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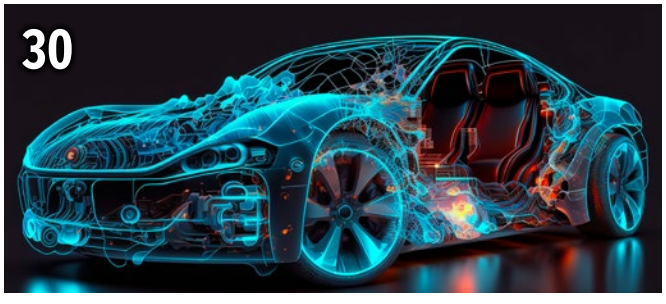
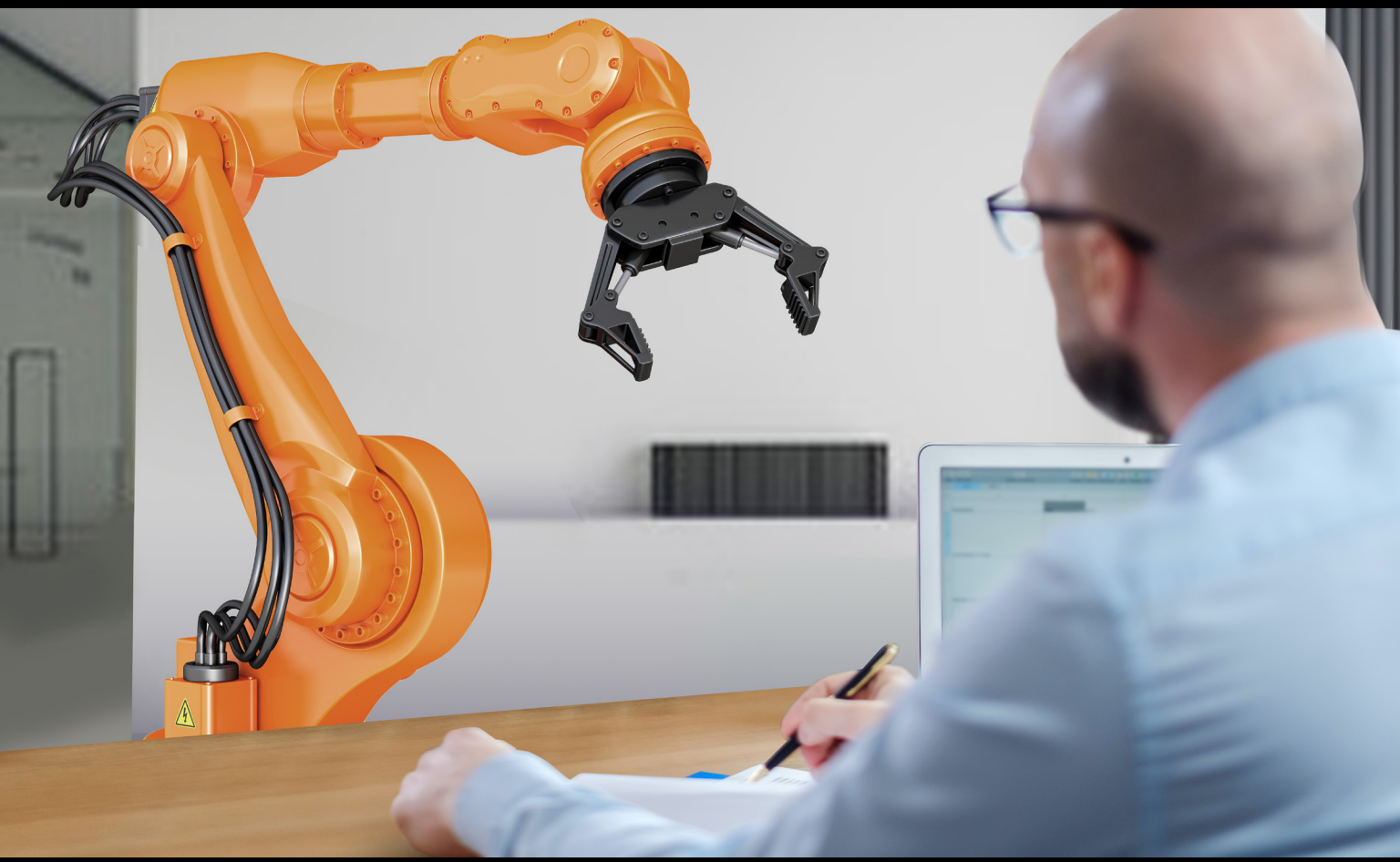
Today's EMS Landscape

Electronics manufacturing services face some key strategic opportunities to not only grow their businesses but also to advance the industry economically and technologically. In order do this effectively, the challenge is to collaborate as well as simultaneously compete. Cue the re-emergence of technical conferences as a forum for responding to the changing EMS landscape.



How to interview a robot



It's important to know in the interview if the job-seeking robot:

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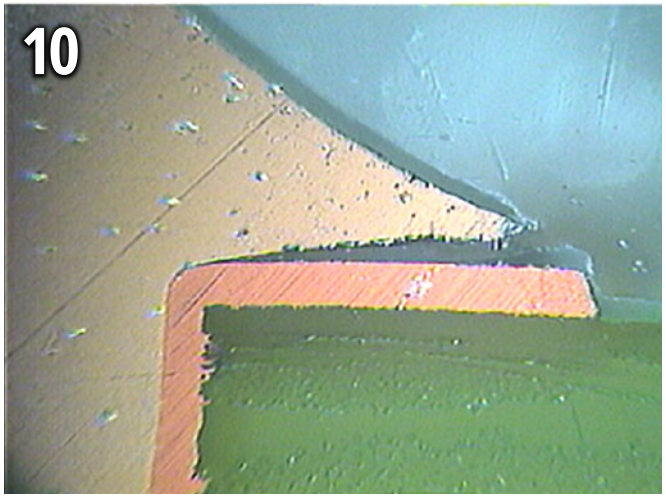

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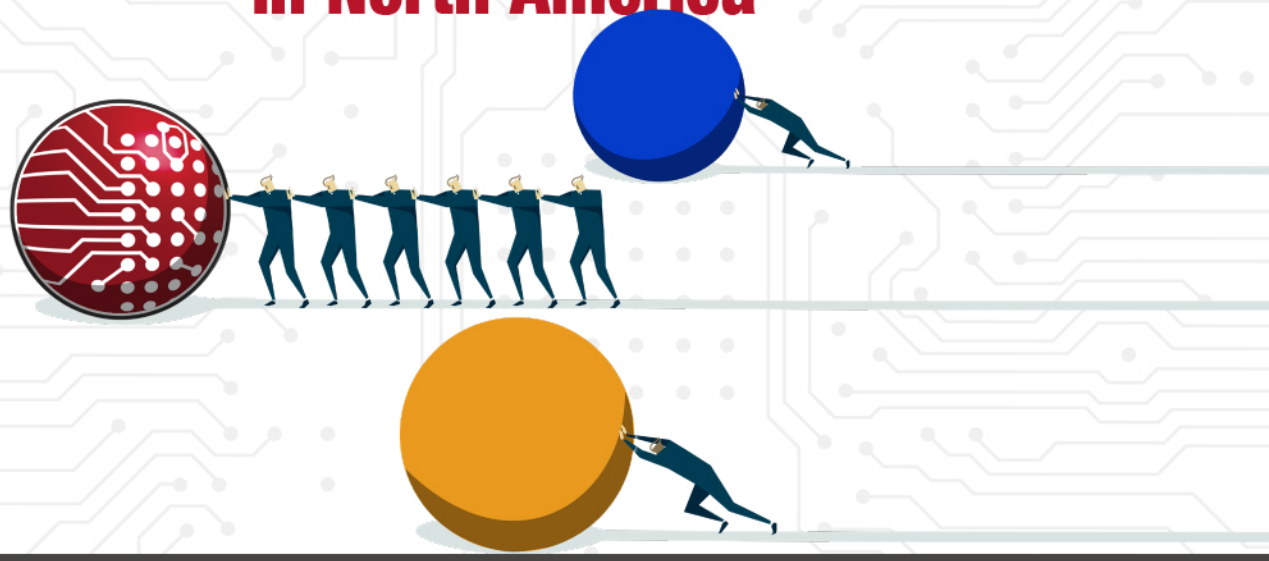

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The Rise of the EMS Summit

Nolan's Notes

by Nolan Johnson, I-CONNECT007

A summit is defined as "a meeting or conference of heads of state, especially to conduct diplomatic negotiations and ease international tensions. Or, any meeting or conference of top-level officials, executives, etc." With that in mind, I believe the EMS Leadership Summit at IPC APEX EXPO was well named.

I spent the entire day at the summit, listening to the speakers and talking to attendees. I found a high level of engagement from both speakers and guests, and rightly so; there was plenty to talk about. What surprised me was the relatively low attendance. "This is information that everyone needs to hear," I thought to myself.

More than at any time in the past 20 years—more than ever, perhaps—there are myriad simultaneous dynamics in motion. In early 2020, as the world temporarily shut down in reaction to the outbreak of COVID, some business organizations (IPC among them) created forums where business leaders in that industry could get the latest updates, compare notes, and generally help each other navigate all the uncertainty. Here at I-Connect007, we took a similar tack, opening our publications to industry leaders. Anyone who had an update to share got an interview. We kept it short (five minutes or so), on topic, and up-to-the-minute whenever possible. We were all trying to get the word out about the rapidly changing pandemic situation.

Personally, I see parallels between those COVID crisis management sessions, and events such as the EMS Leadership Summit, the Pan Pacific Conference hosted by SMTA, and the conferences hosted in Europe by EIPC. Sure, changing market dynamics may move more slowly and methodically than the flash flood of a viral pandemic, but the slow drip-drip of water can move the earth just as dramatically as a flood. It's just a matter of pacing; the impact can be just as significant.

To that end, this issue allows the presenters of the EMS Leadership Forum a wider stage, an opportunity to reach more of the industry with their findings. We reached out to all the presenters on the agenda, and quite a few chose to participate. Attend next year's session if you want to get all the insight. I'm reminded of Mark Wolfe's piece in this issue, in which he both qualifies and quantifies the effect these sessions had on his 30-year career in EMS.

Industry CEOs widely stated that the COVID leadership briefings were a critical channel for updates and information specific to our industry. Participants shared in an open forum and helped each other navigate a rapidly unfolding situation, for the survival of us all. That need to hang together continues; our industry is better for us all when there are more companies specializing in a wider range of capabilities, complementing each other. Why wouldn't we continue with that spirit? If not at the EMS Leadership Summit at IPC APEX EXPO, then somewhere else. We're much stronger when we support each other.

