soldering, IPC-A-610 specifies the acceptable criteria for various solder joints, ensuring that they meet the required quality standards. This standard classifies solder joints into different classes based on their application, with Class 3 being the highest standard for high-performance electronic products, and Class 1 being suitable for general-purpose electronics.

2. IPC-J-STD-001 *Requirements for Soldered Electrical and Electronic Assemblies*

Developed by IPC in conjunction with the Electronic Industries Alliance (EIA), J-STD-001 is another crucial standard focusing specifically on the requirements for soldered electrical and electronic assemblies. This standard provides detailed requirements for soldering processes, materials, and inspection criteria.

J-STD-001 emphasizes the importance of proper training and certification for soldering operators. It defines the skills and knowledge necessary for individuals involved in hand soldering processes, ensuring they possess the expertise required to effectively perform rework tasks.

3. ESD (Electrostatic discharge) control

While not solely focused on hand soldering, ESD control is a critical aspect of electronics assembly, including rework processes. Industry standards, such as ANSI/ESD S20.20, provide guidelines for establishing an ESD control program. Proper ESD control is essential during hand soldering to prevent damage to sensitive electronic components, which are prevalent in modern circuit assemblies.

Best Practices Derived from Standards

Incorporating the principles outlined in these standards into the rework process significantly contributes to the success of hand soldering. Some key best practices derived from these standards include:

1. Training and certification

- Ensure that personnel performing hand soldering tasks are adequately trained and certified according to industry standards
- Regularly update training programs to align with the latest revisions of soldering standards

2. Process control

- Establish and maintain control over soldering processes, including temperature profiles, soldering iron calibration, and equipment maintenance
- Monitor and document soldering parameters to ensure consistency and traceability

3. Inspection and quality control

- Implement thorough inspection processes based on the criteria outlined in IPC standards
- Conduct regular audits to verify compliance with soldering standards and identify areas for improvement

4. ESD mitigation

- Integrate ESD control measures into the rework environment to prevent electrostatic discharge-related damage
- Use ESD-safe tools, workstations, and personal protective equipment to safeguard sensitive electronic components

In the ever-evolving landscape of electronics manufacturing and rework, adherence to industry hand soldering standards is the linchpin for achieving excellence. These standards not only set the bar for quality but also contribute to the overall reliability and performance of electronic assemblies. By embracing the principles outlined in IPC-A-610, IPC-J-STD-001, and related standards, manufacturers and engineers can elevate the precision and reliability of hand soldering in the pursuit of excellence in electronic assembly and rework.

Conclusion

Reworking circuit assemblies is a complex yet essential aspect of electronics manufacturing. The challenges demand a combination of expertise, precision tools, and adherence to best practices. With an understanding of the types of rework and the reasons behind them, manufacturers and engineers can navigate this intricate landscape, ensuring the reliability and quality of electronic devices. **SMT007**

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

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Advanced Electronics Assembly Conference	26 April 2024 Budapest, Hungary
High Reliability: Strategic Technology Advancement Research Forum	May 2, 2024 Olathe, KS, USA
Electronics in Harsh Environments Conference and Exposition	14 - 16 May 2024 Copenhagen, Denmark
Symposium on Counterfeit Parts and Materials	June 25 - 27, 2024 College Park, MD, USA
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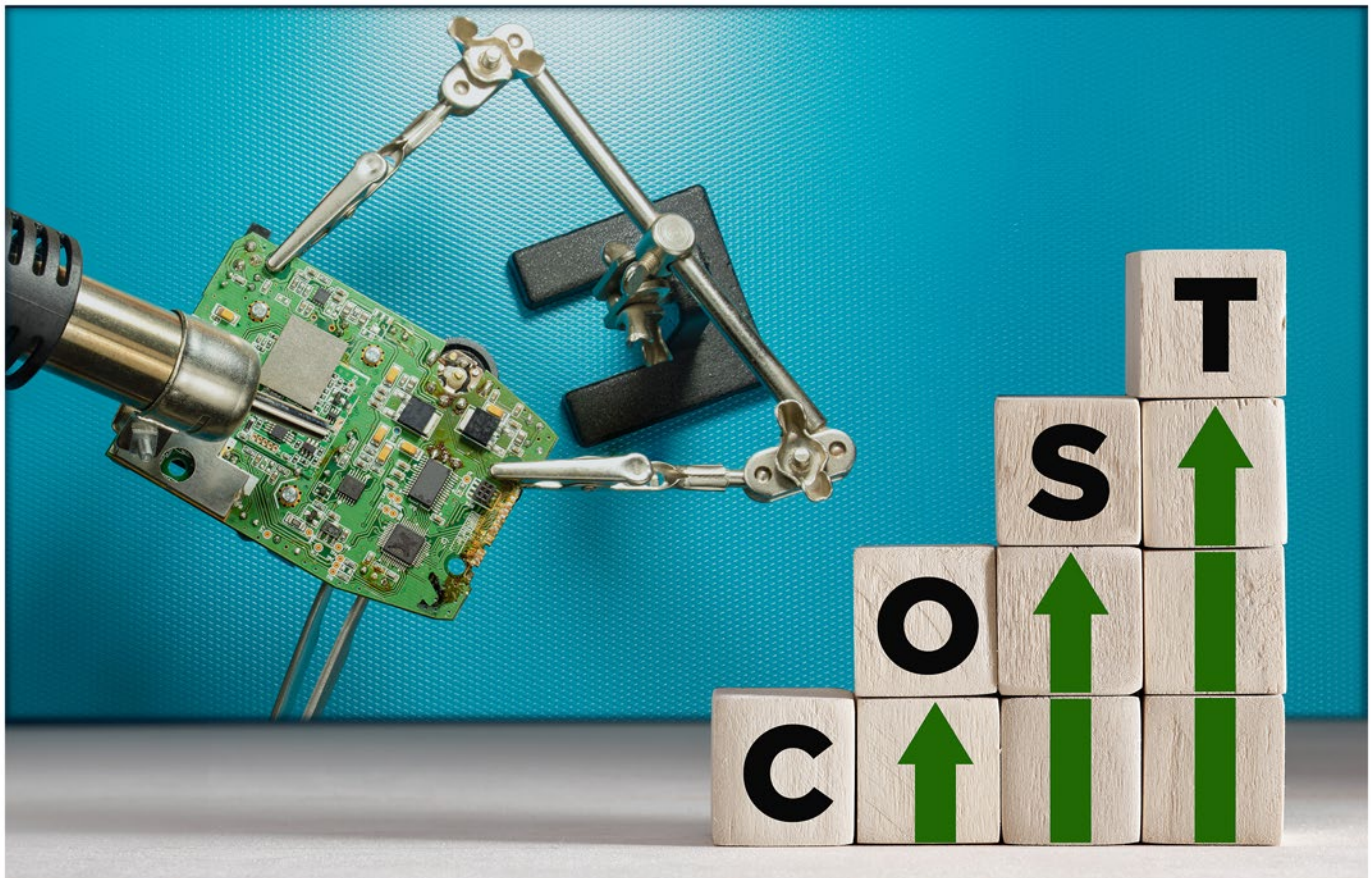

The High Cost of Repair

Feature Interview by Nolan Johnson
I-CONNECT007

When talking to the staff at BEST, Inc., there's one key message: Not much has changed in the repair business, except for all the things that have changed. We spoke with Dan Patten, general manager; Laura Ripoli, customer service manager; and Nash Bell, president, to learn just how much the cost-benefit analysis is changing for their clients and their business. It's safe to say that change for the good is in the air at BEST.

Nolan Johnson: What is the overall economics of having to do repair?

Dan Patten: One of the biggest challenges is the cost of repair. Unless it's the higher-end, Class 3 product, repair usually exceeds the value the manufacturers wish it would be. Ultimately, they want it not to need repair because they designed it that way. Usually, if there's a justification for repair, it means that the value is high, which means the parts are unavailable, or it will take too long to rework the boards. It's a time factor they're paying for—not necessarily the value—because the initial value of a robot throwing a bunch of parts on a board correctly is pennies. Anytime you open a repair, it starts at hundreds of dollars.

We find that no one is repairing Class 1 electronics. They're throwing them away and waiting for more, or they're replacing them with something higher—Class 1 or 2 plus. Automotive, medical, and aerospace usually hit Class

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Dan Patten

3. Everything below that is headed for the garbage can, or the manufacturer is using their own technician to touch it up.

What you don't see everywhere is the repair of bottom-terminated components and that's because there's a lack of ability. We see ball grid arrays (BGAs) the size of your thumbnail with 1,000-plus connections underneath. Those must be done with specialized machinery and highly technical people who are capable of working with that. It's followed by X-ray imagery to make sure the repair is okay. It's a sensitive repair—which no board or chip manufacturer wants—because it typically involves multiple heat cycles before it goes out into the field.

Is there a trend for the contract manufacturers to increasingly outsource repair to specialists, or is it a skill set they develop in-house?

Patten: I don't see signs they're growing it in-house unless their problem becomes more than, say, a quarter-million to a half-million dollars in a year. If you've got a quarter-million-dollar problem, something horrible happened and it's a massive problem. They like it when I fix the problem, but they do not want to have that problem. That's when you certainly would want to invest in equipment to do it yourself.

If you are one of the bigger BGA manufacturers, you have your own abilities. But we see a lot of issues from a variety of customers, so we have the "variety" skill set here.

If repair increasingly requires skilled soldering technicians and special equipment, what's involved in setting up a system?

Patten: The simple solution is a machine, such as for BGA repair. A very simple one-trick pony might be in the tens of thousands of dollars. But if you need to do multiple types of devices on it, it will be more like hundreds of thousands of dollars. You can buy that machine, but it won't likely get delivered for three or four months because these machines are hard to come by. Everybody forgets that a machine will need experienced technicians to run it. You use one of your engineers or hire one from a place already doing it, which means they lost an engineer. Now it's months to be up and running—a long time before they can take on any project. That's a massive time cost.

Now, will they stay? If the technician leaves, you start over again. This is why I believe we've had such a successful and sustainable business in this sector. We are just a small part of the industry, where providers want to do it all robotically and get it right 99.99% of the time. If they're doing it right, they shouldn't need us. But they all do.

Laura Ripoli: You also need X-ray equipment.

Patten: Exactly, and those start at $150,000 to $250,000. Do you have a tech who can run it, or is it the same tech who runs both? If it goes down, for how long? This is a critical path, so do you have a backup? To have it in-house could easily turn into a million-dollar investment. We like to think we are the insurance policy for much less money.

Ripoli: You also need an operator, a QC tech who's certified to inspect to the IPC specifications.

Patten: All the customers require an inspection to the IPC-610 standard, as well as someone who knows how to read and interpret the X-ray because that's not specified in the 610 standard.

Nash Bell: When our customers come to us with a problem, such as a BGA removal, we have multiple ways to remove that BGA that may reduce the risk to adjacent components or the rest of the board. We have the knowledge, expertise, and a lot of very skilled people with experience doing that type of work to tell us what the best method is to remove that BGA and minimize the risk of compromising anything else on that board, too. That tribal knowledge is important as well.

> "It's fun being able to do projects we couldn't do previously..."

Patten: We could have a whole separate conversation just to tell designers not to put 5,000 0201 components next to a BGA. We'd tell them to put a little space in there because if that BGA ever has to come off, there are only two ways, and they require a lot of heat. If the small components were further away, designing for repairability could go a long way, but no one is doing that. Think of the phone in your pocket, for example. There are multiple BGAs on that phone. It's not Class 3, and it's not repairable. Unless there's just a cracked screen, it gets thrown away.

You mentioned multiple ways to remove a BGA?

Patten: We certainly have ways using the traditional method of heat, because that's how you melt solder. We find underfilled components to be the most challenging with heat because the underfill beneath a BGA melts at a different temperature than the solder. It's pushing solder balls and squirting everywhere. Sometimes heat is not the solution, in which case there could be no solution.

We have recently acquired an ESD-safe milling system that can mill down in layers—down to one-micron layers at a time—to do cold removal of chips. This allows removal of BGAs so we don't have to put the board through multiple heat cycles to get the component off. There are only so many times you can apply heat cycles to a single board, and you definitely hit your limit somewhere around eight times. Now we're cold-milling chips that have no value, but the board still does. What's beautiful with the underfill is it's like leaving a stencil in place with a little bit of solder. If I get that down to about six-thousandths of an inch, it's no different than a 6-mil stencil. I could put a new part right on top of it.

It's fun being able to do projects we couldn't do previously because the yields weren't in the high 90% range. Even BGAs that aren't underfilled sometimes work fine—and sometimes everything just goes wrong. We have not traditionally warrantied work on anything underfilled, but customers still take that chance, so we found a better way for them.

You mentioned cold milling, which is new to me. Are there some other new techniques that might not be so well known?

Patten: It's easily the newest technique in the last 10 years. We switched from hot air stations to infrared rays, which has helped with certain situations. We're unaware of anyone else with a commercially available cold milling solution and vacuuming for ESD and foreign-object debris (FOD). I know some big players are experimenting with this, but it's usually the prototype houses or Department of Defense projects because they're only making 100 of something, like $100 million antenna towers.

Nash Bell

Does robotics play a part in repair at this point?

Patten: A little. I have robotic placement machines, balling machines, and milling, but it must be a high quantity to afford to program the robotics. How often do you see high quantity in rework and repair? The highest quantity that I've seen are in the thousands, not tens or hundreds of thousands.

As you mentioned, if you have a problem that big, you've got a big problem.

Patten: I guess we could do robotic removal if it's a simple thing, like robotic epoxies. It's not prevalent in the repair world. To make the capital investment work, you need to be doing it a lot and know more is coming. Just because new technology machines are available, which are exciting to a geek like me, doesn't mean we have to get it. The costs are too prohibitive.

What do you see with the emergence of advanced packaging? We're hearing BGAs as much as 100 millimeters per side.

Patten: We are absolutely at the razor's edge of Moore's law. Trust me, it is getting too small to repair. They do not expect these to ever be removed. As soon as you add components onto a component, and if you're using heat or anything like that, everything is out the window. We're still having success with it in very controlled environments, but the smaller they get—and the package-on-package is getting more difficult when it's all built into the BGA or the package—it's getting close to impossible to repair some of the latest packages.

What are some of the other challenges you're seeing with respect to efficient repair work?

Patten: Some of the biggest challenges in starting and finishing projects have nothing to do with the engineer or the project itself; it's the internal politics of the company that is sending things to us a certain way. The most logical reason for that would be a chain of command—for example, devices can't go out of the company's hands, but customers bring devices in with them. We've worked on them with the company representative in front of us, or we've gone out in the field and advised.

Otherwise, it's things like somebody wanting to change the due date after the deal is done because the marketing department found out and now they're asking us, "If you can do 10 in a week, then we'd like 100 the week after, and we'd like 10,000, the week after that." It's that kind of communication. The purchasing agents sometimes don't understand what the engineers are working on, and management might not understand the purchasing role. There can be multiple conflicts trying to solve the problem they're facing.

The world does not want to even think about us unless they have a problem.

Thanks for taking the time to speak with me.

Bell: Thank you, Nolan. **SMT007**

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Making Rework a Smart Business Opportunity

Smart Factory Insights

Feature Column by Michael Ford, AEGIS SOFTWARE

Rework in manufacturing can bring waste, unplanned responses to an error, or too much variation. You also have to retain specialist skills to perform the work. Since rework cannot always be completely eliminated, let's consider how we can create a new business opportunity.

The strive for zero defects has been going on forever and will perhaps always remain elusive. There will always be a risk for mistakes to be compounded in the market. Thus, inspection and test are that all-important filter to assure (to a reasonable extent) no immediate defects leave the factory. Analyses of inspection and test data, as well as machine performance, can detect the root causes of potential defects, and provide automated closed loops.

The Smart Approach to Quality in Management

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defects but is an active part of quality management in preventing defects. In some cases, as the rate of defects lowers, it may become more cost-effective to scrap defective units rather than repair or rework them, while building extra units into the work order to compensate. This is the state of the art for many, but not perfect, certainly in terms of material waste.

In most cases, defective products will need rework at some point, so you must prepare. But the cost of skilled engineers does not decrease with the reduced number of defects. Instead, these key people have more free time and it's challenging to utilize them effectively as other jobs in manufacturing don't require their specific skills. When there's not enough work to do, engineers become bored and search elsewhere for challenges. That's when you need to look for a new solution.

What We Can Learn

Most of us today have grown to value the data in manufacturing in terms of how to understand the root causes of inspection and test failures, and help resolve weaknesses in manufacturing processes, including material choices and handling.

Learning from repair and rework is our final opportunity in manufacturing to gain a higher-level understanding of the health of the product design and production process. Though the design passes traditional design-rule checks, conditions remain that may be sensitive to the effects of variation and simple mistakes.

Subtle changes in design may avoid creating those conditions. Intelligence is required to expose design improvement opportunities, going well beyond the root causes of specific defects. Such determinations depend on complex contributors, for example, the capabilities of machines and manual processes, not just to execute the assigned work, but to understand how "comfortable" the work is. This can be quantified and measured, for example, by the amount of variation created in product completions, which increases as machines are pushed to their limits.

Some machines may place a certain component with ease, while another struggles. The mix of material sourcing for a specific component also plays its part, as slight deviations in shape and size from different vendors, or even different lots, become significant in terms of a cause for the variation. In times like these, where supply is constrained, there is a strong likelihood that materials selected and purchased may not match the original design intent. Whether such variation implies a problem or is a benign function of the material change, requires intelligence to assess. Many analyses differentiate the responsibilities of manufacturing operations, machine or operator performance, design, or material-influenced variation. Association and analysis of such variation in turn helps improve design, manufacturing planning, machine selection, material purchasing, and more.

> "In most cases, defective products will need rework at some point, so you must prepare."

It has been proven statistically that reliability rates for products in the market are directly related to defect opportunities in manufacturing. The dwindling opportunities for feedback from repair and rework in manufacturing, therefore, represent only the start of this opportunity.

In today's design-for-demand driven economy, repairability is not a high priority. Products under warranty are simply replaced or a major component is swapped out. Beyond that, the product is usually discarded. Very little effort goes into troubleshooting what actually failed. Information about unknown and

endemic weaknesses in products, which could have been addressed by subtle design changes, processes, or material choices, are lost to the designer and manufacturer who are simply told instead that the product performance did not achieve its design intent.

As our culture shifts from consumption to sustainability, the right to repair is emerging and receiving more support through government legislation. Sustainability advocates are pushing for products that last a lifetime, and have materials that can be recovered, recycled, and reused. The remanufacturing industry is predicted to grow and exceed that of original manufacturing. Designers need to start planning their future designs with this in mind, facing the prospect that some design information—for an uncontrollable number of third-party repair, recycling, or recovery operations, all of which have a legal right to obtain certain portions of the product design IP—will need to be shared. Rather than let this market opportunity develop at random, designers and their manufacturers should plan the part they will play and whether it will be beneficial to replace original manufacturing in terms of their growth with more managed market-based product repair, recovery, and recycling.

> **A growing and tangible opportunity exists for design and manufacturing partners to plan their remanufacturing operations.**

A growing and tangible opportunity exists for design and manufacturing partners to plan their remanufacturing operations. Their first step would be to create a business plan that uses existing and underutilized rework experts in manufacturing to create an in-house business for repairs, returns, and material recovery. Access to the original design and MES manufacturing data allows the streamlining of many maintenance, repair, and overhaul (MRO) activities. These can range from repairs, servicing for extended life (product as a service), repurposing into another product, recovery of key materials and modules, and the ultimate recycling of materials.

The advantage of taking a simple first step into in-house repair allows the discovery of what has contributed to the need for repair, in terms of usage, abuse, accidental damage, or product weakness caused by manufacturing or materials defects that could have been improved by design. It allows designers to refine the reliability of products and life expectancies based on real product usage. The result will be more reliable products in the market, reduced costs, and less need to share design information with third parties.

The concept of needless rework reduction is clear to those in manufacturing today, and potentially represents a forward-thinking business opportunity to those in the business chain. For some, this practice has been successful for many years. Advanced MES tools include MRO support, achieving the benefits of understanding design and manufacturing the original product in context with the need for repair or reuse. The remainder of the industry has not been so driven to follow suit, but that is changing. **SMT007**

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

Cold Milling as an Alternative PCB Component Removal Method

Feature Article by Bob Wettermann

When a PCB undergoes multiple heat cycles, inherent risks emerge, primarily due to the expansion and contraction of materials. This thermal stress can induce various issues, including delamination, warping, compromised solder joints, and damage to heat-sensitive components like integrated circuits or capacitors.

To counter these risks, one approach involves a unique process called "cold milling," designed to mitigate the adverse effects of additional thermal stress. Unlike traditional methods involving direct heat application, this solution utilizes a laser-guided precision mill to remove components. This ESD-safe process includes a vacuum nozzle that simultaneously removes debris during the milling process, ensuring cleanliness.

The genesis of "cold milling" stems from a customer's challenge with removing underfilled BGAs. They encountered issues with underfill leaching into the adjacent solder during reflow, causing solder shorts. By utilizing this cold milling process, we were able to remove the component without applying heat and place a new component in its place resulting in a yield >90% and a successful solution for the customer.

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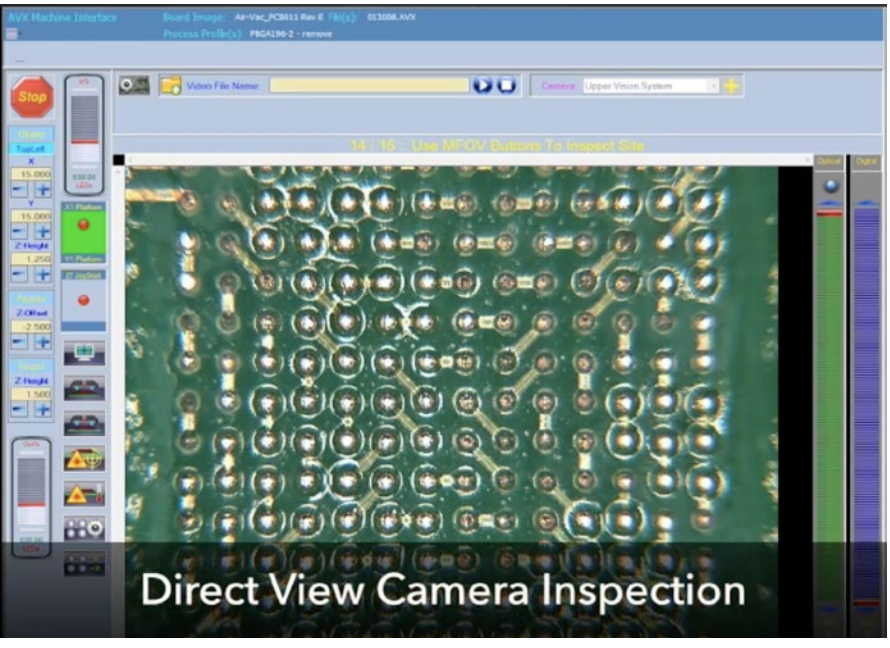

Challenges with rework of underfilled components include but are not limited to the following:

1. Solder displacement: Softened underfill can displace solder at elevated temperatures which can result in defects.

2. Can be expensive: Low yields and prohibitive cost of long processing times for experienced "high touch" rework are typical.

3. PCB damage: The underfilled rework process may cause laminate damage, mask destruction, and lifted pads, impacting reliability, and resulting in additional repairs.

4. Difficult rework: Due to the inherent instability of underfilled components, traditional rework methods using thermal or thermal/mechanical options become less feasible.

The process begins with thoroughly examining the board to identify any components that might interfere with milling. Using a universal fixture which accommodates most PCBs, we mount the board onto the mill platform. Subsequently, the mill is programmed to precisely locate the component, measure board coplanarity, and determine its depth relative to the board. Shaving off layers as thin as a few microns per pass, the mill continually assesses coplanarity and depth while gradually approaching an appropriate depth above the pads. The remnant solder becomes the pre-tinned pad for the replacement component.

Cold milling becomes a viable alternative for component removal under specific conditions:

- High risk of heat damage to the PCB or rework location
- Components can be sacrificed during the removal process
- Previous issues arising from traditional heat-based removal methods
- Underfilled components requiring rework

Benefits of cold milling:

- No additional thermal stress and associated risks
- The mill contains an integrated active ionizing source reducing the risk of ESD-related issues
- A vacuum chuck surrounding the bit which removes debris as material is milled
- Laser-based measurement system for precision cuts within 0.001" from the board surface
- Cost-effective
- Expedited lead-times (depending on quantity)

Risks with cold milling:

- Pad damage especially when no underfill is present
- Milling too deep exposing the copper layer
- Physical damage to adjacent components if not removed prior to milling **SMT007**

Bob Wettermann is the former president of BEST, Inc.

A Look Back at 2023

MilAero007 Highlights

RTX to Create Network of 'Energy Webs' for DARPA ▸

Raytheon, an RTX business, has received a $10 million contract from DARPA to design and develop a wireless airborne relay system to deliver energy into contested environments. The Persistent Optical Wireless Energy Relay program, known as POWER, aims to revolutionize energy distribution by leveraging power beaming for near-instantaneous energy transport in a resilient, multi-path network.

New Hampshire's Microelectronics Center Wins $35 Million Through CHIPS Act ▸

The U.S. Department of Commerce and BAE Systems Electronic Systems, a business unit of BAE Systems, have signed a non-binding preliminary memorandum of terms (PMT) to provide approximately $35 million in federal incentives under the CHIPS and Science Act to support the modernization of the company's Microelectronics Center, a mature-node production facility in Nashua, New Hampshire.

Missile Defense Agency, Boeing-Led Industry Team Conduct Early Release Intercept Test ▸

The U.S. Missile Defense Agency and a Boeing-led industry team successfully intercepted an intermediate-range ballistic missile in space during the latest test of the Ground-based Midcourse Defense, or GMD, system. The test validated GMD's Capability Increment 6B configuration, which gives the Missile Defense Operators more time, space, and flexibility to intercept ballistic missile threats to the U.S. homeland.

Nokia to Acquire Fenix Group, Strengthening Wireless Offering in the Defense Segment ▸

Nokia has signed an agreement to acquire Fenix Group, a privately held company that specializes in tactical 3rd Generation Partnership Project (3GPP) communications solutions for the defense communities. Fenix systems are designed to provide high-speed, low latency data connections to many devices and users simultaneously, making them ideal for supporting a wide range of military applications.

Boom Supersonic Selects Honeywell Anthem Integrated Flight Deck for Overture Aircraft ▸

Boom Supersonic, the company building the world's fastest airliner, has selected the Honeywell Anthem integrated flight deck for its Overture aircraft. As part of the agreement between the two companies, Honeywell's next-generation flight deck and its modular avionics platform will be incorporated into Overture.