We're always on the lookout for challenges, topics, and opportunities in EMS. Let us know what's on your mind. **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.

Careers In Electronics: Field Applications Engineer

The field applications engineer is a technical support engineer for marketing and salesman at technology companies. You will have the opportunity to travel and work with other engineers to seal up design and product contracts.

The field applications engineer works with regional sales managers, company customers, and manufacturer's representatives to design and manage technical methods for quality control to ensure compliance with the ISO laboratory accreditation. They are technically expert and knowledgeable about sales techniques to boost sales and to develop new organizational objectives by maintaining their relationship with the consultants, inspectors, subcontractors, and potential clients regularly.

Some duties and responsibilities include customer assistance to help customers understand all products and services, providing technical support and configure services, and analyzing customer requirements.

As a field applications engineer, Yyou will also bring new technologies and different design approaches that can make top-selling charts. Similarly, you will come up with reports and present the reports to others and the management convincingly to get their support. As the field applications engineer, you are in charge of coming up with product specifications.

(Source: Careersinelectronics.com)

The Role of Bismuth (Bi) in Electronics, Part 7: A Case Study in Fillet-lifting

SMT Prospects and Perspectives

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

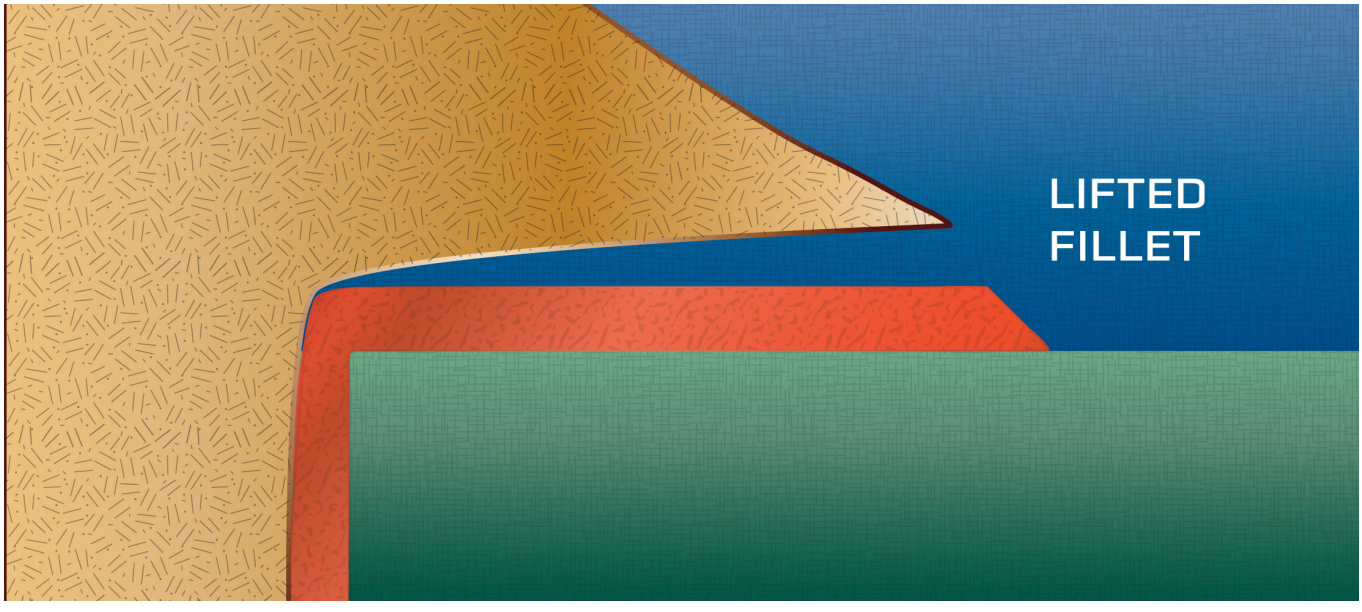
In my column series on "The Role of Bismuth (Bi) in Electronics," I have addressed the properties, safety, resources of elemental bismuth (Bi), the effects of Bi in SnPb, and the effects of Bi on the properties and performance of solder interconnections when Bi is not a constituent element in lead-free solder alloys.

The intricate interactions of the four elements—Sn, Ag, Cu, Bi—in a Sn-based lead-free SnAgCuBi or SnAgCuBi+ systems ("+" denotes other doping elements incorporated in the system) were also previously highlighted. Additionally, the plausible underlying operating mechanisms and resulting mechanical behavior of a lead-free alloy containing these commonly and likely-used elements were outlined. This installation focuses on a case study illustrating a problematic phenomenon called fillet-lifting, what lessons have been learned, and how these findings have helped and will continue to help develop new lead-free alloys.

The fillet-lifting phenomenon has "inspired" fruitful thoughts and deeper examinations in the role of Bi in a Sn-based alloy system. This understanding has substantially helped shorten the development time to reach viable alloy formulae that can deliver the desired performance under thermal fatigue environments that microelectronic/electronic products inevitably encounter.

Background

A decade before the Restriction of Hazardous Substances Directive (RoHS) was proposed in

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December 2000 and adopted in February 2003 by the European Union (and then implemented by the U.S., Japan and other countries), much research and development efforts have been conducted by individual laboratories in the U.S.[1–8], Japan[9, 10], and consortia. One of the primary performance targets was to have a "drop-in" or "nearly drop-in" replacement for SnPb eutectic alloy so that the SMT manufacturing infrastructure, including PCB materials, reflow, and wave soldering processes could remain intact without being subject to disruptions.

With comprehensive studies and thorough examinations of the potential of "logical" alloys, including perusing the entire periodic table, it was found that the most challenging property to be delivered was (and still is) to keep the melting temperature (liquidus temperature) of the lead-free alloy in the range of 175°C to 195°C, while meeting all other necessary properties and manufacturing requirements.

Without delving into historical details and granularity, in order to keep the melting temperature low enough, one approach adopted was to add the element Bi to the Sn-based system.

Phenomena

A phenomenon termed as fillet-lifting was reported in the late 1990s and early 2000s, which refers to the partial separation (crack) of the solder fillet between the solder and the through-hole land on the PCB after the completion of wave soldering (Figure 1). It is worthwhile noting that this phenomenon has hardly been observed in surface mount solder joints; however, it repeatedly occurred with through-hole joints. It should also be noted that such fillet-lifting phenomena were evident immediately after processing (before being subjected to any accelerated reliability testing).

Overall, key observations were:

- Fillet-lifting were associated with through-hole solder joints after wave soldering
- There was no detectible solder joint separation (crack) associated with SMT components
- The solder joint crack often started from the far end of the through-hole joint (Figure 2)

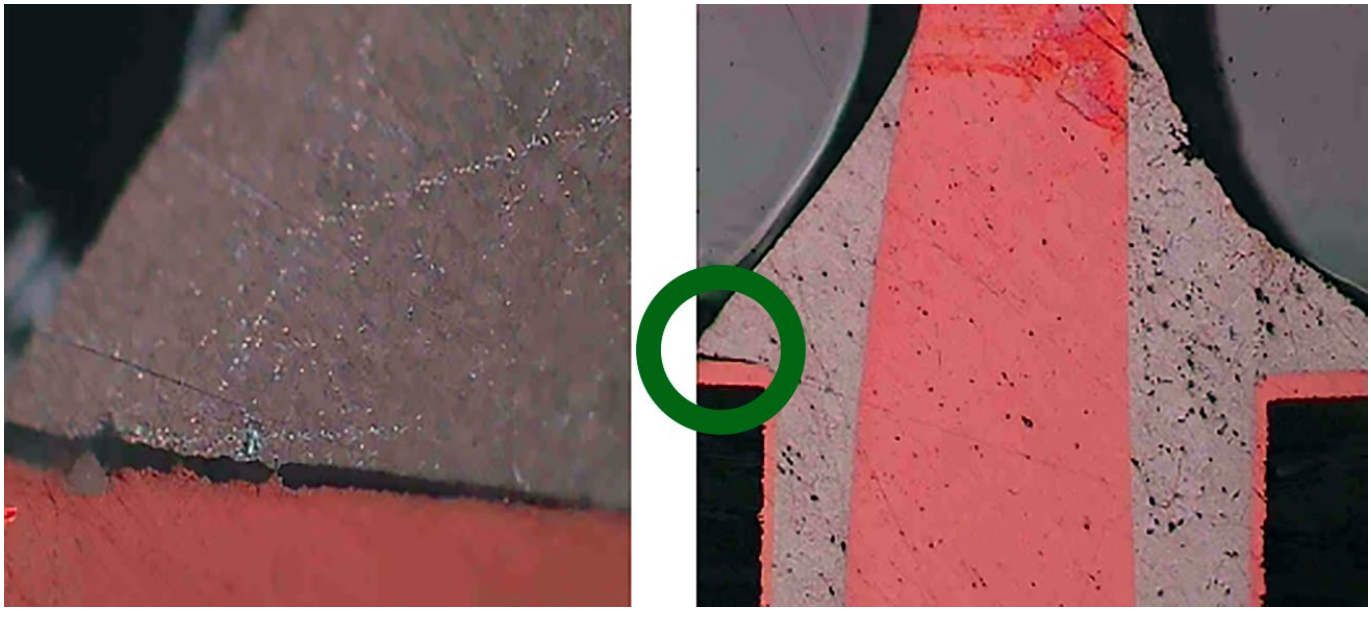

Figure 1: Fillet-lifting phenomenon.

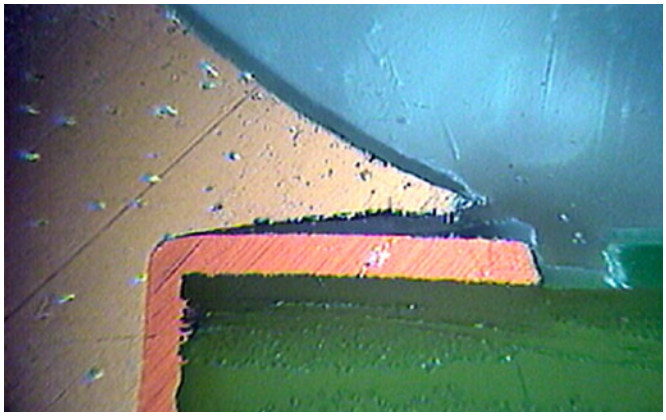

Figure 2: The solder crack joint often started from the far end of the through-hole joint.