Future Leaders in Aerospace Prepares the Next Generation for Research Careers ▸

MIT's Department of Aeronautics and Astronautics (AeroAstro) recently hosted the 2023 Future Leaders in Aerospace Symposium, inviting women and underrepresented minorities in aerospace fields to campus for a two-day program. The symposium was open to applications from recent graduates and students within one to two years of earning their PhD, helping early-career academics to launch and navigate an academic career in aerospace engineering.

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TECHNICAL PAPER

Novel Automatic Repair of Populated PCBs in a Cost-effective and Adaptive Way

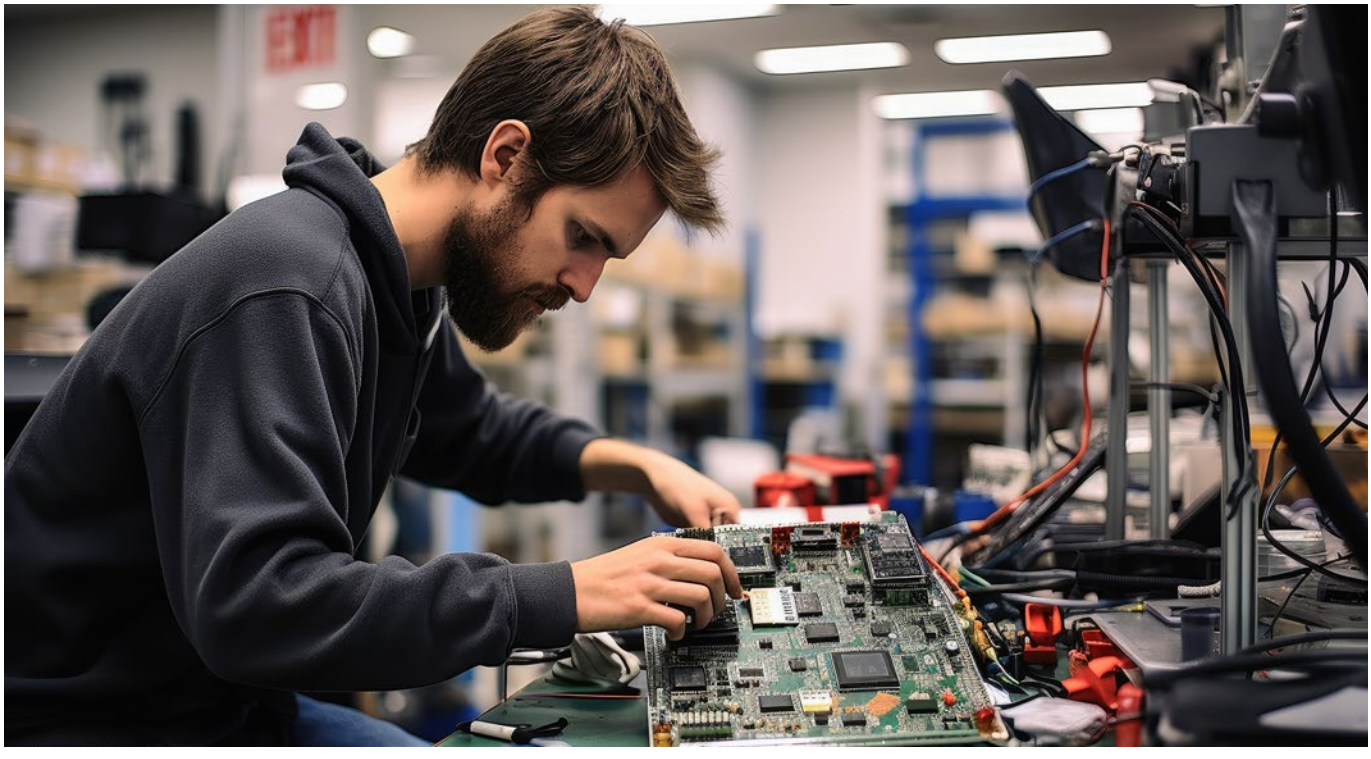
Feature Article by Irving Rodríguez
ESSEMTEC, A NANO DIMENSION DIVISION AESCH,
LUCERNE, SWITZERLAND

This paper was presented at the technical conference during IPC APEX EXPO 2023 in San Diego, Calif.

Introduction

Did you ever have to consider repairing an electronic product? Repairing populated boards is getting more and more popular due to several reasons, for example, placement of wrong components, refurbishment or function enhancement of existing products, counterfeit components, etc. The cost of the top five most counterfeited parts represents $169 billion worth of semiconductor revenue[1]. Around 140,000 tons of electronic products are wasted every day globally with few repair options on the market [2], representing the fastest-growing category of waste in developed countries [3].

Changing an electrical component is a tedious job. Desoldering it from the board, removing the extra solder from the pads, applying fresh solder and flux to the component or pads, placing the new component, and finally soldering the component again are the typical processes involved. Regarding soldering, there are two ways to perform this process, the first is heating only the affected component locally, and the second is using low-temperature solder, which allows submitting the whole product to temperature. Two main disadvantages



of the current repair process are the use of the valuable time of expert personnel and that only one component per product can be replaced at a time [4]. Applying solder paste and placing the component is very problematic, especially on fine-pitch components—the risk of short circuits due to misplacements of packages or solder paste is high.

The proposed method in this work is focused on applying solder paste and placing the component. By using solder jetting instead of printing or dispensing, the time required to deposit solder paste can be significantly reduced. Special needles were designed to perform the jetting process without damaging the already populated components. Another advantage of using a fully programmable jetting system is that the required volume can be customized per pad; for example, pads for a TQFP package with 200 µm width pins and a large pad in the middle can easily be jetted, delivering the correct amount depending on the situation. Pick and place of the components is performed with the same instrument as well in a fully automatic way and the throughput is further improved. The possibility to replace several components on the same product is also given. There is no need for an expert operator once the equipment is programmed.

The repair process has been implemented with different alloys, including SnPb, SAC305, and SnBi [5]. This work presents the results of products reworked using SnPb and SnBi. The results show that the XY positioning accuracy and dot repeatability exceed acceptable expectations for a 400 µm pitch. With this fully automatic jetting and pick-and-place method, the repair of a product can be made in a very accurate and agile way. This represents remarkable cost advantages for companies performing repairing activities.

Experimental Methodology

The experimental studies aim to test the positioning accuracy of the solder deposits as well as the dot repeatability. The throughput achieved with the proposed repair method was also measured. The positioning and dot accuracy was assessed against product needs, and the throughput was compared with the current customer experience. All the accuracy data was collected at Essemtec's lab, and the throughput data was collected at the customer's facilities.

Even though every soldered component type can be repaired with the proposed method, this work only analyzed two cases. The first one is a product with a TQFP (thin quad flat package) component requiring a type 6 paste with a Sn63Pb37 alloy. This TQFP has 128 terminals of 200 µm in width with a pitch of 400 µm and a contact area in the middle of 8.4 x 8.4 mm. The size of the TQFP is 14 x 14 mm. The second case is a product with a BGA using a low temperature soldering type 6 paste with a Sn63Bi37 alloy. This BGA has a total of 1599 terminals with a diameter of 200 µm and a pitch of 400 µm, the size of the BGA is 18.5 x 27 mm.

A total of 20,000 dots were jetted to verify the stability of the jetting process. For every 1,000 dots jetted on production, 10 dots were jetted on a separate test plate where the dot's diameter and X-Y accuracy was measured. A total of 200 data points were collected per experiment.

Positioning accuracy and precision together with the dot diameter were measured utilizing the ePlace software which is integrated into Essemtec machines. A normality test was performed on all data using the Anderson Darling method [6]. A capability analysis was performed on every data set using the Minitab software version 19.

Results

Figure 1 shows the first case study of a component to be repaired—a TQFP. For practical purposes, the component was divided into three zones. Zone A are pads with a width of 200 µm and a pitch of 400 µm. Zones B and C are regions used mainly for thermal dissipation or electrical grounding. It is important to notice that Zone B is not flat. It is an area surrounded by 3D topography with valleys of around 1 mm

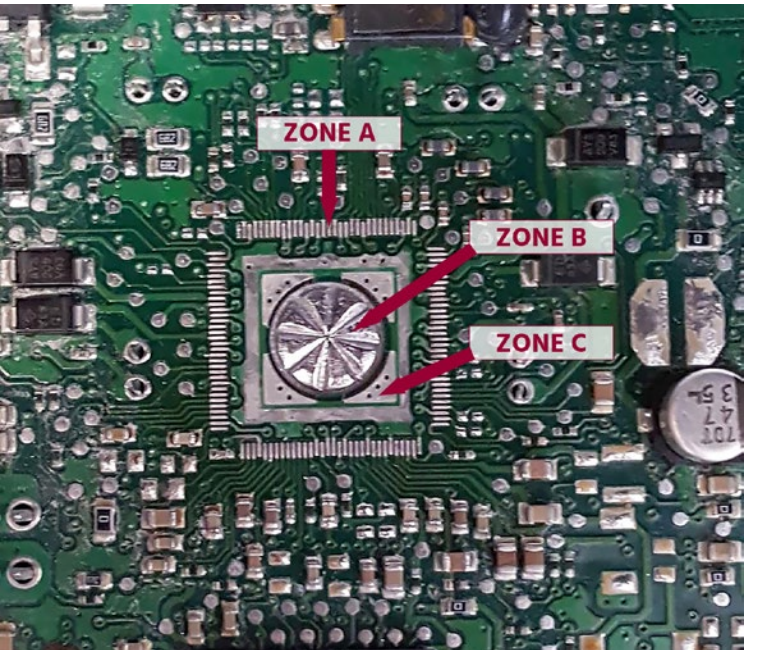


Figure 1: Component to be repaired, TQFP (thin quad flat package).

depth. As can be observed the component is surrounded by packages with different dimensions and heights. This component required a solder paste type 6 with a Sn63Pb37 alloy.

As a first step, a dedicated needle was designed. Figure 2 illustrates the needle, needle holder, and bayonet. As can be observed in Zone A, a collision between one of the parts and the placed components can occur. To avoid this collision a needle with enough length must be used. The length of the needle shall be long enough to avoid collisions but as short as possible to reduce the resistance to flow. Based on internal experience at Essemtec, high resistance to flow impedes jetability and tends to block the nozzle. For this case, a needle length of 6.5 mm with an opening of 0.15 mm was designed. Zones B and C can be jetted with conventional jetting nozzles because there are no components close to these regions. Conventional jetting nozzles do not have long channels as the needles do, for this reason, the resistance to flow is much smaller.

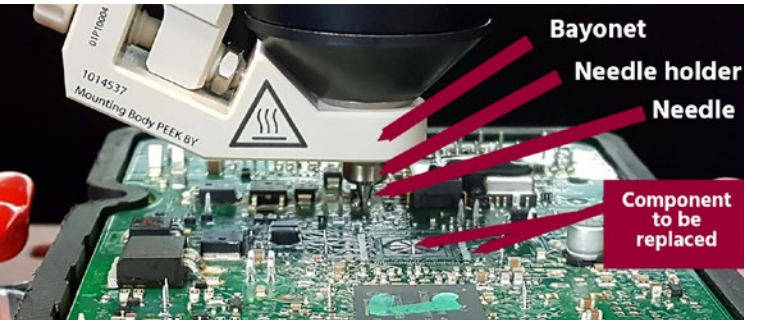


Figure 2: Needle, needle holder, and bayonet.

Figure 3 and Figure 4 show the process capability report for X and Y positioning. The positioning in the X axis gives a process capability of ± 20.4 µm at 3-sigma and in the Y axis of ± 24 µm at 3-sigma. The process capability report for the dot diameter is shown in Figure 5. The

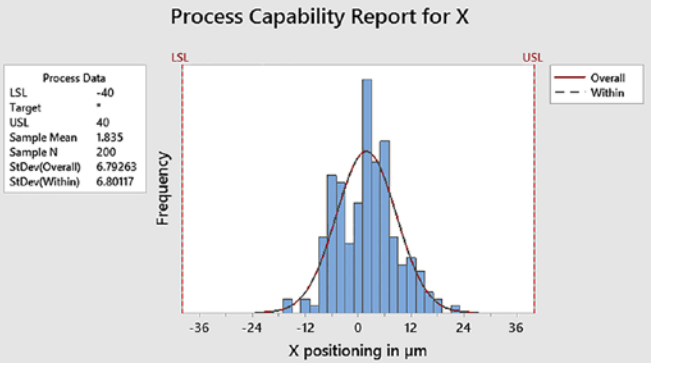


Figure 3: Distribution of the X positioning in Zone A.

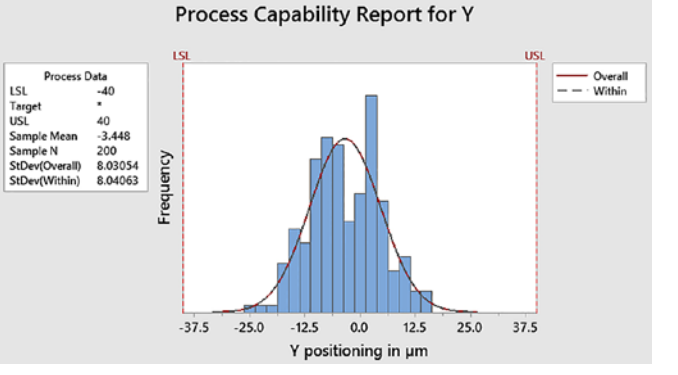


Figure 4: Distribution of the Y positioning in Zone A.

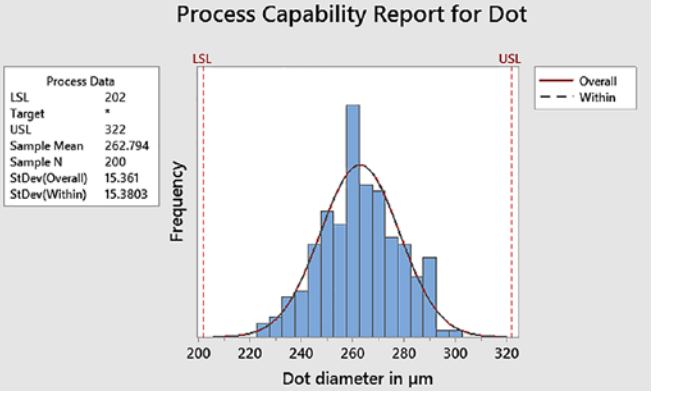


Figure 5: Dot diameter distribution in Zone A.

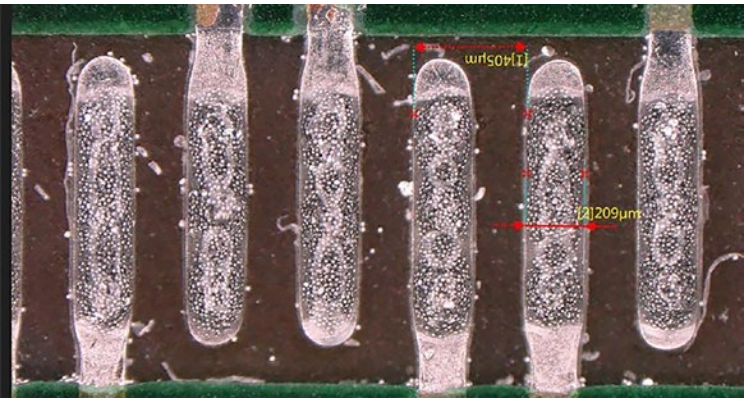


Figure 6: 400 µm pitch after jetting.

average dot diameter is 262.7 µm and its process variability is ± 17.5% at 3-sigma. Figure 6 illustrates the 200 µm pads after jetting.

The same procedure was used to verify the capability of the process applied for Zones B and C. In these zones, the use of a nozzle is possible because there are no components close to the jetting areas. Figure 7 and Figure 8 show the process capability report for X and Y positioning. The positioning in the X axis gives a

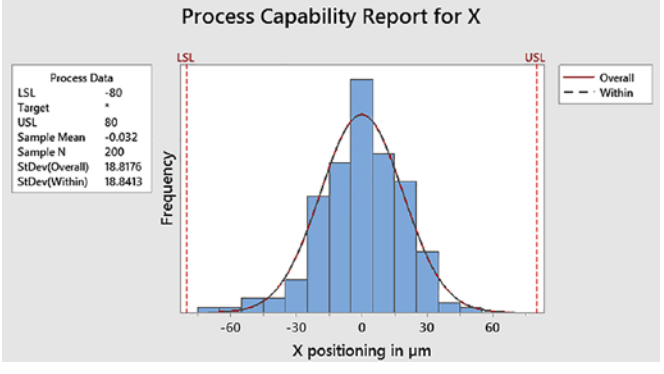


Figure 7: Distribution of the X positioning in zones B and C.

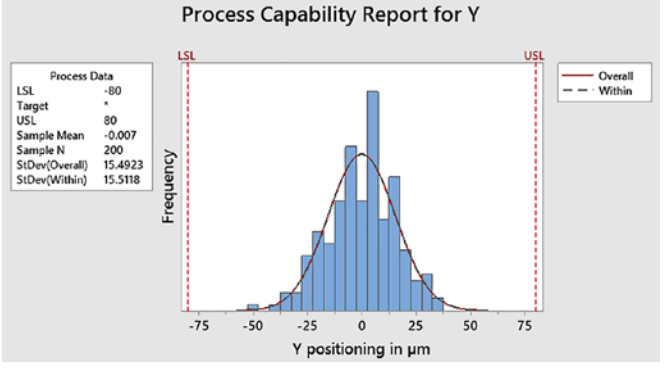


Figure 8: Distribution of the Y positioning in zones B and C.

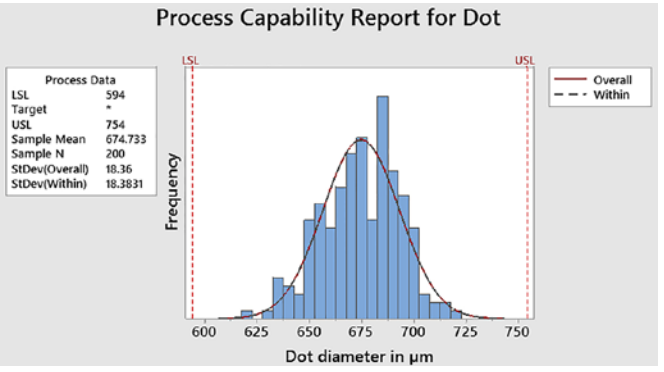


Figure 9: Dot diameter distribution in zones B and C.

process capability of ± 56.4 µm at 3-sigma and in the Y axis of ± 46.5 µm at 3-sigma. The XY positioning of this dot is considerably more inaccurate compared with the dot of Zone A because to be able to jet the uneven area of the center of the TQFP (Zone B), the jetting distance must be substantially higher. Higher jetting distances tend to give less accurate positioning results. The process capability report for the dot diameter is shown in Figure 9. The average dot diameter is 674.7 µm and its process variability is ± 8.1% at 3-sigma. Figure 10 illustrates the complete TQFP after jetting.

A second jetting process to replace a BGA with 200 µm pad diameter with 400 µm pitch was analyzed. This component required a low temperature type 6 paste with an Sn63Bi37 alloy. For this product, a needle length of 1 mm with an opening of 0.15 mm was selected. The same procedure as in the previous product was

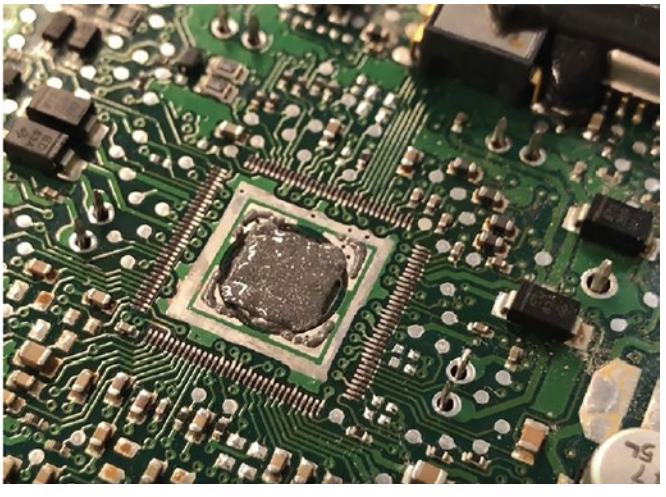


Figure 10: Complete TQFP after jetting.

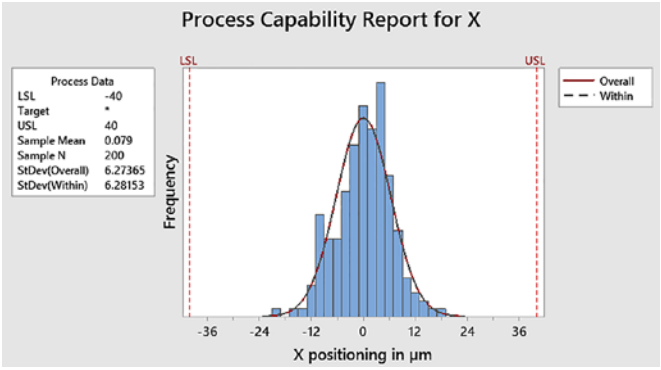


Figure 11: Distribution of the X positioning of the BGA component.

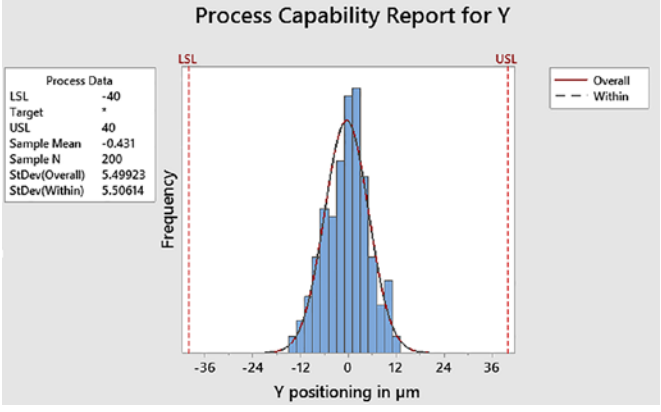


Figure 12: Distribution of the Y positioning of the BGA component.

used to verify the capability of the jetting process. Figure 11 and Figure 12 show the process capability report for X and Y positioning. The positioning in the X axis gives a process capability of ± 18.8 µm at 3-sigma and in the Y axis of ± 16.5 µm at 3-sigma. The process capability report for the dot diameter is shown in Figure 13. The average dot diameter is 294.4 µm and

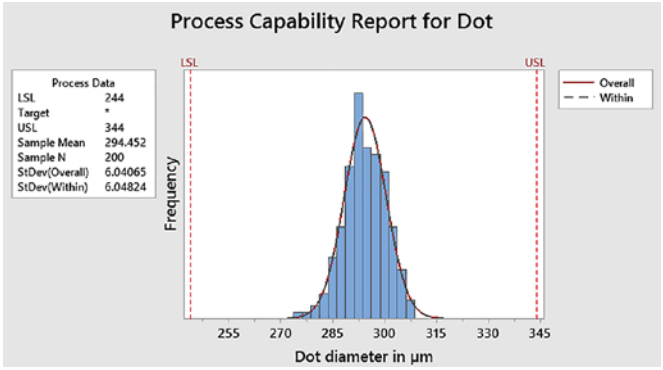


Figure 13: Dot diameter distribution of the BGA component.

its process variability is ± 6.2% at 3-sigma.

Figure 14 shows the BGA pads after the jetting process. A complete image of the product is not allowed due to nondisclosure agreements. In this case, there is no comparison between a manual or semiautomatic process because the customer used the fully automatic solution from the beginning.

Discussion

The customer used to replace the TQFP component manually, which means that after removing the component, the solder paste was applied through a stencil and the pick and place was performed using semiautomatic equipment. Due to the high automation and flexibility of the proposed method, throughput improvements of 500% have been reported. Desoldering the component and performing X-ray and visual inspections remain in the bottlenecks of the repair. The solder dots used

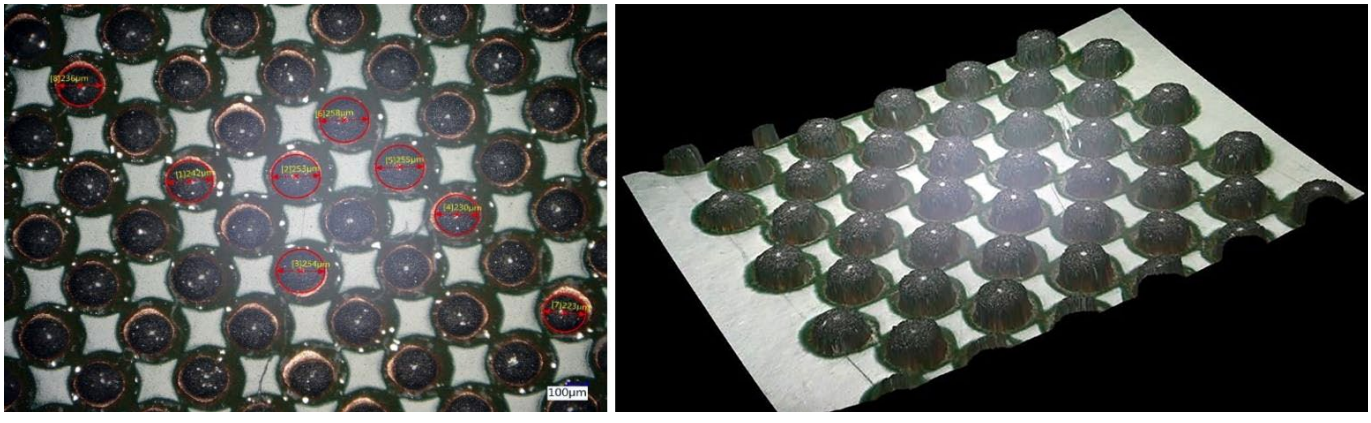


Figure 14: BGA component after jetting.

for the 200 µm pads are accurate and precise enough to fill up the pads properly. Additionally, the reported method facilitates the possibility of repairing several components at a time without the need for expert personnel. These improvements can help to reduce the economic barriers to repairing existing products. The reliability of the repaired products was not part of this study; analysis regarding the new life span, ability to cope with harsh environments, etc., shall be made at the product level.

Conclusions

Due to the current amount of electrical waste, the issue with counterfeit components, or simply due to device enhancement, replacing electrical components is an increasing necessity. Replacing components, especially those with fine pitches, is complicated and not always economically attractive due to the number of manual processes related to this task.