The following list outlines key findings in relation to a variety of lead-free compositions. Studies on fillet-lifting can be summarized as follows[9, 10], where fillet-lifting occurred in:

- More than 90% of through-hole joints with Sn3.4Ag>4.8Bi
- More than 90% of through-hole joints with SnAg>7.5Bi
- Severe occurrence in through-hole joints with various lead-free alloys (in the absence of Bi) when SnPb-coated components were used
- Some through-hole joints with Sn3.5Ag0.5Cu1Zn
- Some through-hole joints with Sn2.6Ag0.8Cu0.5Sb
- 30% of through-hole joints with 96.5Sn3.5Ag
- 0% of through-hole joints with 58Bi42Sn
- 0% of through-hole joints with 63Sn37Pb
- 0% of surface mount joint cracks with any alloys tested

Factors and Causes

Based on the observation that the fillet crack appears to initiate from the far end of the land from the barrel in conjunction with the finding that the crack occurs only with through-hole joints, fillet-lifting was attributed to the excessive stress generated during the cooling and solder solidification of an assembly. The contributors to this excessive stress may emanate from several sources:

- Cooling rate
- Maximum temperature gradient (solder pot temperature)
- PCB construction (land design, board thickness)
- Solder alloy composition (melting temperature, metallurgical pasty range, metallurgical phases)
- Solder alloy (stress and strain behavior)
- Wetting ability (intrinsic alloy wetting ability)
- Wettability of PCB land

In most practical cases, fillet-lifting was highly likely contributed to from more than one of the above factors.

Metallurgically, the phenomenon was also considered a result of segregation during solidification and/or the formation of low melting Sn-Bi eutectic phase, when applicable. If or when low-melting SnBi eutectic or other low-melting phases are formed, low-melting phases may be a culprit. Nonetheless, low temperature Sn-Bi phase does not always form when Bi is just present.

Fillet-lifting may or may not cause a circuit board failure or a product failure. However, even when there is no mechanical or electrical failure, the fillet-lifting phenomenon should be examined and remediated.

Remediation and Prevention

To alleviate the problem from the assembly operation (when PCB design is given and not subject to change), the following areas are to be considered:

In process:

- To lower the cooling rate
- To avoid using high soldering temperature, if feasible

In material:

- To choose alloy composition properly (e.g., possessing adequate plastic strain)
- To choose alloy composition with narrow pasty range (less than 10 degrees)
- To choose alloy composition having good intrinsic metallurgical wetting
- To assure adequate wetting condition on PCB land
- To assure the compatible soldering flux

What Was Learned

Achieving one performance property that could jeopardize another performance parameter should be avoided at the outset (i.e., design stage). This may sound as though it's stating the obvious, but the mishap resulting from the lack of holistic understanding of process, materials, and the compatibility between the process and materials has happened, and happened too frequently.

Bi is a unique element which can deliver significant utilities that are beneficial to electronic products, but it has to be used properly and scientifically.

Bi is a unique element which can deliver significant utilities that are beneficial to electronic products, but it has to be used properly and scientifically.

The interplay of the four elements—Sn, Ag, Cu, Bi—in Sn-based lead-free systems is intricate in the underlying metallurgical interactions and reactions. For a Sn-based lead-free alloy system, adding or removing an element, solely reducing or increasing the dosage of an element to target one property or performance parameter, is not a robust approach from the reliability perspective.

Manufacturing process, materials, and compatibility are closely intertwined in relation to reliability; setting, selecting, and designing an electronic system must consider process, material, and compatibility as an inter-dependent triad.

Caution (Awareness)

The discussion in this writing is on a Sn-based system that contains Bi element—in practice, the "base" is practically defined as the element that constitutes 50 vol% or greater of an alloy (i.e., serving as the metallurgical matrix). Distinctions should be drawn between Bi-containing Sn-based alloys and Bi-based alloys. This distinction is profoundly important when we design, select, and use lead-free solder alloys for microelectronic/electronic packaging and assemblies.

- Bi-containing Sn-based alloys
  e.g., 93Sn3.0Ag1.0Cu3.0Bi
  e.g., 93Sn3.0Ag1.0Cu1.0Bi2.0XYZ
- Bi-based alloys
  e.g., 57Bi41Sn2Ag
  e.g., 57Bi41Sn1.5Ag0.5XYZ (dopants)

The distinction in properties, performance, and most importantly to the reliability of electronic products, will be discussed in future columns. **SMT007**

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Appearances: As a part of IPC Engineering Education Webinar Series, Dr. Hwang will present lectures on “PoP and BTC Package and Assembly: Materials, Process and Reliability” April 4, 6, 11, 13, 18, and 20; and on “Lead-free Reliability for Harsh Environments Electronics,” May 16–18 and Nov. 7–9; and “Top Lead-free Production Issues – Causes, Prevention & Solutions” July 11, 13, 18, and 20.

Dr. Jennie S. Hwang—an international business-woman and speaker and a business and technology advisor—is a pioneer and long-standing leader to SMT manufacturing since its inception as well as to the development and implementation of lead-free electronics technology. Among her many awards and honors, she was inducted to the International Hall of Fame–Women in Technology, elected to the National Academy of Engineering, named an R&D Star to Watch, and received a YWCA Achievement Award. Having held senior executive positions with Lockheed Martin Corp., Sherwin Williams Co., and SCM Corp., she was the CEO of International Electronic Materials Corp. and is currently CEO of H-Technologies Group, providing business, technology, and manufacturing solutions. She has served on the board of Fortune-500 NYSE companies and civic and university boards; the Commerce Department’s Export Council; the National Materials and Manufacturing Board; the NIST Assessment Board; as the chairman of the Assessment Board of DoD Army Research Laboratory and the chairman of the Assessment Board of Army Engineering Centers; and various national panels/committees and international leadership positions. She is the author of 600+ publications and several books and is a speaker and author on trade, business, education, and social issues. Her formal education includes four academic degrees, as well as the Harvard Business School Executive Program and Columbia University Corporate Governance Program. For more information, visit JennieHwang.com. To read past columns, click here.

Why the EMS Leadership Summit Matters

Feature Article by Mark Wolfe
IPC

When I first entered the electronic manufacturing services (EMS) industry in 1989, I had some engineering experience, but zero knowledge as to how to manufacture anything. At that point, I didn't realize how little I understood about the real, yet alone subtle differences between an EMS company and OEMs. A colleague of mine suggested I contact IPC to see what resources they had available. The recommendation: Join an upcoming meeting of senior EMS industry leaders, known as the EMS Management Council. I attended my first EMS management meeting that year and started participating on the EMS Council Steering Committee shortly after. That initial experience has drawn me back yearly for over three decades.

The content has always been relevant, but relationships are one of the primary reasons I keep returning. I always look forward to the roundtable conversations with my peers as a great opportunity to hear from others who may be facing the same challenges, but often approaching them in ways that I can learn from. From an industry perspective, these meetings spurred important projects like Program Management Certifications and an EMS Industry Services agreement that is still used today, not to mention being the genesis of renaming the industry from contract manufacturing to electronic manufacturing services more than 30 years ago.

These foundational goals have remained for the time I have participated: provide relevant

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content, leave ample time to start and grow relationships, learn from peers, and help influence the industry.

This past year in San Diego (held during IPC APEX EXPO) was no exception. We certainly discussed very relevant content: sustainability, the economy, today and tomorrow's supply chain, cybersecurity, workforce training, continuous improvement in the factory, and more.

The content has always been relevant, but relationships are one of the primary reasons I keep returning.

To foster relationships and learning from peers, we had more than three hours of an agenda dedicated to roundtables and member-to-member conversations, not to mention a participant-only dinner that evening.

To garner more influence in the industry, not only did we have a meeting with more than a dozen IPC leaders who shape future content and programs, we left with several new ideas regarding how to better serve the industry as a result. When we were done, 96% of surveyed attendees indicated that they planned to attend next year and 100% agreed they would refer the event to a colleague.

One subtle, but very important change over the past few years has been encouraging executives to invite their future leaders to attend as well. The meeting has traditionally been limited to senior executives, but we felt that with so much demand for talent at all levels of the industry, this event could be a great development opportunity for high-potential managers to benefit from the experience. We knew that the opportunity to listen first-hand to the conversations between current CEOs and senior executives as they discuss today's hot topics was a great way to learn and gain insight into their future roles. We have had several companies use this opportunity over the past few years and the feedback has been excellent. We don't feel it has detracted from the foundational goals and we will continue to promote this event as a development opportunity for a broader group of attendees.

We certainly welcome any size EMS company to participate. We saw companies attending that range from a few million dollars of annual revenue to over $1 billion. That said, the meeting is typically 90% attended by EMS companies that are at $100 million and below.

One of the more recent off-shoots of the EMS Leadership Summit has been the emergence of regional meetings. There is a group in the Northeast that has been meeting for many years as a complement to the annual IPC event. IPC has been working with several companies over the past year to help them form additional virtual and face-to-face events that are much more regionally focused and can complement the annual meeting.

Overall, I have always enjoyed the attitude of the attendees, who understand that with the ongoing combination of growth and challenges in the electronics industry, there is more than enough opportunity for everyone over the long term. The attendees come really wanting to both learn and share with one another. It is rare that participants receive without giving insight and there is a very appropriate level of "coopetition," which makes it a unique opportunity. **SMT007**

Mark Wolfe is a former director of supply management/VP of supply management and strategic partnering at John Deere, and now runs a consulting company, and is a consultant for IPC.

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Manufacturing: Meet the Flintstones

Smart Factory Insights

Feature Column by Michael Ford, AEGIS SOFTWARE

As a kid, I loved "The Flintstones" cartoon series. Recently, I watched some of the old shows and as I listened to the dialogue, I saw how our social landscape has changed significantly, except for one character, "Bamm-Bamm Rubble."

Pounding things with a club, like Bamm-Bamm, appears to be the enduring default approach of our sustainability and recycling industries, yet I believe a business opportunity exists in the form of reverse manufacturing where EMS companies and others can potentially double the scale of their activities and value in an area that appears to be locked into the Stone Age.

A very significant example is the recycling of car batteries from modern electric vehicles. I was amazed to discover that these are currently shredded in the same way we would shred limbs of overgrown trees in our gardens to make sawdust. The whole battery pack is simply put into a massive shredder. When cells are not completely or properly discharged, there are frequent fires and explosions. Following this, only about 30% of the core minerals and materials can be recovered through a series of

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vibrators and sieves; further recovery is possible from the "black dust" that remains. It requires special processing and is often done overseas.

Personally, and perhaps naively, I thought we had progressed a little bit since "The Flintstones." For probably one of the most significant new products and technologies of our age, it seems we would have figured out from the start how to make the recycling end of this business sustainable, especially considering the rarity and difficulty to source these materials, as well as the cost and pollution caused by these basic recycling methods. There is then the volume to consider. Right now, such batteries need recycling only in the event of a battery failure or damage to a car in an accident. In perhaps a decade or so, we will be well on the ramp-up curve, as all of today's electric cars reach their end of life. Other immediate examples of "Flintstones" recycling include the recovery of rare-earth magnets from products such as mechanical hard disks and speakers, where the part of the product containing the magnets is simply cut off—and Bamm-Bamm is called in.