This work demonstrates that is possible to remarkably improve the throughput of solder deposition on populated PCBs, this method can be used for different solder paste alloys. Even components with pads as small as 200 µm can be repaired with the proposed method. Thanks to special jetting tooling and the use of a state-of-the-art equipment, collisions with neighboring components are easily avoided. These new features reduce the repair cost, making it more attractive to the industry. **SMT007**

Acknowledgments

Special thanks to Kujtim Shala and Kevin Domancich from Essemtec's Customer Application Engineering for helping with experimental work.

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‘Blocking and Tackling’ During Tough Economic Times

One World, One Industry

by Dr. John W. Mitchell, IPC

There never seems to be an easy time to work in the electronics industry. Supply chain challenges are prevalent and never seem to be solved, finding talent has been a challenge for 30 years, and constant pressure on margins means a business leader can never sit still as regulations and tariff rules change on a regular basis.

Not to mention just trying to manage the normal day-to-day challenges of finding new business and keeping current customers happy, then add an unpredictable economic climate, and the worry of a possible recession. No wonder many industry leaders are in a tailspin.

As IPC Chief Economist Shawn DuBravac shared with me, “We are about a month away from a recession, and I’ll tell you the same thing next month—until it happens.” In speaking with industry executives, I have heard some exclaim, “I wish we would just have the recession already, so we can get on with dealing with it and then moving past it.”

How are industry leaders handling all this stress? Here are a few blocking and tackling efforts that I have seen industry leaders undertake:

- **They take care of their people.** These are your greatest asset. We cannot expect that the

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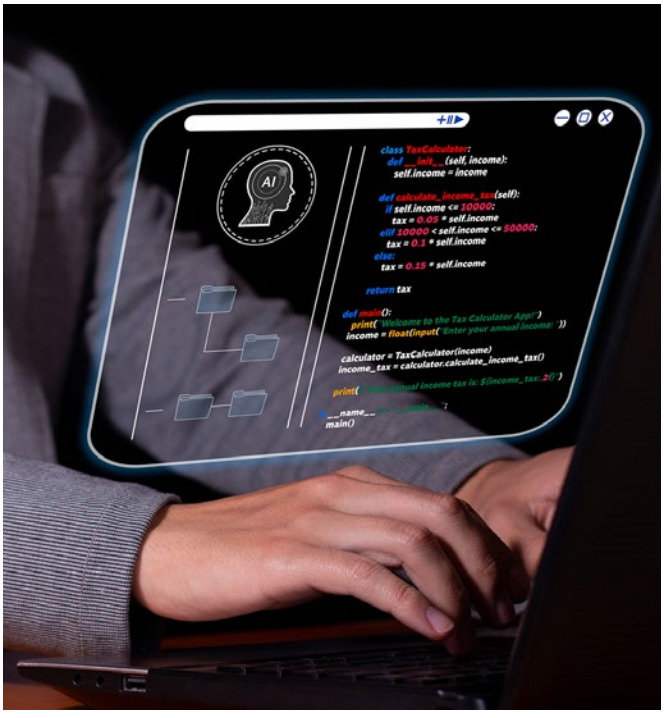
people we hire for the skills they possess will be as valuable if we don't continue to advance and expand those skills. Keep training your people. There are new tools and information available to offer your employees to encourage their growth. Invest in your people by making them more valuable. They are your greatest asset.

• **They embrace efficiency.** We have been given a great boon with the latest AI developments. Much of the routine work or initial ideation can be accomplished faster and with less effort than before with the help of AI. Make sure you are informed about the best tools available, and that your team is well versed in their usage. (See my first point about people.)

• **They look to IPC to supplement internal training.** If I am talking about training, let's talk about how you can get IPC training to supplement your internal training, and have it covered by government funding. IPC recently had some of its programs recognized by the U.S. government as official apprenticeship programs. This means you can get thousands of dollars from your local state to do IPC training and relevant internal training as well. Improving your people with other people's money sounds like a good idea to me.

IPC PCB Fabricator Apprenticeship Curriculum

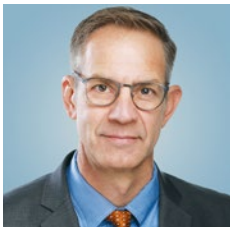
CORE COURSES	HOURS
Apprenticeship Employer Onboarding	16
ESD Control for Electronics	1
Safety for Electronics Manufacturing	1
Foreign Object Debris/Damage	1
Printed Circuit Board Fabrication for Operators	40
IPC 6012 for Operators	8
IPC 6012 Certification Endorsement (CIS)	40
IPC A 600 for Operators	8
IPC A 600 Certification Endorsement (CIS)	40
Total Hours	155



• **They are innovative.** Involve diverse segments of your team to attack challenging problems. Instead of only engaging engineers to solve a manufacturing problem, or just engaging business or finance staff on business challenges, add people from different parts of your organization to expand and broaden your innovation. People of different backgrounds, levels of experience, and parts of the business will increase the creativity needed to solve big problems.

While there seems to be a continual threat of recession or economic downturn, there are many positive ways to approach these challenges, particularly if you invest in your people and provide them with opportunities and challenges that will make them eager to help your company thrive. **SMT007**

This column originally appeard in the December 2023 issue of *PCB007 Magazine*.



Dr. John W. Mitchell is president and CEO of IPC. To read past columns, click here.

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Rework: A Perspective From the Source

Feature Interview by the I-Connect007 Editorial Team

Maria Mejias and her team at Intel work on the cutting edge of rework techniques. Tasked with characterizing rework processes for Intel's boards and packages, Maria's work is on the vanguard. We spoke to Maria about how her team works, what it's like to be on the cutting edge of rework, and what contract manufacturers should expect.

Nolan Johnson: We're exploring rework and the associated costs. What is your involvement with it?

Maria Mejias: I have been with Intel for 24 years, with my last nine in Oregon as part of the Test and Platform Technology Development (TPTD) group. I have been involved in rework as a module engineer, a program manager, and as an engineering manager. My group oversees the rework development for Intel's new products, and we create and define the rework process recommendations. Before I joined this team, I was part of the engineering team at Assembly and Test group in Intel Costa Rica where I had different roles during my 15 years there.

Johnson: What are the emerging trends from the semiconductor sector?

We are seeing a trend where space is very important; we try to optimize the space and the functionality as much as we can. There are a lot of challenges where there are more limitations in space, which could induce the risk to create defects on the board and adjacent components during the component repair. The range of packages sizes varies and on one

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Maria Mejias

side you have small packages with small ball pitch and on the other side we have large form factor packages. We work with both tendencies in package sizes and designs to develop robust rework processes that meet the product requirements.

Johnson: How will that change life for assembly providers?

There are more challenges when rework is needed. We use different kinds of tools for rework. We work on boards with long lists of different kinds of components and sizes. You cannot do all the repairs with only one tool. Now, not all the defects can be fixed with hand soldering tools; you need a combination of BGA repair tools, through-hole component tools, hand soldering tools, ovens, microscopes, and X-ray tools, so you can perform a good inspection to be sure that your repairs are successful. Additionally, to perform the repairs, you need other collateral. For example, there are nozzles with designs that help to keep the temperatures uniform during the reflow without high temperature deltas across the component. Like this one, other collaterals are also important for success. Rework is like a mini factory that needs to have all the tools necessary to be capable of executing the repairs.

To that end, there is the knowledge and skills of the team performing rework; they are definitely artists. They need to have very good skills and good cross-training because there isn't just one thing they will be focused on. In other modules along the assembly line, you can control the variables more easily. But in rework, you have a lot of variables plus a human component there.

Johnson: As microprocessors become more capable and complex, and as we continue forward with Moore's law, it's become more of a packaging issue than a semiconductor fabrication issue. What might we expect to see a microprocessor package look like in five years?

It's an interesting market where you have the small size packages segment and the trend to increase the package size in another segment of the market. We see also challenges with temperature-sensitive components—in which you need to be more careful about the maximum temperature on the body of the components—in comparison with past years.

Johnson: At symposiums for advanced packaging, some of the talk is about components 100 millimeters on the side. Contract manufacturing companies may be doing pick-and-place and soldering for BGAs that large, and at the same time placing 0105s with the same machinery. This movement in both directions at the same time screams out that there will be challenges in rework.

For the industry, these are big challenges. Customers, including Intel, will need the skills and capabilities for this kind of work. Suppliers of rework tools need to continue developing tools capable of supporting these demands.

Barry Matties: Where does rework become

impractical? As we start getting these increasingly finer features, at some point it just becomes scrap. Likewise for the very large ones with multiple thousands of ball grid solder joints underneath that massive package. Have you seen the limit yet?

I'm not seeing a limit yet, but the challenges are there and are more aggressive year by year to have successful results in rework. But we need to continue working closely with the industry and the tool suppliers, so they continue to develop tools we will need to support these necessities.

The other component is to work with the board designs, so they understand the limits—proper use of keep-out zones, for example, around the BGA.

Matties: Do I hear you saying it's the role of the designer now to understand what the limits are for rework?

Yes, but it's important to give the feedback. For example, if you have a very populated board with a lot of components around the BGA, it takes a skilled technician to know how to properly place your mini stencil and apply the paste without introducing defects in the components around it; you may be contaminating the other components with solder paste.

Matties: I've heard that if there's one process that needs better understanding, it's the solder paste process. We're using too much solder paste—or not enough, or too much flux, or not enough, and so on. How do we optimize that process?

Good point. Technicians commonly use the microscope to inspect the solder printing with mini stencils before placing and reflowing the new part on the board. When they use a "flux only process" instead of solder paste, they need to validate the material is covering all the PCB pads affected. If they are printing solder paste on the package solder balls, the stencils must be designed accordingly to ensure a good percentage of solder paste transfer during the package placement, and similarly for alternative methods such as flux dipping or others. That could be risky depending on the package design. If you don't have enough material there, that could induce some defects like opens or shorts. If you have too much material, that could induce solder bridging defects.

This is why inspection is very important. Depending on the case, you could sacrifice inspection and only use a microscope or an SPI inspection for the solder paste volumes. You would have more data collected and available, especially when we are talking about new package rework recommendations. In conclusion, there are different rework processes depending on the type of repair and the type of component and board design; on all of them it is important to do the measurements and process validations to facilitate good results.

"If you have too much material, that could induce solder bridging defects."

Matties: What are the typical types of errors that you have to rework? What do you see the most?

We dedicate a lot of time to development. Regarding defects typical from the SMT lines on fully populated boards, time after time, we see defects as solder bridging, opens, insufficient solder, and polarity issues. Defects could be on BGAs and on non-BGAs, it's the polar components—capacitors and resistors—in different locations where they are very populated on both sides.

Figure 1.

Matties: When you come across a defect like that, what's your process to remedy it? What do you need to do?

A lot of them can be repaired with hand soldering tools, for example, capacitors, resistors, miniport USBs, and the like.

Other defects need more time and effort. For BGA repair, the process is more complex and more steps are needed (Figure 1).

Matties: Do you have an average amount of time that you would spend on each board for rework? Is that three minutes? Maybe 10 minutes?

For hand soldering, it could be seconds or a few minutes. Depending on the thickness of your board, it's recommended to prebake the board for some minutes. It's a fast process, maybe one or two minutes. Remove the components—that's maybe less than 20 seconds. Then the technician performs a clean-up, and it probably takes more time to replace again.

For BGA repairs, it will depend on the package size and the board complexity. After the rework reflow profile is ready, the rest of the process could vary between 30 minutes to two hours. And again, it will depend a lot on the skills and experience of the rework technician.

Matties: I'm curious if you have data on boards that have been thoroughly inspected with SPI vs. relying on process alone. Which ones need more rework? Is there a case to be made for every board and panel being inspected?

It's not necessary in my experience. We do SPI as part of rework development from time to time when we want to collect the solder paste volume data, but this is not typically done when the process is mature. Microscope inspection is enough for the technician to be sure that all the parts have coverage with flux or paste.

Matties: We recently interviewed a company that says they're not doing any SPI because they have their process dialed in so well. It seems to me that SPI inspection does not add much cycle time, and minimizes the potential of scrap, or a lot of repair time. Are there other strategies for minimizing rework?

One very good practice is to inspect the first article to be sure you don't have an issue in the SMT line; that will help prevent a lot of issues. I know many companies that do that.