Personally, and perhaps naively, I thought we had progressed a little bit since "The Flintstones."

In the case of electronic products, we have started to disassemble the products rather than just crushing them. Governments have created legislation to reduce electronic waste in landfills, such that discrete products made up of sub-assemblies, key components, and hazardous materials can be separated out by reverse assembly, then reused, recovered, or recycled. There are new technologies on the horizon to replace the PCB base FR-4 material, such that when everything has been removed, we are left with something that can actually be recycled.

The "circular economy" is often thought about in terms of the recoverability of materials which can be reused in manufacturing, but this focus is too narrow. Success will remain elusive if we continue with the way things are, as the cost of material recovery is simply not yet a viable business model in most cases. The flaw in the plan is expecting that one day the recycling business model will become realistic if it relies on materials becoming rarer and, hence, more expensive to justify the cost of recycling. By then, as most materials will have been wasted and lost, it will be too late for recycling to scale to the level needed to replace raw material availability. Therefore, the focus needs to be on creating a sustainable recycling business plan now, reducing the cost, and increasing the yield of current recycling strategies.

Car batteries are based on relatively new and evolving technologies. The focus of their design is on operational and cost performance, as well as physical attributes that make up the design of the car itself. Little or no effort appears to be made on design for recycling. One reason is that there are no common guidelines in the design and manufacturing process; everyone is doing it for themselves. There are, however, some very simple things that can be done. Knowing where key bolts are located, using standard symbols or RFID technology, for example, can reduce the manual labor for disassembly significantly, allowing disassembly by robot automation.

Today we are needlessly investing in projects that try to reverse engineer these bolts, using AI-driven vision processing, size, and torque estimations that will never become commercially viable. Instead, we need to take the simple steps to standardize, or at least document, the way things are made and should be disassembled. Another challenge is the glue used to seal the battery cells within the housing. This glue is intentionally extremely difficult to penetrate, but could be replaced with a glue that dissolves, for example, when subjected to a high concentration of hydrogen. These ideas do not limit or compromise

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functionality or performance, but hugely impact the ability to disassemble and recycle more efficiently. With the right approach, the circular economy is not just about material recovery, but includes the element of design for recycling.

With the right approach, the circular economy is not just about material recovery, but includes the element of design for recycling.

There is, however, a significant and fundamental difference between manufacturing and recycling. Manufacturing is commercially viable due to its scale, even when considering the increasing variability of products and shortened factory-to-customer lead times. There is a full set of documentation based on the CAD design data with which to manufacture products. Manufacturing engineering, featuring the automated creation of product-specific work instructions, as well as program data for automated processes, should now be completely automated for most manufacturing companies. Manufacturing is, therefore, a known, continuous, efficient, and repeated process.

In the recycling industry, by contrast, products become end-of-life randomly. Almost every unit presented for processing is completely different from the one before. There is no provision for access to any of the details of assembly or disassembly methods, or of the material content—including embedded chemicals, and locations of key materials and components—all of which are key elements needed from the design and manufacturing data. As we have seen with the massive increase in software automation for MES in recent years, we are now on the precipice of "RES," meaning recycling execution, rather than manufacturing. This is simply MES in reverse gear. Examples already exist in the best MES tools available today, which include RMA/MRO processing, where products from the field are repaired, overhauled, upgraded, or remanufactured into other products. While this is currently happening only at the high end of the market, there are lessons to be learned by the industry.

Due to the random nature of recycling, and with the need for product data from many OEMs to be available to recycling companies, there is an element of security and risk of IP leakage. However, hardware and software technologies exist that uniquely identify products, and allow access to only the needed data of their design and manufacturing in a way that does not reveal intellectual property and other private information. These technologies are being utilized and developed for the supply-network applications supporting manufacturing, but really, the greatest need will be in the recycling industry, which should be included in such projects. After all, materials and elements from recycling are then intended to go back into the supply network.

Revolutions in recycling do not happen overnight, but we all need to be headed in the same, logical direction, rather than just hoping that Bamm-Bamm will continue to be the answer. Let's hope that, instead, MES technology for disassembly will become as important as for manufacturing. It will include automation with Smart hardware and software and create many new high-skill jobs with built-in security and trust, building the future we imagine not only for future generations, but in knowing that we are making the world better. Before it's too late. **SMT007**

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

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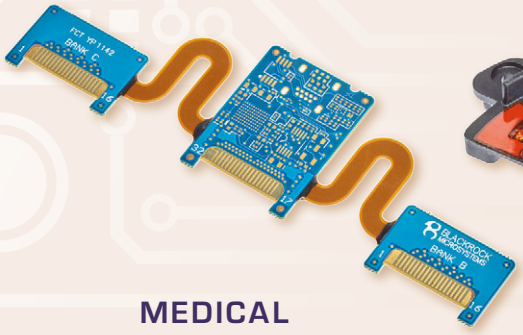

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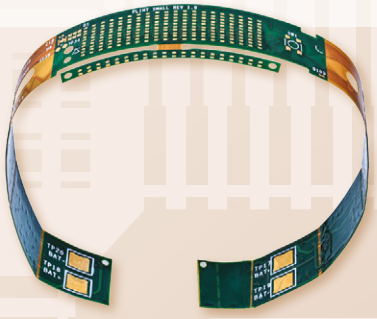

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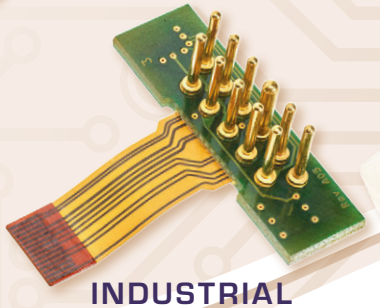

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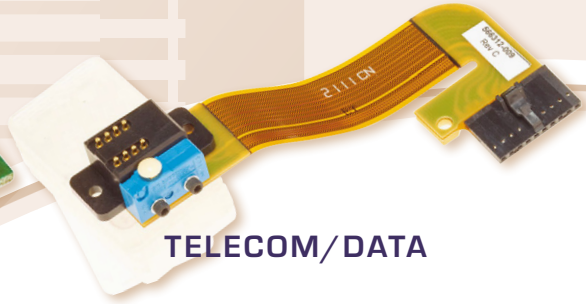

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Shawn DuBravac

A Complex and Contradictory Economic Outlook

Feature Article by Shawn DuBravac
IPC

Editor's note: Shawn DuBravac, IPC chief economist, delivered a keynote at the EMS Leadership Summit at IPC APEX EXPO 2023. Here, Shawn provides an update on what is a complex and sometimes contradictory economic outlook.

At this year's EMS Summit held at IPC APEX EXPO, I shared IPC's economic outlook for 2023 and 2024. The electronics industry overcame significant hurdles and headwinds in 2022, thanks in large part to strong underlying demand. While many of those hurdles and headwinds have subsided, the industry faces new challenges in the year ahead. At the EMS Summit, I shared three key themes defining the year ahead.

First, the industry starts the new year on solid footing and a generally strong optimistic tone. Companies continue to report solid order flow. While fewer companies are reporting order growth than they did in 2021 and 2022, companies are still optimistic about the months ahead. Capacity utilization remains strong, and in the U.S., the electronics manufacturing sector has added about 35,000 new jobs in the last year. The industry has the highest employment levels it has had since 2009. Backlogs have settled as incoming orders have slowed and supply chain disruptions have dissipated, but overall, companies remain cautiously optimistic about the first half of the year.

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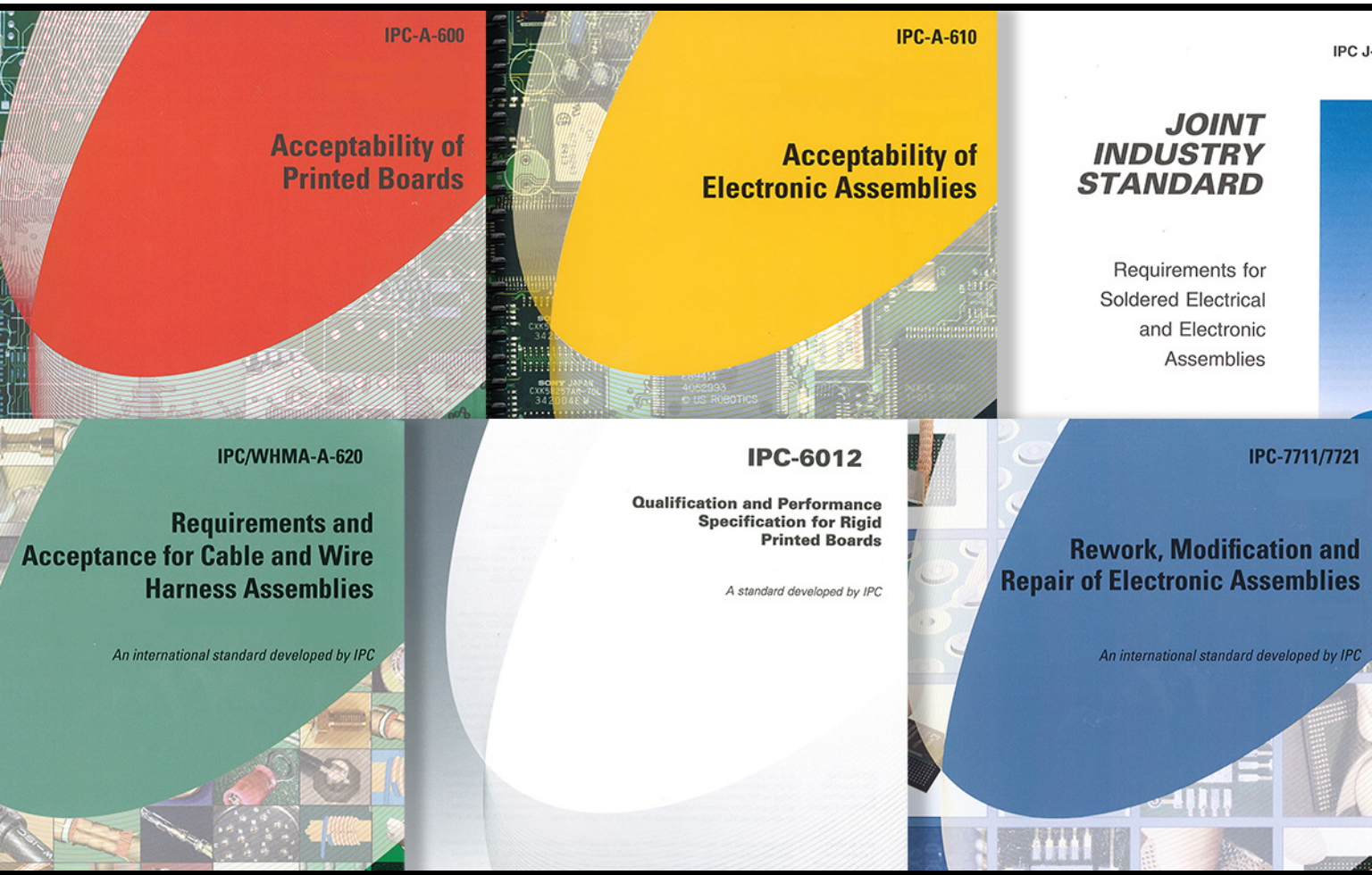

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Secondly, we are entering a period of subdued growth in the economy, which began in 2022 and will continue this year and push into 2024. At the start of 2022, our forecasts called for North American GDP growth of 3.7% in 2022 and 2.6% growth in 2023. The economy grew just 2% in 2023 and we now expect the economy to expand just 0.5% in the year ahead. Part of this decline was exacerbated by Russia's invasion of Ukraine, but there are other headwinds as well.

Finally, we are past peak inflation, but inflation will remain elevated in the year ahead. Labor markets will remain tight and wage rates elevated. The labor force participation rate flattened out over 2022 at a level that is about 1 percentage point lower than pre-pandemic levels, primarily reflecting an estimated 2.5 million in excess retirements, as well as some impact from long COVID. Immigration has also been low in recent years. All this combines to keep pressure on wages and keep inflation higher for longer. This means that the Federal Reserve will also keep interest rates higher for longer as it seeks to slow inflation.

In the months since the release of our 2023 forecast at the EMS Summit, we have received additional data that supports our view. Inflation remains stubbornly elevated and that will push interest rates higher and keep them there longer than many might have expected. At the start of the year, the futures markets were even suggesting the Fed might cut rates in the back half of the year.

It is also important for leaders to recognize that growth is slowing, and the decline will not be even and orderly. The recent and sudden collapse of Silicon Valley Bank is just one example of the type of shocks that happen during an economic recession and companies should be vigilant against contagion that spreads from parts of the economy adjacent to our own industry. It is not events within our sector that catch companies off guard, it is the shocks outside our domain that pose some of the greatest risks. **SMT007**

For more details about Shawn's analysis of the tech industry, read a review of his keynote address here, and watch his *Real Time with...* interview here.

Hands-free Tech Adds Realistic Sense of Touch in Extended Reality

Researchers from Rice University, Baylor College of Medicine and Meta Reality Labs have found a hands-free way to deliver believable tactile experiences in virtual environments.

Users in virtual reality (VR) have typically needed hand-held or hand-worn devices like haptic controllers or gloves to experience tactile sensations of touch. The new "multisensory pseudo-haptic" technology, uses a combination of visual feedback from a VR headset and tactile sensations from a mechanical bracelet that squeezes and vibrates the wrist.

"Wearable technology designers want to deliver virtual experiences that are more realistic, and for haptics, they've largely tried to do that by recreating the forces we feel at our fingertips when we manipulate objects," said study co-author Marcia O'Malley, Rice's Thomas Michael Panos Family Professor in Mechanical Engineering. "That's why today's wearable haptic technologies are often bulky and encumber the hands."

O'Malley said that's a problem going forward because comfort will become increasingly important as people spend more time in virtual environments.

Haptic refers to the sense of touch. Pseudo-haptics are haptic illusions, simulated experiences that are created by exploiting how the brain receives, processes and responds to tactile and kinesthetic input.

(Source: Northwestern University)

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Keep Your Foot on the Gas

Feature Interview by Nolan Johnson
I-CONNECT007

Digi-Key's Mike Slater is vice president of global business development and responsible for supplier and customer business development around the world. After his presentation at the EMS Leadership Summit at IPC APEX EXPO 2023, Nolan Johnson reached out for additional market perspective. Here, Mike talks about the current component supply chain and what to expect in the upcoming years. He provides insight for assemblers and OEM design teams alike.

Your presentation at the EMS Leadership Summit was well received. What was the general theme of your remarks?

I've been at this business more than 25 years and it tends to be cyclical. We're always interested to know where we are in the cycle, and how it affects our ability to get product. What does the overall demand look like?

Where do we see the market headed in the next five to 10 years? Over the past 20 years, the market has grown annually on average about 6-7%. The global electronics or semiconductor market will tell you there really hasn't been anything new that has driven that growth in that time. But we see some significant pockets of opportunity in the next five to 10 years.

We break it down into a few areas: automotive and industrial, compute and data storage, and wireless. If you look at the electric vehicle (EV) market and electrification, you're just scratching the surface. EVs are just one small piece of the whole pie. Whether we're talking about EVs, or even gas- or diesel-powered cars, electronics included in these vehicles have

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multiplied, and that will have a huge impact on the industry.

When you look at the support infrastructure it will take to manage the number of electric vehicles by 2025, we are nowhere near where we should be. We must get to a point where EVs are convenient to charge and a part of our everyday lives.

Of those three market drivers you mentioned, which is the most significant?

They're all significant in their own way. Specific to Digi-Key, our industrial customer base is probably at the center of what we do and will be key for us in the long term because that sector represents most of our customer base. We certainly touch the EV market and the EV connectivity and infrastructure—we touch virtually every customer but at different levels. For us, it's the industrial and internet of things applications that will affect our customers.

In your presentation at the leadership summit, you looked ahead in the next decade. What was your analysis?

We believe there will be a short-term correction in the market, something that's already started. In the past two years, there has been exponential growth across many businesses. At Digi-Key, we are up more than 80% over the past two years. We are seeing a leveling off in the market, but we expected it, and think it's a short-term dynamic.

The market was roughly $600 billion in semiconductor sales in 2022 and is expected to be $1 trillion by 2030, so we still see the long-term growth above average for the next decade. When I mentioned 6–7% annual growth for the past 20 years, we think it will be closer to 8–10% for the current decade.

What are the implications for EMS providers as they weather that short-term correction before returning to a healthy growth rate?

Some of the pain they've felt over the past few years regarding availability is certainly not going away forever. These production fabs and test and assembly sites—which we need to build in order to realize and sustain that growth—are massive investments from these manufacturers. It takes years of planning and development to get them ready. Since our industry is cyclical, you must be ready for that next cycle.

You also must anticipate the technologies that will feed the explosive areas of growth. Where do you need to spend some time making sure you're balanced? What visibility do you have into what's driving these technologies so you can make sure you're positioned in the right way?

It sounds like demand will continue to outstrip growth and capacity, but by how much?

There will be areas where the capacity will not catch up to demand, for years in some cases. If markets grow like they're expected in 2025-26, we will see additional shortage issues on certain technologies again.

What's your expert advice for EMS providers in responding to what's ahead?

We've made a lot of progress in the last few years from a data and visibility standpoint. This pain with the supply shortages hit virtually every type of customer; no one was immune. I think we learned a lot.

Because of that, we've taken a step back, and we're planning better today than we ever have. Don't go back to the old ways of looking at things, for example, forecasting no more than 90 days or 120 days. Make sure we're planning our businesses with a long-term perspective and learn from what we had to go through since 2020. Keep that visibility, be forward-looking, and take a longer view than you did before.

Planning ahead seems to also have implications for designers and OEMs: the parts they should put in their parts library, future-proofing their bill of materials, etc.

What is your advice for design teams for the rest of this decade?

The market tends to be cyclical even from the design standpoint, and especially for those doing second sources, or trying to have a lower-risk BOM. It seems we became too comfortable; from 2013 to 2019, the risk of not sourcing products was low, so many design teams took their foot off the gas. They might not have taken as much initiative to de-risk the BOM, to pick parts that are very common in the market, and to secure second sourcing where possible.

During past cycles, the shortages tended to be one type of technology or another. We might have had a tantalum problem, or certain types of products or technology. This time it was across the board. You really take a holistic approach to the BOM, look at all technologies on all part numbers, and verify you've done the due diligence. Putting in a little more time up front will make a big difference in the long run.

Any final thoughts on the topic of sourcing or something else we haven't addressed yet?

Inventory has certainly become more available today than even six months ago. That's a good thing. But there are still pockets of struggle and hard-to-find parts in the world. I don't see that working through the system until maybe later this year.

In the EMS world—distribution and manufacturing—we've probably built more inventory as a combined group than ever before. Everybody will need to work through those inventory excesses and shortages in certain areas to return to normal.

Will we see you at the EMS Leadership Summit next year?

Absolutely; I'd love to attend.

Thanks very much for taking the time.

No problem, I appreciate the opportunity. **SMT007**

Trends in Supply Chain Dynamics

Feature Article by David Sharp
CALCUQUOTE

Editor's note: CalcuQuote CEO Chintan Sutaria used his presentation at the EMS Leadership Summit to share market insights that could be concluded from usage data within the CalcuQuote environment. This article, authored by David Sharp, vice president of products, summarizes and updates the information shared at the summit.

The electronics industry experienced significant growth in size, complexity, and sophistication in the last decade. This growth was driven in part by:

1. Globalization: The electronics supply chain became increasingly globalized, with companies sourcing components and parts from all over the world. This led to greater efficiency and ability to source more parts, but also increased the risk of supply chain disruptions.

2. Shorter product life cycles: The demand for new and innovative products reduced product life cycles. This created a need for faster production and supply chain processes to keep up with the changing market demands.

3. Increased complexity: The industry and products became more complex. Companies had to innovate faster and adjust their systems and processes to keep pace with the rapid changes in products and competition.

4. Focus on sustainability: More companies focused on sustainability, and sought to reduce their environmental impact and improve the

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ethical and social aspects of their operations. This includes efforts to reduce waste, improve energy efficiency, and ensure responsible sourcing of materials.

These trends will continue to influence demand within the electronics supply chain for years and are partially responsible for recent boom/bust cycles. Unfortunately, while recovering from the latest cycle, the pandemic, factory closures, and other challenges led to pent-up demand, which drove component availability to an all-time low.

Everyone in the industry felt the impact and it was rough.

These trends motivated stakeholders up and down the supply chain to adjust their practices and processes to better collaborate with their suppliers and customers. As this disruption moved further downstream and suppliers looked at their processes to increase productivity, solution providers like CalcuQuote offered a unique vision to these challenges. Our integration allows companies to make nearly 60,000 sourcing decisions every day. These activities provide insights to help stakeholders better understand the market and make informed decisions to remain competitive.