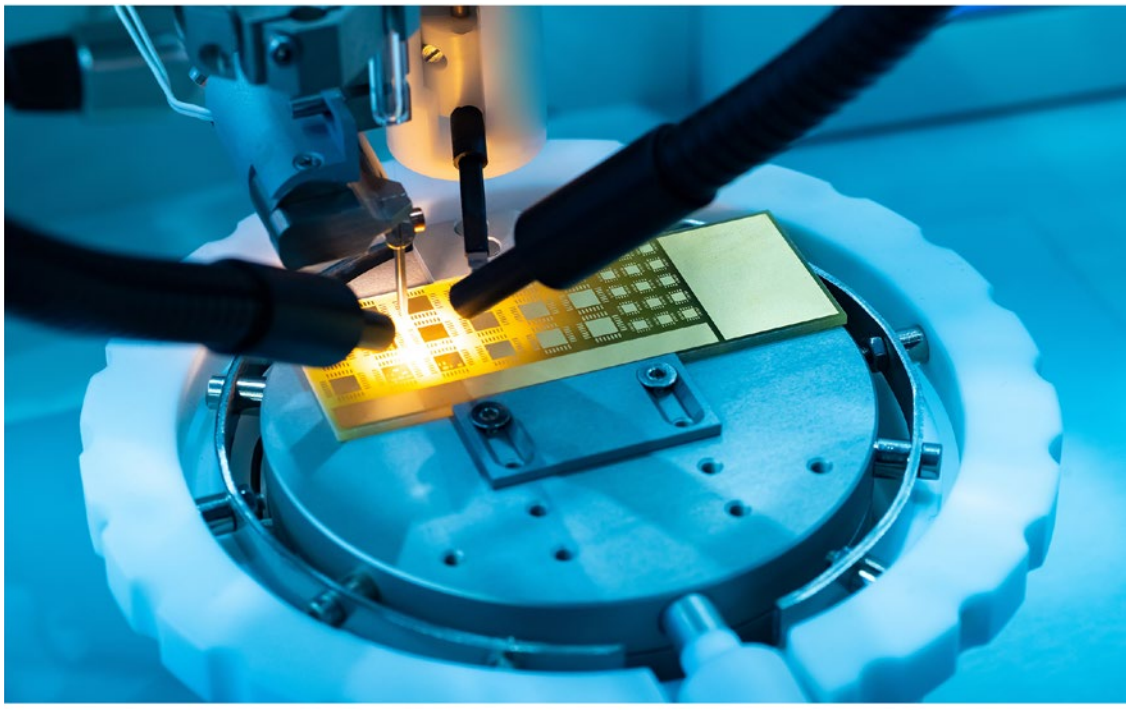
Johnson: First article inspection could also give the design team the opportunity to critique it and maybe even spin the board one more time to increase manufacturability. How important is the role of the design team in trying to drive rework to zero?

I consider it very important, especially when a design is very risky. An example would be a board designed with BGAs on the primary side and BGAs on the secondary side, just under the other one. With respect to rework, that's taking a big risk when trying to optimize the space.

Matties: I'm curious about no-clean flux and how the cleaning process plays a role in

rework volume. Do you recommend cleaning for all boards whether you're using no-clean or otherwise?

One of the steps here is the inspection at the end of the process, including any rework just before packing. We review all the residuals from rework to be sure that they are properly cleaned from the board. Residuals from rework definitely could affect the functionality of the individual boards.



Matties: In a state-of-the-art rework station, what tools do you expect to see?

I think the ideal rework area needs to have a group of tools for hand soldering, repair microscopes for through-hole component and automated tools for BGA repairs. There's also a lot of automation in that area. You would expect to have tools capable of managing small as well large package sizes, thin and thicker boards. Ideally, you should be capable of picking and placing parts and meeting the thermal reflow requirements without damaging adjacent components.

Johnson: That would stand to reason; we're talking about such very small parts for the passives: resistors, capacitors, and so forth. Can those even be humanly soldered?

Hand soldering tools work for very small ones, but it definitely requires a lot of skill.

Matties: What IPC standards are in play here? Do you follow any IPC standards for rework?

All the technicians are certified with the IPC IPC-A-610.

Matties: What training do you need to have to be in rework?

For technicians, it's ideal when we can have people with experience. When we need to hire a new person, it's more difficult to find. It can sometimes take a number of months to find the right person.

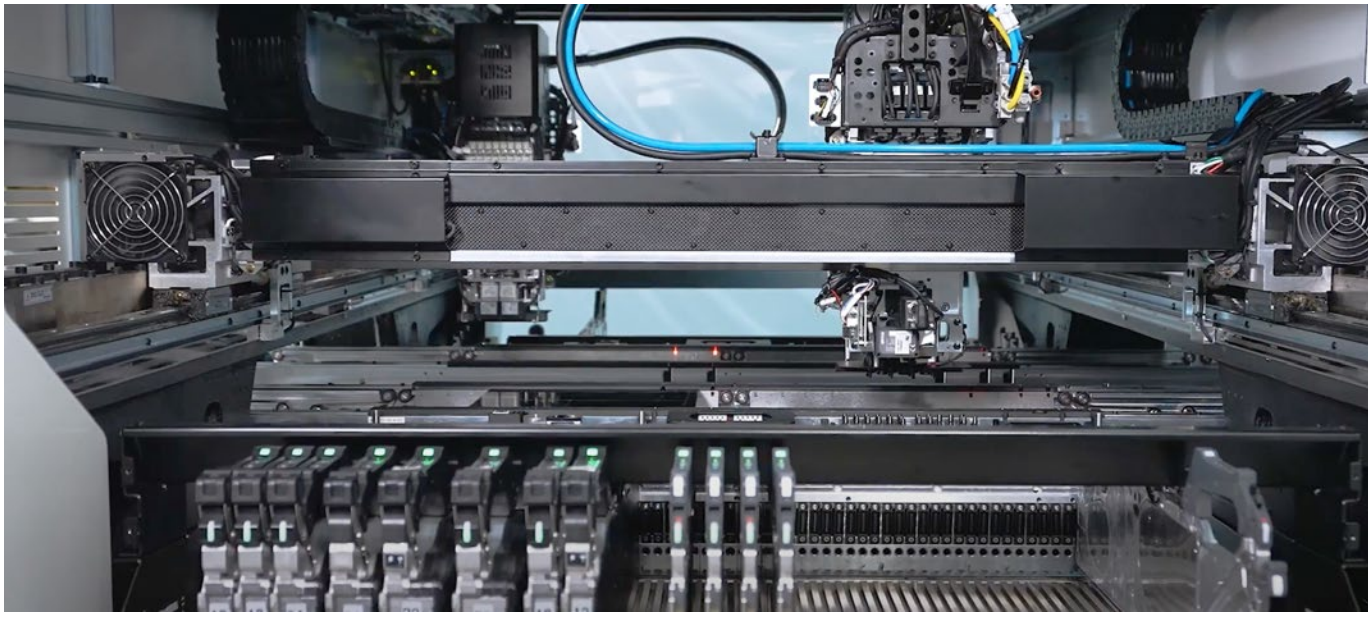
When they join us, they go through our internal training, so they are familiar with the boards and the packages that we run here per our internal specifications.

Matties: Is that all internal training or do you send them out to any IPC or other sorts of training?

We have IPC certifiers. In the past, we'd send people outside, but we now have people who are certified by IPC trainers in our group. When we need specific training on a specific tool, we work with the tool suppliers to do the training here.

Johnson: This has been really insightful, Maria.

Thank you. **SMT007**



Jonny Nichols: The Hanwha Future-proof Proposition

Interview by Nolan Johnson
I-CONNECT007

With expansion, added personnel, and a new view on onshoring, Hanwha Corporation is alive and well. Vice President of Marketing Jonny Nichols details just what it takes for a supplier like Hanwha to remain competitive amongst shorter lead times and itchy customers anxious to get their product to market. The key, Jonny says, is to deliver systems that can do it all.

Nolan Johnson: Jonny, what is new and developing at Hanwha?

Jonny Nichols: Our group (HTAA) has expanded significantly in personnel and technology centers to better serve our customers. We've opened operations in Mexico with Hanwha's Queretaro Technology Center (HQTC). We've also added personnel in applications and field service engineering and we're expanding our inventory so that we can be ready to deliver quickly for our customers.

Suppliers are facing many demands, including shorter lead times and supply chain instability. Although the supply chain is stabilizing, we're seeing greater demand on suppliers to have ready-to-go inventory so assemblers can take advantage of shorter lead time opportunities. Assemblers are being challenged to have more capacity available to support reshoring to North America, and they're being asked to assemble a wider variety of assemblies, including mixed technology assemblies that require automated SMT mounting and THT insertion.

North American assemblers can no longer accept 24 weeks or more lead times from equipment suppliers. They need to be ready to run production on any project within a 16- to 20-week window. Hanwha is aware of this and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maintains an inventory of various machinery configurations in quantity for this reason.

As a precision machinery supplier to the industry, Hanwha is challenged to inventory not only standard configuration pick-and-place machines in quantity, but to have optional system configurations available for the quickest possible delivery to anywhere in North America.

You're preparing for additional business because you see it coming.

Yes, and that's not mere speculation. It's here. As a mission-critical supplier to many of our customers, we're adding personnel and constantly improving support systems while increasing inventories of advanced technology solutions to ensure we're ready when and where our customers need us to be.

Has there been a shift in what customers say is a priority when selecting new equipment?

Well, although machine inventory is a hot and trending topic among suppliers, there's increasing chatter about extreme component range, specifically larger, heavier, odd-forms of which some require precision mounting while others require heavy insertion force.

For instance, it's still a requirement to handle connectors up to 150 millimeters in length, yet we're being asked to go far beyond that. We have machines capable of handling parts up to 200 x 130 millimeters, up to 55 millimeters tall, and weighing up to 300 grams which is about the weight of my Samsung Galaxy S22 Ultra. Then we look at SMT packages like 0201 metric devices that can be much smaller than a speck of pepper; the same machine being asked to handle these larger odd-form parts is being asked to handle 0201s, albeit at an upstream position in the PCB assembly lines. Hanwha machines now have a process window for going smaller and larger, while going taller and heavier. This includes odd-form component handling that requires lead cutting, forming, and insertion of select radial and axial components for automotive/EV applications and more.

> "The demand for next-generation electronic control systems has never been higher."

How does all that influence new equipment development?

Automotive/EV and mil/aero applications are certainly drivers of future technology for manufacturing. The demand for next-generation electronic control systems has never been higher. However, the challenge to machinery makers is to offer systems that deliver a broader range of capabilities to support next-gen electronics assembly without compromising the assembler's ability to cost-effectively produce legacy electronic assemblies with advanced machinery solutions.

Integrating with ERP and MRP systems is another driver that is challenging suppliers to deliver more comprehensive software solutions to improve tracking and traceability for cost controlling at machine, line, and operation levels. Hanwha solutions deliver this and more, including compatibility with third-party hardware and software systems for scalability, flexibility, and broad usability by any size and type of PCB assembly operation.

When you look at some of the differences between a CM and an OEM, you see it in their production environments. Hanwha's technology is applicable to everyone. You don't have to be a large CM or OEM to utilize the features and benefits our machine families offer.

If only one prototype machine is needed, Hanwha can supply that. If multiple machines are needed for higher volume/capacity applications, Hanwha can supply that too. Suppose

a PCB assembly operation needs both prototyping and high-volume production capacity. In that case, Hanwha offers innovative machinery and line solutions for building both mix and volume assembly simultaneously on the same line of equipment (aka HMD2) which maximizes floor space performance and overall equipment effectiveness.

Jonny Nichols

Hanwha offers leading-edge technology solutions that help our customers sharpen their competitive edge with improved efficiency, productivity, and profitability solutions at the right time (now) in the right place (North America).

North America seems to be driving the innovation, so tell me more about that. Why are we suddenly commanding so much attention?

Obviously, the cost of labor in North America is high so the timing for more flexible, more scalable, more efficient, more productive automation is here and now. Automation is the key to leveling the global playing field for PCB assemblers. North America is primed and already taking action by investing in technology solutions that are geared to leverage the human factor with machinery capable of dramatically making higher quality products in less time and space than ever before.

The trend for North American PCB assembly operations is reshoring and insourcing, and no longer offshoring and outsourcing. OEMs are carefully investing in NPI systems while aligning with strategic CM partners who mutually recognize the opportunity to invest, wisely going forward in state-of-the-art automation solutions that lock and secure PCB assembly in North America for many years to come.

With the U.S. positioned as the largest untapped market for this sort of automation, let's take it down to some specific features.

How is Hanwha equipment prepared to deliver on that need?

Hanwha offers scalable machinery and software solutions that address a broad range of SMT and mixed technology applications for PCB assemblers. These include systems optimized for high-precision chip shooting, flexible mounting, multifunctional mounting, odd-form, and large board applications in single- and dual-lane configurations. Multifunction and odd-form variants support gripper nozzle technology and offer industry-leading insertion force ranges. To support these systems, Hanwha offers a broad array of feeder solutions for tape including cut/strip tape, tubes including stack-stick, trays including modular direct tray feeding, multi-part number bulk feeders, and radial/axial THT feeders with integrated lead-cutting and forming capabilities.

Software-wise, Hanwha excels with solutions for single-machine lines, multi-machine lines, multi-lines, and multi-operation scenarios including compatibility with third-party software solutions. From offline programming to lot tracking with advanced traceability bundled with integrated intelligent setup verification and LCR, Hanwha has been successfully delivering this technology for many years. Within the same suite of software designed and produced by Hanwha, equally powerful software solutions are available for production planning, defect prediction/prevention with integrated line monitoring, and maintenance management to maximize efficiency, productivity, and profitability for PCB assemblers using Hanwha technology.

Dual lane is a valuable feature because you can run high volume product on both lanes, then you can interrupt one lane for a short run prototype.

That's correct with Hanwha technology. Hanwha's HMD2 and XMD2 configurations are unrestricted in terms of being able to run mix plus volume independently yet simultaneously. The same line can quickly transition to building volume-plus-volume and/or mix-plus-mix then back to mix-plus-volume on each lane respectively for infinite possibilities.

Not to mention that OEMs are putting in their own lines.

Yes, and it's not to take away business from the contract manufacturers. Instead, it enables OEMs to experiment and get that product tuned so that they can get to market quicker, and be more efficient in handing off projects to the contract manufacturer. This is where incremental costs are chiseled away so the OEM products can achieve better overall price competitiveness ultimately.

As you're getting the product ready for production, and if you can create a completed, tested, debugged data package before you hand it over, it will go a lot faster. What about labor costs?

This is where we come full circle to automation from Hanwha—mixed mode production lines that build more in less time, less space, for less investment combined with scalable, intuitive software that will undoubtedly help fewer operators multiply efficiency, productivity, and profitability, thereby controlling labor costs.

However, it's a tricky time in finance now. The U.S. Federal Reserve and the banking industry continue reacting to market conditions. At the same time, those who watch the market see that private equity has a lot of dry powder ready for investment, so the messages are definitely mixed. For an EMS company, what's the best approach?

Cost of ownership and/or cost of operation models are tried and true places to start when investment opportunity knocks, and there certainly appears to be plenty of business floating around the marketplace looking for a place to land. That said, the importance of discovery by EMS companies related to equipment alternatives is now more important than ever. Of course, all applications are not the same, nor is there a one-size-fits-all machine solution, but there are systems available that can do it all. OEMs' pick-and-place machinery like Hanwha are delivering exceptional values in technology that provide assemblers the opportunity to upgrade to scalable, modular technologies that provide a unique readiness and reliability for short- and long-term PCBA opportunities, no matter the mix and/or volume of production.

Forward and backward compatibility of automation systems is equally important. Hanwha is second to none when comparing returns on CapEx investment. Hanwha machines are robustly built for a wide variety of production environments. There are many configuration choices available to address quality control, technical/applications, production/capacity, and budgetary/financial requirements. Existing business customers have clear upgrade paths to new-generation platforms like Hanwha's model XM520, which blends advanced feature functionality with legacy system feeders and select options and accessories. New business customers appreciate this because the time will come when they too will need to add to or upgrade their Hanwha machinery, and when that time comes, Hanwha will be there, ready and willing to support their needs.

Final thoughts, Jonny?

Hanwha is very much on the move and continuously improving so our customers can make more in less time, less space, for less investment.

Thanks for talking with me. SMT007

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A Lesson From Elon Musk's Playbook

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.

Ivy University Professor Patty Coleman was seated next to John Archer on her flight home. It had been a rough start to her day. Patty had been having trouble charging her phone and laptop, but her seatmate had come to her rescue.

Now, they were both talking about Walter Isaacson's biography of Elon Musk, and Patty became so engrossed in the conversation that she was able to forget about some of her earlier troubles.

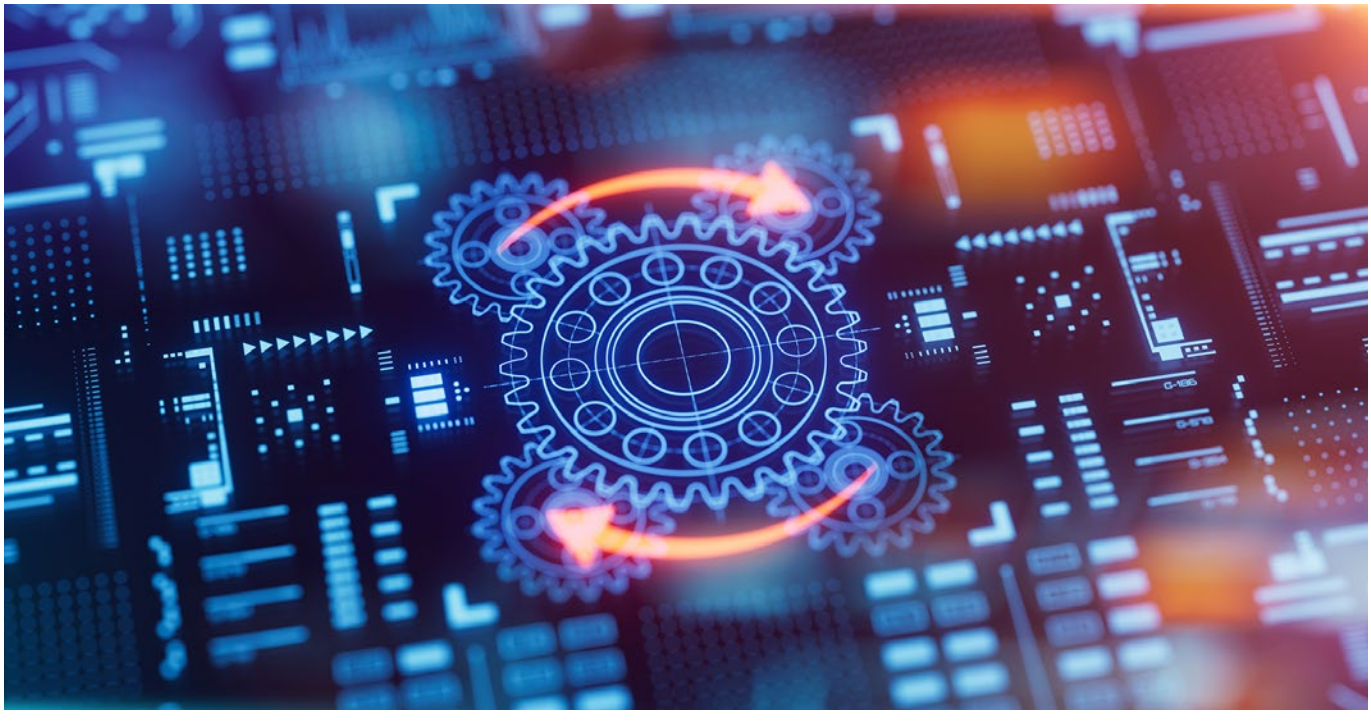
"I have to admit, reading about Musk's 'The Algorithm' and 'The Idiot Index' was really humbling," John said.

"How so?" Patty inquired.

"After you read about them, they seem so obvious in 2023, yet no one had ever come up with them before," he said. "I have already implemented several aspects of both of them and the results are astounding."

"Can you give me an example?" Patty asked.

"Certainly," John said. "My company makes metal castings that typically have some mechanically precise referencing points. So,



Ivy University Professor Patty Coleman

after casting the parts, they require precise machining. For one customer, we had been making the same part for over 40 years. During this time, costs had risen due to an increase in both materials and labor."

Patty felt sympathetic and said, "That makes sense. It is hard to escape the increase in materials and labor costs."

John continued his story. "However, this customer has been complaining about the cost. The part was sold to this customer for $20 in 1985 and is now almost $100."

"But," Patty determined, "$100 seems reasonable given inflation."

"I know, but my customer was under pressure from his customers," John responded. "He said I had to lower his cost to $90 or he would go offshore for the part." He paused for a moment, then continued. "We managed to lower the price the customer had to pay to $85 by following Musk's 'Algorithm' and 'Idiot Index.'"

"Wow, what did you do?" Patty asked, excitedly.

"We started by implementing The Algorithm's 'Question Every Requirement,'" John told her. "First was the material: The requirement was 316L stainless steel, and we asked why much cheaper 304 stainless steel couldn't be used instead. After some environmental testing by the customer and us, we concluded that 304 stainless was fine."

"How did that affect the cost?" Patty asked, and John answered: "We got it down to $92."

"Were you able to get it to the desired $85?" Patty queried.

"Yes, we did get it to $85," John shot back.

"How?" Patty asked.

"We used the 'Idiot Index,'" John said. "We found that our casting process improved over the years, and we needed fewer precision machining operations. Also, the customer had specifications that required time-consuming measurements that were not really needed. So, we were able to charge our customer $85 and our profit actually increased by 7%."

"Wow, what a story," Patty responded. "I'll bet your customer was pleased."

"Very much so, and they even gave us new business," John said. "They are working on implementing Musk's concepts into their processes."

"The Algorithm" and "The Idiot Index" from Walter Isaacson's book:

The Algorithm

At any given production meeting, whether at Tesla or SpaceX, there is a nontrivial chance that Musk will intone, like a mantra, what he calls "the algorithm." It was shaped by the lessons he learned during the production hell surges at the Nevada and Fremont factories. His executives sometimes move their lips and mouth the words, like they would chant the liturgy along with their priest.

"I became a broken record on the algorithm," Musk says. "But I think it's helpful to say it to an annoying degree." It had five commandments:

1. **Question every requirement.** Each should come with the name of the person

who made it. You should never accept that a requirement came from a department, such as from "the legal department" or "the safety department." You need to know the name of the real person who made that requirement. Then you should question it, no matter how smart that person is. Requirements from smart people are the most dangerous because people are less likely to question them. Always do so, even if the requirement came from me. Then make the requirements less dumb.

2. **Delete any part or process you can.** You may have to add them back later. In fact, if you do not end up adding back at least 10% of them, then you didn't delete enough.
3. **Simplify and optimize.** This should come after step two. A common mistake is to simplify and optimize a part or a process that should not exist.
4. **Accelerate cycle time.** Every process can be speeded up. But only do this after you have followed the first three steps. In the Tesla factory, I mistakenly spent a lot of time accelerating processes that I later realized should have been deleted.
5. **Automate.** That comes last. The big mistake in Nevada and at Fremont was that I began by trying to automate every step. We should have waited until all the requirements had been questioned, parts and processes deleted, and the bugs were shaken out.

Elon Musk, by Walter Isaacson, pp. 284-285.

The Idiot Index

Ever since he flew back from Russia and calculated the costs of building his own rockets, Musk had deployed what he called the "idiot index." That was the ratio of the total cost of a component to the cost of its raw materials. Something with a high idiot index—say, a component that cost $1,000 when the aluminum that composed it cost only $100—was likely to have a design that was too complex or a manufacturing process that was too inefficient.

As Musk put it, "If the ratio is high, you're an idiot." "What are the best parts in Raptor as judged by the idiot index?" Musk asked. "I'm not sure," Hughes responded. "I will find out." This was not good. Musk's face hardened, and Shotwell shot me a worried glance. "You better be [expletive] sure in the future you know these things off the top of your head," Musk said. "If you ever come into a meeting and do not know what are the idiot parts, then your resignation will

be accepted immediately." He spoke in a monotone and showed no emotion.

"How can you [expletive] not know what the best and worst parts are?"

"I know the cost chart down to the smallest part," Hughes said quietly. "I just don't know the cost of the raw materials of those parts."

"What are the worst five parts?" Musk demanded.

Hughes looked at his computer to see if he could calculate an answer.

"No! Don't look at your screen," Musk said. "Just name one. You should know the problematic parts."

"There's the half nozzle jacket," Hughes offered tentatively. "I think it costs $13,000."

"It's made of a single piece of steel," Musk said, now quizzing him. "How much does that material cost?"

> **Musk started smiling. This had been one of his themes.**

"I think a few thousand dollars?" replied Hughes.

Musk knew the answer. "No. It's just steel. It's about two hundred bucks. You have very badly failed. If you don't improve, your resignation will be accepted. This meeting is over. Done."

When Hughes came into the conference room the next day for a follow-up presentation, Musk showed no sign that he remembered reaming him out. "We are looking at the 20 worst 'idiot index' parts," Hughes began as he pulled up a slide. "There's definitely some themes." Other than wringing a pencil, he was able to hide his nervousness.

Musk listened quietly and nodded.

"It's mainly the parts that require a lot of high-precision machining, like pumps and fairings," Hughes continued. "We need to cut out as much of the machining as possible."

Musk started smiling. This had been one of his themes. He asked a few specific questions about the use of copper and the best way to do stamping and hole-punching. It was no longer a quiz or a confrontation. Musk was interested in figuring out the answers.

"We are looking at some of the techniques that automakers use to keep these costs down," Hughes continued. He also had a slide that showed how they were applying Musk's algorithm to each of the parts. There were columns that showed what requirements had been questioned, what parts had been deleted, and the name of the specific person in charge of each component.

"We should ask each of them to see if they can get the cost of their part down by eighty percent," Musk suggested, "and if they can't, we should consider asking them to step aside if someone else might be able to do so." By the end of the meeting, they had a roadmap to get the cost of each engine down from $2 million to $200,000 in 12 months.

Elon Musk, by Walter Isaacson, pp. 363-365, Simon & Schuster. Kindle Edition. 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, or contact Lasky, click here.

TOP TEN

EDITOR'S PICKS

Real Time with... productronica 2023: Koh Young Discusses Semiconductor and Advanced Packaging Inspection

Koh Young's Harald Eppinger talks about the company's technology for the semiconductor and advanced packaging market and how they address the challenges introduced by reflective components and micro solder deposits.

Ringing in Some Holiday Cheer at SMTA Silicon Valley

It was a pleasure to attend SMTA Silicon Valley on Thursday, Dec. 7 at the Flex campus. The show hosted just over 60 exhibitors, which meant the narrow aisles remained full of attendees throughout the day.

The Finer Points: World Champions of the IPC Hand-Soldering Finals

Friday, Nov. 17 brought us to the venue for the world finals of the IPC Hand Soldering Competition. After many regional competitions, the finalists gathered in Munich to compete against one another to gain the title of world champion.

Mek Launches the SpectorBOX X1: A Revolution in 3D THT Inspection

SpectorBOX X1 can be used bottom-up for volume measurement of THT solder joints and pin height measurement, or top-down for a 150 mm + clearance for 3D THT components measurement, making it the first compact 3D AOI system for precision inspecting of THT solder joints and components.

SMTA Releases Second Batch of Training Resources Donated by Bob Willis

The Surface Mount Technology Association (SMTA) announces the release of several more webinars, photo libraries, and poster sets as part of a generous donation from renowned industry expert, Bob Willis.

IPC Attains U.S. Dept. of Labor Approval of National Apprenticeships Standards, First-Ever in U.S. Electronics Manufacturing Industry

Megan Baird with John Mitchell

The U.S. Department of Labor (DOL) approved IPC's National Program Standards of Apprenticeship—the first-ever in the U.S. electronics manufacturing industry—in a move designed to expand the skilled workforce for this strategically vital industry.