The following summary highlights turning points and important trends:

Ease of decision making: Lines automatically sourced through APIs and other integrations:

- January 2019–July 2020: Automated Decisions Increased by 24%
- August 2020–June 2022: Decisions Reverted Back to Early 2019 levels
- July 2022-January 2023: Decisions Increased Again by 15%

Insufficient Stock: Percent of lines with insufficient stock to meet demand:

- April 2019: Lowest level of out-of-stock lines at 6%
- November 2021: Highest level of out-of-stock lines at 38%
- January 2023: Trending back down and now at 24%

Multi-sourced a BOM: Count of approved manufacturers per BOM:

- Steady increase in average number of MPNs per BOM
- Minor fluctuations haven't changed the trend, which will likely continue

Unit price index: Average unit price per part:

- March 2019–March 2020: Index dropped 18%
- March 2020–March 2021: Index rose 84%
- March 2021–March 2022: Index rose 35%
- March 2022–January 2023: Index rose 2%

Manufacturing lead time: Average number of days to receive all parts on a BOM:

- March 2019–March 2020: Lead times decreased 6%
- March 2020–March 2021: Lead times increased 31%
- March 2021–March 2022: Lead times increased 52%
- March 2022–January 2023: Lead times decreased 11%

Note: Lead times decreased 13% since the peak in August 2022.

While the electronics supply chain is still feeling the effects of the shortages, lead time and price increases, and other supply chain challenges, recent trends indicate stabilization and even improvement. The pains will likely persist for a while, but the steady progression toward integration and automation will further mitigate the impact and allow companies to remain competitive through whatever lies ahead. SMT007

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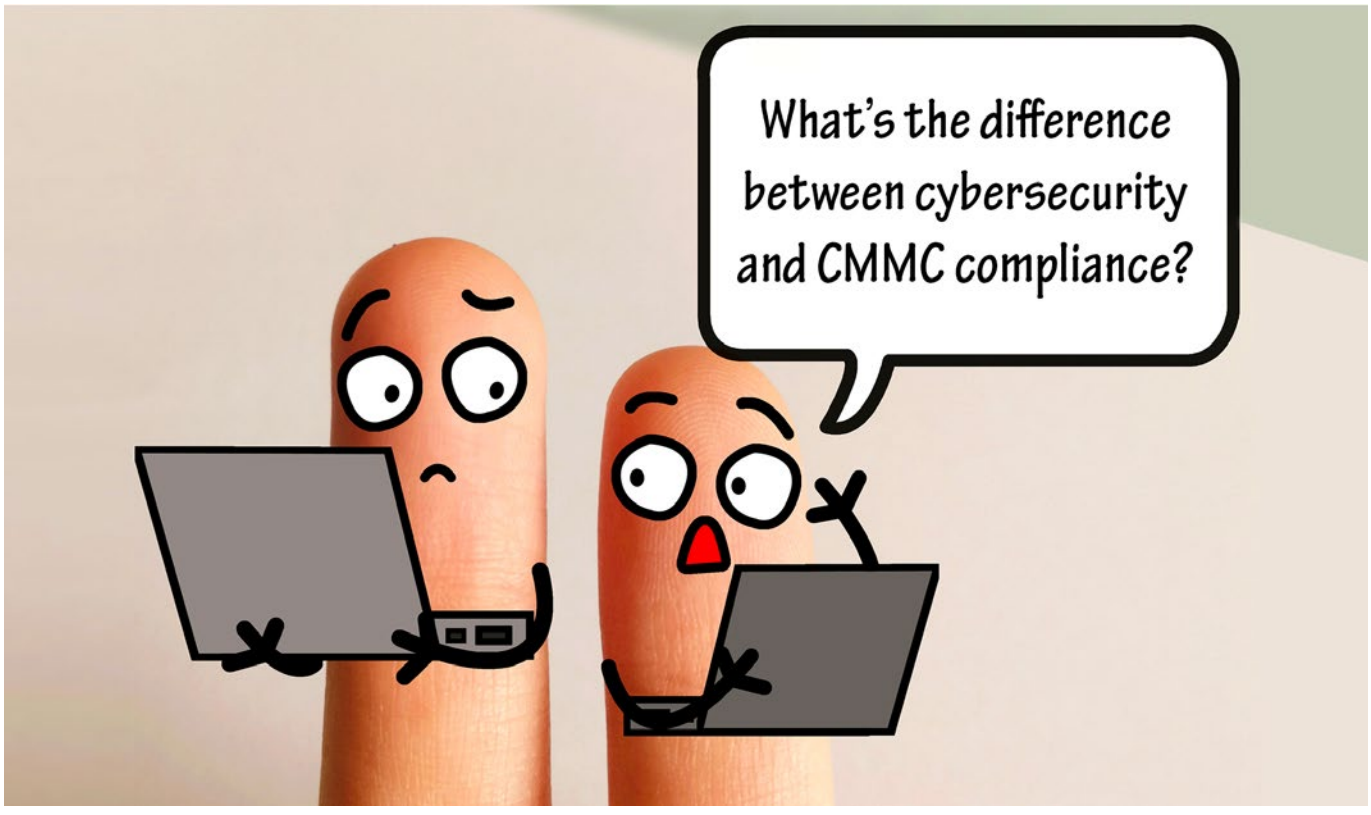

Panel Discussion: CMMC and Cybersecurity

Feature Q&A by Maribel Hernandez

The electronics manufacturing sector faces unique challenges when it comes to cybersecurity, given the highly sensitive nature of the information that it handles. With the introduction of the Cybersecurity Maturity Model Certification (CMMC) framework, businesses will soon be required to meet specific, more stringent cybersecurity standards to bid on Department of Defense contracts. This has made cybersecurity hygiene and CMMC compliance more important than ever for businesses in the sector, as non-compliance can result in lost revenue and reputational damage.

At the recent EMS Leadership Summit, held during IPC APEX EXPO 2023 in January, summit organizers arranged a panel discussion with three industry experts. The panel, moderated by Maribel Hernandez, followed a question and answer format. Panelists included Joaquin Hernandez, Allen Anderson, Vijay Takanti. They discussed the details and intricacies of CMMC compliance, and how it can affect a business. The experts shared their insights into the challenges that businesses in the sector are likely to face, the specific requirements tied to CMMC compliance, and the steps that businesses can take to ensure that they are adequately protected and able to achieve compliance within the framework. This article, compiled by the participants, summarizes portions of the discussion from the summit event.

What's the difference between cybersecurity and CMMC compliance?

Joaquin Hernandez: Cybersecurity is the practice of protecting computer systems, networks, and data from unauthorized

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access, theft, and damage. It's a broad concept that encompasses many different tactics, techniques, and procedures. The CMMC compliance, on the other hand, refers to the requirements set forth by the DoD to ensure that contractors are meeting a minimum level of cybersecurity readiness before being awarded contracts.


Joaquin Hernandez

In other words, cybersecurity is the foundation upon which compliance is built. A company must have a solid cybersecurity posture that extends to cover compliance safeguards in order to achieve compliance. While CMMC compliance is a specific set of requirements that a company must meet to do business with the DoD, cybersecurity is a broader and ongoing practice that should be applied to all aspects of a company's operations to protect against cyber threats.

What are the current DoD cybersecurity requirements?

Allen Anderson: Effective Dec. 31, 2017, the Defense Federal Acquisition Regulation Supplement (DFARS), and specifically DFARS clause 252.204-7012, mandates security controls defined in National Institute of Standards and Technology Special Publication 800-171 (NIST 800-171) be followed by all defense contractors, relying on the contractor's self-attestation of compliance through DFARS clause 252.204-7019 and the Supplier Performance Risk System or SPRS.

NIST 800-171 recommends certain cybersecurity standards. It consists of 110 controls to protect unclassified, but sensitive, information, and to govern timely reporting of cyber incidents.

CMMC—or DFARS clause 252.204-7021—will move the level of proof of compliance from mere self-attestation to third-party audit and verification. In short, CMMC is designed to ensure defense contractors are acting as they have been attesting with respect to the NIST 800-171 controls.

What is CMMC?

Vijay Takanti: The DoD created CMMC in response to the ongoing compromise of sensitive unclassified information that threatens our national security. The existing security requirements imposed on members of the Defense Industrial Base (DIB), those companies that directly or indirectly serve the DoD, have proven ineffective.

While CMMC remains a work in progress ahead of its official implementation, the current version of the framework, CMMC 2.0, consists of three Maturity Levels. Maturity Level 1 comprises 17 requirements, known as practices, designed to protect Federal Contract Information (FCI). Maturity Level 2 contains 110 practices, including the 17 from Level 1, which will protect Controlled Unclassified Information (CUI). These 110 practices directly align with the 110 controls defined in NIST 800-171, the standard to which companies that handle, process, or store CUI are held today. Maturity Level 3 has not yet been fully defined because it will apply only to a small number of contracts and contractors, but it will encompass the 110 practices of Level 2 and additional practices drawn from other standards like NIST 800-172.

There's an important difference between CMMC and its predecessors. In the current environment, companies can self-attest their compliance with NIST 800-171. Most companies seeking CMMC Maturity Level 2 accreditation, and all pursuing Maturity Level 3, will have to pass an assessment conducted by a CMMC Third Party Assessment Organization (C3PAO) or the Defense Contract Management Agency's (DCMA) Defense Industrial Base

Cybersecurity Assessment Center (DIBCAC).


Vijay Takanti

Who must comply with CMMC?

Hernandez: Any company that wants to do business with the DoD must comply with the CMMC requirements. This includes both prime contractors and subcontractors at all tiers of the supply chain.

The CMMC requirements apply to all DoD contracts, including those for goods and services. It's important to note that compliance is mandatory and that companies must undergo a CMMC assessment to verify their compliance level before being awarded a contract. The CMMC framework is designed to ensure that contractors are meeting a minimum level of cybersecurity readiness, so it's crucial for companies to take these requirements seriously and invest in cybersecurity measures to protect themselves and their clients.

When will CMMC come into effect?

Anderson: Frankly, the CMMC rollout continues to be a moving target, and, in fact, it now appears there may be further delays in CMMC 2.0 reaching final ruling as the Pentagon considers additional revisions to the proposed rule. As might be expected, much of the delay can be attributed to internal politics and concerns related to business impact. Notwithstanding these delays, which could push the CMMC rollout into 2024, it is important to remember that the underlying NIST 800-171 requirements—excepting the third-party audit requirements—have been in place for defense contractors since Dec. 31, 2017, and those remain.

What happens if a company fails to comply?