Matric and Koh Young: Collaboration Leads to Efficiencies, Growth

Faced with ever-increasing sales and production complexities, Matric Group responded by challenging themselves to increase efficiencies and yields on their manufacturing line. Achieving their goals included working closely with Koh Young to bring inspection up to cutting-edge capability. In this roundtable discussion, Nolan Johnson gets the whole story from Matric's Patrick Stimpert and Doug Bevier, and Koh Young's Ivan Aduna.

Aegis Software & Arch Systems Partner to Digitize Continuous Improvement in Manufacturing

Aegis Software, provider of MOM/MES software, and Arch Systems, provider of data and analytics for manufacturing operations, announce a partnership toward digitizing continuous improvement of factory operations.

Indium Announces Updates to Global Supply Chain Management Team

Indium Corporation is pleased to announce several key hires and promotions within its global Supply Chain Management team to ensure the efficient and timely delivery of materials for its customers.

Real Time with... productronica 2023: KIC Introduces Proprietary New Technology

KIC's proprietary new embedded barometer enables real-time detection of temperature change, board jams, and more. Miles Moreau, KIC's General Manager–EMEA, Americas, Australia, details features that lead to reduced changeover time and improved manufacturing efficiency.

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

Career Opportunities

Find Industry-experienced Candidates at jobConnect007

For just $975, your 200-word, full-column ad will appear in the Career Opportunities section of all three of our monthly magazines, reaching circuit board designers, fabricators, assemblers, OEMs, suppliers and the academic community.

In addition, your ad will:

- be featured in at least one of our newsletters
- appear on our jobConnect007.com board, which is promoted in every newsletter
- appear in our monthly Careers Guide, emailed to 26,000 potential candidates

Potential candidates can click on your ad and submit a resume directly to the email address you provide, or be directed to the URL of your choice.

No contract required. Just send over your copy and company logo and we'll do the rest!

Contact barb@iconnect007.com to get your ad posted today!

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I-Connect007
GOOD FOR THE INDUSTRY

smt007 pcb007 pcb design007

Career Opportunities

pluritec®
MACHINES FOR PRINTED CIRCUIT BOARDS

Sales Manager, Remote

Location: North America

Experience: Minimum of 4 years in the PCB industry

Job Description: We are looking for a highly motivated and experienced sales manager to join our team. The ideal candidate will have a minimum of 4 years of experience in the PCB industry and a proven track record of success in sales. The successful candidate will be responsible for developing new business and sales network, maintaining existing accounts, and achieving sales targets. The candidate must be able to work independently, have excellent communication and interpersonal skills, and be willing to travel.

Qualifications:
- Minimum of 4 years of experience in the PCB industry
- Proven track record of success in sales
- Excellent communication and interpersonal skills
- Strong technical process background
- Ability to work independently.
- Willingness to travel

Education: Technical or related field preferred

Compensation: Competitive salary and benefits package

Pluritec develops high end equipment for the printed circuit board (PCB & PCBA) manufacturing industry. We offer a wide range of equipment including drilling and routing, wet processing, spray coating and more. We are a global supplier with more than 3,000 systems installed worldwide.

Contact Nicola Doria
nicola.doria@pluritec.org to apply.

apply now

GEN3™
Precision as Standard

Technical Sales Manager

Gen3, based in Farnborough, UK, who designs, manufactures and distributes test equipment to minimize risk of failure in the field, has an exciting opportunity for a Technical Sales Manager to join its team to drive growth in the southern half of the UK.

Responsibilities & Experience
- Promote Gen3's and its principles' equipment.
- Identify opportunities in existing and new customers.
- Report all commercial developments related to the activity of Gen3's customers, actively seeking the specification of Gen3's products, into new projects.
- Be fully familiar with all Gen3's products, technology, USPs, features, benefits and international standards.
- Follow up all enquiries for products and services; convert them into contracts/orders.
- Provide technical support – remotely and onsite.
- Be widely recognised and acknowledged as an "Industry Expert."
- Technical Sales and Account Management skills from an electronics background is desirable.
- Excellent sales, customer service, communication, presentation and negotiation skills.
- Recognised qualification in Electronics Engineering or related field.
- Knowledge of the electronics/SMT assembly process.
- Excellent written and verbal communication skills in English.
- Competent user of Microsoft Office applications.
- Ideally living in the Southern half of the UK.
- Willing and able to travel within and outside UK.
- A full, clean UK driving license is essential.

To apply, please contact John Barraclough at john.barraclough@gen3systems.com or by using the link below.

apply now

Career Opportunities

ventec
INTERNATIONAL GROUP
騰輝電子

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

apply now

ViTrox®

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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TAIYO AMERICA

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".

apply now

Career Opportunities

BLACKFOX
Premier Training & Certification

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)
- Capacity for growth
- Excellent quality
- Production quality quick-turn services in as little as 24 hours
- 5-day standard lead time
- RF/microwave and special materials
- AS9100D
- MIL-PRF- 31032
- ITAR
- Global sourcing option (Taiwan)
- Engineering consultation, impedance modeling
- Completely customer focused team

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

apply now

Career Opportunities

KYZEN
Where Science and Care Converge.

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

apply now

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

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.

apply now

Career Opportunities

MivaTek Global

Field Service Technician

MivaTek Global is focused on providing a quality customer service experience to our current and future customers in the printed circuit board and microelectronic industries. We are looking for bright and talented people who share that mindset and are energized by hard work who are looking to be part of our continued growth.

Do you enjoy diagnosing machines and processes to determine how to solve our customers' challenges? Your 5 years working with direct imaging machinery, capital equipment, or PCBs will be leveraged as you support our customers in the field and from your home office. Each day is different, you may be:

- Installing a direct imaging machine
- Diagnosing customer issues from both your home office and customer site
- Upgrading a used machine
- Performing preventive maintenance
- Providing virtual and on-site training
- Updating documentation

Do you have 3 years' experience working with direct imaging or capital equipment? Enjoy travel? Want to make a difference to our customers? Send your resume to N.Hogan@MivaTek.Global for consideration.

More About Us

MivaTek Global is a distributor of Miva Technologies' imaging systems. We currently have 55 installations in the Americas and have machine installations in China, Singapore, Korea, and India.

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eptac

TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

Opportunities are available in Canada, New England, California, and Chicago. If you love teaching people, choosing the classes and times you want to work, and basically being your own boss, this may be the career for you. EPTAC Corporation is the leading provider of electronics training and IPC certification and we are looking for instructors that have a passion for working with people to develop their skills and knowledge. If you have a background in electronics manufacturing and enthusiasm for education, drop us a line or send us your resume. We would love to chat with you. Ability to travel required. IPC-7711/7721 or IPC-A-620 CIT certification a big plus.

Qualifications and skills

- A love of teaching and enthusiasm to help others learn
- Background in electronics manufacturing
- Soldering and/or electronics/cable assembly experience
- IPC certification a plus, but will certify the right candidate

Benefits

- Ability to operate from home. No required in-office schedule
- Flexible schedule. Control your own schedule
- IRA retirement matching contributions after one year of service
- Training and certifications provided and maintained by EPTAC

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Career Opportunities

American Standard Circuits
Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

Summary of Functions

The CAD/CAM engineer is responsible for reviewing customer supplied data and drawings, performing design rule checks and creating manufacturing data, programs, and tools required for the manufacture of PCB.

Essential Duties and Responsibilities

- Import customer data into various CAM systems.
- Perform design rule checks and edit data to comply with manufacturing guidelines.
- Create array configurations, route, and test programs, penalization and output data for production use.
- Work with process engineers to evaluate and provide strategy for advanced processing as needed.
- Itemize and correspond to design issues with customers.
- Other duties as assigned.

Organizational Relationship

Reports to the engineering manager. Coordinates activities with all departments, especially manufacturing.

Qualifications

- A college degree or 5 years' experience is required. Good communication skills and the ability to work well with people is essential.
- Printed circuit board manufacturing knowledge.
- Experience using CAM tooling software, Orbotech GenFlex®.

Physical Demands

Ability to communicate verbally with management and coworkers is crucial. Regular use of the telephone and e-mail for communication is essential. Sitting for extended periods is common. Hearing and vision within normal ranges is helpful for normal conversations, to receive ordinary information and to prepare documents.

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APCT
Passion | Commitment | Trust

APCT, Printed Circuit Board Solutions: Opportunities Await

APCT, a leading manufacturer of printed circuit boards, has experienced rapid growth over the past year and has multiple opportunities for highly skilled individuals looking to join a progressive and growing company. APCT is always eager to speak with professionals who understand the value of hard work, quality craftsmanship, and being part of a culture that not only serves the customer but one another.

APCT currently has opportunities in Santa Clara, CA; Orange County, CA; Anaheim, CA; Wallingford, CT; and Austin, TX. Positions available range from manufacturing to quality control, sales, and finance.

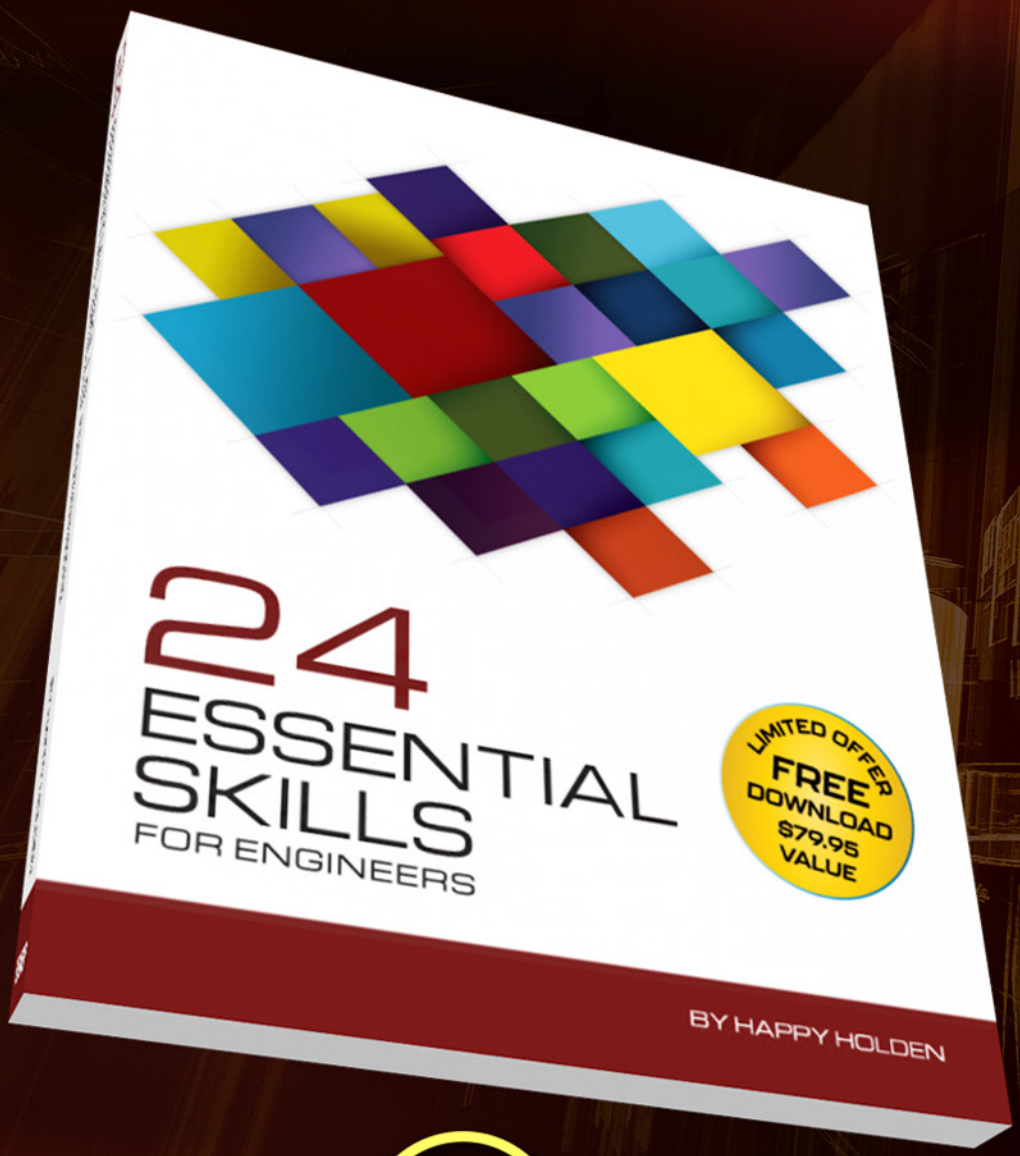
We invite you to read about APCT at APCT.com and encourage you to understand our core values of passion, commitment, and trust. If you can embrace these principles and what they entail, then you may be a great match to join our team! Peruse the opportunities by clicking the link below.

Thank you, and we look forward to hearing from you soon.

apply now

Engineers: Here are 24 Real-world Skills You Didn't Learn in School

Industry veteran Happy Holden shares his strategies for overcoming engineering challenges.



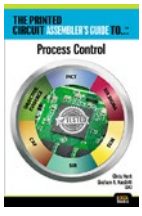
ON DEMAND! Free 12-part Webinar Series

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



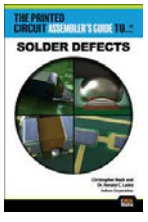
Process Control

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.

Our library is open 24/7/365. Visit us at: I-007eBooks.com

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