Takanti: In the near future, as existing DoD contracts come up for renewal and the DoD seeks partners for new programs, solicitations will include DFARS clause 252.204-7021, which links to CMMC. Solicitations also will include the Maturity Level accreditation which must be possessed by the prime contractor and subcontractors at all tiers.

Failure to possess the proper CMMC Maturity Level accreditation affects all members of the DIB. Prime contractors lacking accreditation may be unable to bid, costing them anticipated renewal revenue or new business opportunities. Subcontractors at any tier will face being left off the bid team by the prime contractor and replaced by one of their competitors.

DIB companies that received CMMC Maturity Level 1 or 2 accreditation as the result of a self-assessment may be subject to audit by DIBCAC. Consequences for an inaccurate assessment can be steep, possibly including termination of contract, corporate prosecution under the False Claims Act, and personal liability for executives who must sign a document verifying the accuracy of the self-assessment.

How long will it take a business to prepare for CMMC compliance?

Hernandez: The time it takes to prepare a business for CMMC compliance will depend on several factors, including the company's current level of cybersecurity readiness, the size and complexity of its IT infrastructure, and the level of CMMC certification it is seeking.

Each of the three CMMC Maturity Levels comes with its own set of requirements, and the higher the level, the more rigorous the requirements. For a small business with a basic IT infrastructure, achieving a Maturity Level 1 certification may only take a few months, while a larger enterprise with more complex systems

and processes may take years to achieve a Maturity Level 2 or 3 certification.

It's important for businesses to conduct a thorough self-assessment to identify any gaps in their cybersecurity measures and work with experienced cybersecurity professionals to develop and implement a plan to achieve compliance.

Allen Anderson

How much will the certification cost businesses?

Takanti: Companies should plan on substantial costs to acquire their CMMC accreditations. Several factors serve as cost drivers.

First, regardless of the Maturity Level they pursue, members of the DIB should perform a self-assessment against the relevant CMMC practices. The self-assessment will either be sufficient for accreditation or help prepare for a third-party assessment. Many organizations, particularly small- and medium-sized businesses (SMBs), lack the expertise, resources, and time to conduct an assessment properly. Instead, they must rely on outside consultants or tools, and each comes with a price tag.

Second, audits already conducted by DIBCAC have shown that most companies, even large enterprises, find themselves much further from meeting the relevant requirements than they think. Achieving the necessary full compliance takes significant remediation and implementation activities, which means incurring overhead costs and possibly capital expenditures.

Finally, most organizations at Maturity Level 2, and all at Maturity Level 3, will need to be assessed by an approved outside party to receive their accreditation. The size of the organization and the depth and breadth of CUI throughout its infrastructure impact the scope of a C3PAO's audit, which can span days or weeks and thus become expensive.

Add it all up, and the numbers can become quite large. Expect a minimum of five figures, and perhaps six, of hard and soft costs to successfully acquire CMMC accreditation.

What if my company doesn't contract directly with the DoD, or even with a prime contractor? Does CMMC still apply?

Anderson: While CMMC may not directly apply to a sub-contractor or supplier not contracting with the DoD or even a prime contractor, it will eventually be the cost of doing business in the defense sector and reach the subcontractor or supplier through mandated contractual flowdowns.

Moreover, one can absolutely expect similar or identical requirements for those in the government contracting chain, as similar standards are now being mandated by GSA, NASA, and other civilian agencies.

Where can a business find the resources to get started?

Takanti: CMMC can be daunting, in terms of compliance and cost. Fortunately, members of the DIB have access to a variety of resources to help on both fronts.

The DoD Office of Small Business Programs initiated Project Spectrum to provide companies with a comprehensive platform that includes the tools and training needed to increase cybersecurity awareness and maintain compliance in accordance with DoD contracting requirements. The federal Small Business Administration, along with locally based Manufacturing Extension Partnerships and Procurement Technical Assistance Centers, offer training, counseling, and even grants to improve cybersecurity readiness and maturity in preparation for CMMC and similar mandates.

Easy-to-use, cost-effective tools also exist that do everything from explaining the CMMC practices in plain English and guiding the self-assessment process and progress to creating the policies, plans, and other documentation necessary for accreditation. Look to managed service providers (MSPs) and managed security service providers (MSSPs) as partners with proven capabilities who can efficiently offload much of the compliance burden by reducing the assessment footprint and thus the overall time and cost to CMMC accreditation.

How can a business reduce its burden?

Hernandez: There are several steps a business can take. One important step is to conduct a thorough self-assessment to identify any gaps in its cybersecurity measures, develop a plan to address them, and prioritize its efforts and resources effectively.

Another important step is to work with experienced cybersecurity professionals who can provide guidance on the CMMC requirements and help the business develop and implement a compliance plan. This otherwise might be difficult for SMBs with limited IT staff.

MSSPs possess the knowledge, tools, and credentials to assist with CMMC compliance. They can provide cost-effective solutions and services by leveraging their existing technical controls and expertise.

By outsourcing the self-assessment and preparation to an MSSP, businesses can access the experienced resources needed to achieve compliance without having to invest in building their own cybersecurity programs with dedicated cybersecurity staff. The MSSP will pre-assess the level of compliance, identify the gaps, and help implement the required controls in preparation for the actual assessment.

It's important to remember that CMMC compliance is not a one-time thing but rather continuous maintenance of the certified status, which can be delegated to the MSSP. Businesses need to continually monitor their cybersecurity posture, conduct regular security assessments, and update their security controls to ensure ongoing compliance with the CMMC framework. **SMT007**

Allen Anderson represents local, national, and international businesses, as well as public and governmental entities, on a variety of legal matters, ranging from drafting and negotiation of both commercial and governments contracts; to formation of entity-wide compliance programs in response to an ever-changing political landscape; to disputes arising in both state and federal courts and before various arbitration or governmental panels. Allen is part of F&B Law Firm, P.C., a global practice, providing focused and timely legal advice on issues affecting a spectrum of industries including electronics manufacturing service providers.

Joaquin Hernandez is an electronics and telecommunications engineer with over 15 years of experience helping small- and mid-sized businesses as an information security professional. Currently a cybersecurity and CMMC consultant, Joaquin is the founder and president of Empowered IT Solutions, a security service provider serving companies in the United States and México, offering innovative IT technologies and cutting-edge cybersecurity solutions to implement, maintain, and comply with mandated CMMC and NIST requirements.

Vijay Takanti is SVP of Innovation and Informatics at Exostar, a provider of secure, cloud-based, compliant B2B collaboration capabilities and communities for highly regulated industries worldwide. He is responsible for the strategy and product roadmap, design, development, and customer delivery of The Exostar Platform. Takanti has more than 35 years of experience in electronic data processing, application design and development, and information security solutions for government and commercial customers globally. He facilitates the development of industry best practices and standards by bringing together CISOs and CSCOs from leading companies to focus on improving supply chain cybersecurity and risk management.

Bob Wettermann: Making the 'BEST' of His Career

Interview by Nolan Johnson
I-CONNECT007

Bob Wettermann started his career in the semiconductor industry, but after a series of industry and economic changes, he tapped into his entrepreneurial spirit he learned from his father. For more than 20 years, Bob has been leading and developing BEST, Inc., a PCB rework/repair service provider, solder training company, and stencil manufacturer. In this interview, Bob reflects on highlights of his long career, and we meet Nash Bell, who will be leading BEST through its next phase.

Bob, congratulations on your retirement; we have much to talk about. Let's go back to before you bought BEST. Tell me about your background.

Bob Wettermann: I'm an electrical engineer by training, starting out in the semiconductor industry. I worked in applications engineering for Advanced Micro Devices, but cut my teeth as a co-op engineer at IBM, learning the front end of the semiconductor manufacturing process. When the great PC bust happened in 1985, AMD CEO Jerry Sanders sent everybody home for four weeks. He said, "People are the most important thing and we're never going to lay anybody off." Of course, he didn't say you would be home for six weeks without pay.

I realized I didn't want a career in the semiconductor industry because it was too cyclical, so I came back to Chicago, where I started my career with Eaton Corporation as an applications engineer in industrial controls. The company funded my master's in business administration and with that, I wanted to be CEO and champion of the world. That dream was squashed pretty quickly (laughs). So, I switched gears.

My parents are both first-generation German immigrants and "forced" us to attend German school on Saturdays, which I hated at the time. But I searched for entrepreneurs in the Chicago area that could use my German language skills and found a startup in the secondary plastics processing equipment industry—working for a European-based plasma and corona treating and static control systems company. I did that for 10 years. I learned to love small business

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because you can make decisions rapidly as opportunities or problems come up. We had to package up our own products and send them out via UPS to customers, but it was a really fun job.

I was able to leverage my German experience again, this time with my MBA and some industry knowledge. as I looked for a new job. I traveled to Europe frequently, speaking German to my Danish and German counterparts. I really loved small business, but when the owner died, and his daughter took over, it just wasn't fun anymore.

I think that's when you started to pivot and BEST came into the picture. Tell me about that.

Wettermann: At first, I went to a publicly traded company, Woodhead Industries, where I learned all about corporate decision-making, decision by committee, and so forth. I stuck that out for five years, saved my nickels, then bought BEST.

My father was an entrepreneur, and I started my entrepreneur career with BEST which was right down the street from my childhood house, with eight employees performing contract rework and repair services as well as some solder training.

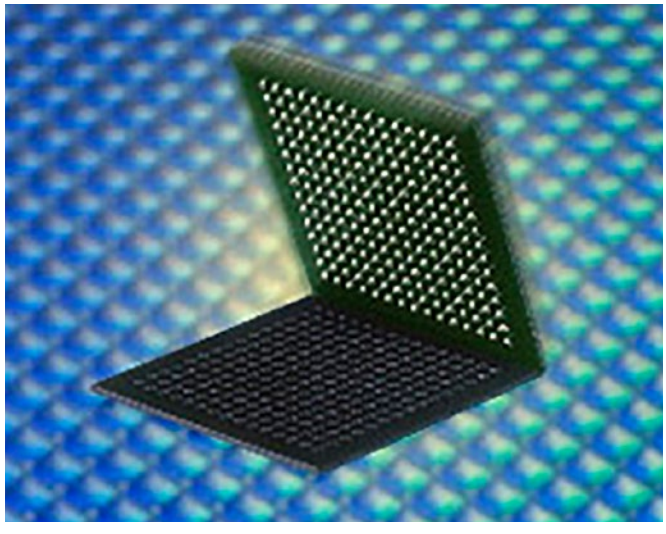
You've seen much change in the industry, and I'm sure you have some stories to tell. What was it like when you started?

Wettermann: The printed circuit board industry looks very different today from when I came into it. When I first bought the company around 2000, I looked at the Midwest to see how big the market was. Market data indicated that the total number of component placements on PCBs in the Midwest were centered in Chicago. I thought, "Chicago is the electronics hub of the Midwest. This is great."

That was before Motorola and many other communications suppliers moved out, and the business of printed circuit boards was offshored. When I started with BEST, close to 25% of the world's electronics were made in the U.S., but it soon went down to 12–15%, so with that offshoring, we had to go and find new BEST customers.

What does BEST look like today?

Wettermann: We have 32 people on staff, some of whom work offsite. We do training services, rework and repair services, and have many products that help companies repair and rework products themselves. We are proud to sell these all over the world.



EZReball

You were doing some analysis 23 years ago as you stepped into your role at BEST. How did you and BEST adjust to those changes?

Wettermann: Most of our customers at the time of the purchase were within 300 miles of our doorstep. Now our reach—at least on our services and training business—is anywhere in the United States, because clients can economically ship their boards from any location.

With training services, we have a unique service offering for our solder training business as we bring everything with us in a mobile training vehicle The previous owner convinced a friend to loan him the money to

Mobile training center.

buy a Winnebago, and that's how he started the company. He outfitted it with soldering stations, and he drove around the Midwest to perform the training. We have done the same since that time and BEST now has an 18-wheeler with the same functionality on board.

The BEST training business has changed dramatically. With online training, we have clients as far away as India, Pakistan, and Europe. While some training might be in the middle of the night for us, we don't have to travel halfway around the world, thereby saving the customer money.

Is that part of your business still in high demand? It would seem to be, given the need for additional hiring and the staffing dynamics EMS companies are facing right now.

Wettermann: We've become an extension of human resources departments for select EMS companies, primarily in the mil-aero and Class 3 environments. In one case, we have a large contract with an EMS company in the military space where our students are brand-new to the company on day one; on day two they get sent through our training vehicle. We see if they show up every day and how they respond to training. Do they have hand-eye coordination skills, and can they grasp some new terms from day zero to day five? We help the client screen who should be kept in the role of a soldering technician. Finding trained individuals to run the machines or engineer the processes—soldering, in our case—is a skill set that is long gone, since the ones who were good at it have mostly retired.

It's interesting that you're part of the hiring process. Bring them in on probation, then work them through training to make sure that they can actually do the job.

Wettermann: During the last three years, it's been very difficult to find trained personnel, so we hold on to those people. We've taken people from different industries and retrained them. They're great soldering techs; they can solder micro-wires inside of hearing aids, for example, but they've never seen a circuit board. They have the hand-eye skills, the skills for the fine work and the detail, and the patience required. They know the basics of soldering, but we have to teach them what a circuit board is. You have to get creative with respect to hiring, which is a big challenge in our industry.

When you asked about what has changed, here's an example: When we used to advertise job openings, we received 30 to 40 responses. You put an ad out now and you're lucky to have anybody call.

Why do you think that's the case?

Wettermann: Is it a job anybody really wants to do? It's tedious work. There are people who have the skills, patience, and acumen to do that, but it's a rarity. What has changed? The workforce and electronics are just very different; it's become a more international workforce.

Bob Wettermann

Does that multilingual aspect add some complexity to your onsite training?

Wettermann: In some cases, interpreters are required to facilitate the training, and there is a lot more over-the-shoulder instruction, which makes it more complex.

You have been a long-time columnist with I-Connect007 and a great technical resource on how to do rework. What was your experience as a columnist like?

Wettermann: We repair circuit boards. Our customers never come to us for the easy projects that they can do themselves. So, we come up with novel techniques to facilitate the rework and repair to solve customers' problems. In doing so, we see things that are not necessarily covered in any specification. Typically, IPC-7711/21 (Rework, Modification, and Repair of Electronic Assemblies) is five to seven years behind the times. That means BEST has to be a creative problem-solver.

Part of business is making sure your name is known and when you're a small specialty shop like ours, that's just part of the mix. I've presented a number of papers for IPC APEX EXPO and SMTA International along with our trainers. While I'm the spokesperson, the trainer is doing the soldering work. We've done technical seminars and webinars. You're seen as a resource. I get article ideas from our clients, and from the feedback on my column. It's fun to write these articles. I also had the opportunity to write a children's book five years ago, which was fun. It combined illustration with very basic storytelling; I enjoy writing.

When the time comes to tell an interesting story about the industry, what will you choose to tell?

Wettermann: I will tell stories about design, manufacturing, and repair worldwide. Probably the most fun I've had was with Research In Motion, in Waterloo, Ontario, Canada, that used to be a large client for BEST. They hired staff from all over the world who were integral in increasing the manufacturing volumes. It's probably the most fun we had with a project. When we would finish with our business, we went across town and socialized with them. I have met so many really interesting people from all over the world because I was fortunate to work in the electronics industry.

Motorola was 80% of the business early on in BEST's history. Those engineers loved to come over at 3 or 3:30 p.m. Fridays, drop off a board, and tell us what they needed done. After we got through with our technical discussion, they would sit in the office telling stories; we would crack open a beer from our mini-fridge and talk. Suddenly, it's 5:30 p.m., and my wife is calling to see where I am at. I'd tell her, "I'm working with a customer," which really was the truth.

I can imagine your phone call home, "Honey, those Motorola boys are here again."

Wettermann: Some of them came with motorcycles in the summer, so we developed specialty motorcycle packaging. It had extra foam around the box. We would use a bungee cord to hook it onto the back of their carrier and it didn't damage the board.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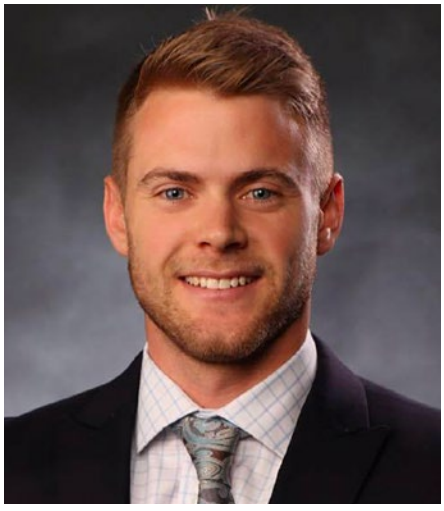
Those must have been fun times. As you move on, what advice do you have for the industry?

Wettermann: Make sure that you stay up on technology because everything has an IP address at this point, and electronics is just exploding in so many fields we haven't even thought of yet. The average automobile has over 100 CPUs on board. Take a look at non-traditional places for electronics: cycling clothing which will monitor my heart, blood pressure, and muscle strain, for example. We will have electronics embedded in all sorts of things.



Nash Bell

Your column and your business have been so valuable to the industry. It's not going away, is it?

Wettermann: Our business is actually scaling up. A family-run financial group from the Chicago area with a lot of operating experience, bought the business. Nash Bell is my successor, and he has many experts available in marketing, finance, and machining to help. There are a lot of contacts that the company brings. They will move BEST to the next level; they've adopted a well-known entrepreneur operating system for monitoring and moving companies forward.

Nash, it's great to meet you. How will you fill the vacuum that Bob leaves behind?

Nash Bell: It's exciting right now, especially with Bob staying on board for bit, so I can learn under his wing. He has accumulated so much knowledge over the years. The circuit board space is still somewhat new to me and it's nice to have as many resources around as possible.

My background is in healthcare; I was a physical therapist, opening and managing various clinics around the country, so I have quite a bit of managerial experience. It's been a steep learning curve over the last couple of months to get my bearings in this space. This team has unbelievable people doing the rework and repair. We have excellent, well-seasoned trainers who know exactly what they're doing. Bob assembled a fantastic team. BEST will continue to run while we determine new directions.

What's your agenda for the first year?

Bell: We want to put in some internal processes, making our in-house data rock solid. We want our people in positions where they can be as successful as possible. We've worked really hard at finding additional workers. I know that's something that has been a struggle over the past few years, especially since the pandemic.

The industry is always changing, so we will be keeping our eyes open for opportunities. Are there other avenues that we can pursue if we find something that fits our skill set? Our goal is to have a strong foundation in understanding where BEST fits before we take off in any new, different directions. We want to make well-educated, well-researched decisions before changing too much too soon.

Will you be carrying the column forward?

Bell: It won't be me, but I know the value of our column, and we have some writers in mind.

Bob and Nash, thank you so much. It was a delight.

Wettermann: Thanks again for all the years, and all the "best" to you. **SMT007**

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MilAero007 Highlights

NextFlex Launches $4.4M Hybrid Electronics Funding Opportunity ▸

NextFlex, America's Flexible Hybrid Electronics (FHE) Manufacturing Institute, released Project Call 8.0 (PC 8.0), the latest call for proposals that seek to fund projects that further the development and adoption of FHE while addressing key challenges in advanced manufacturing that support Department of Defense priorities.

IPC Welcomes U.S. Presidential Determination Prioritizing Domestic Development of Printed Circuit Boards and IC Substrates ▸

IPC, the global association representing the electronics manufacturing industry, welcomes the action of U.S. President Joe Biden in issuing a "presidential determination" that prioritizes the domestic development of printed circuit boards (PCBs) and advanced packaging, including IC substrates, under Title III of the Defense Production Act (DPA).

American Made Advocacy: A Collective Stake in American Microelectronics ▸

Recently, hundreds of thousands gathered in Las Vegas for the annual Consumer Electronics Show, where amazing new tech was rolled out—everything from razor-thin TVs to smart robots that clean your home. As an executive in the materials science space, I was struck not just by the pace of innovation, but also by the incredibly complex supply chains that were necessary to bring those products from the drawing board to reality.

Hughes Circuits Earns IPC-1791, Trusted Electronic Designer, Fabricator and Assembler Requirements QML ▸

IPC's Validation Services Program has awarded an IPC-1791, Trusted Electronic Designer, Fabricator and Assembler, Requirements Qualified Manufacturers Listing (QML), to Hughes Circuits Inc., located in San Marcos, California.

Insulectro and LCOA Install R&D Lab With Partner Kyocera in Orange County ▸

Insulectro, the largest distributor of materials for use in the manufacture of printed circuit boards and printed electronics, has opened a testing and development laboratory for Kyocera tools in its Lake Forest, CA headquarters. The Lab was created in association with backup and entry materials manufacturer LCOA™ in that company's plant.

Fresh PCB Concepts: PCBs for Harsh and Extreme Environments, Part 1 ▸

At the end of 2022, NCAB's Ryan Miller completed IPC's six-week IPC training certification, PCB Design for Military, Aerospace and Other Extreme Environments. This in-depth course provided him with the knowledge and tools to provide support to customers who are designing within these harsh and/or extreme environments.

IPC Issues February Economic Outlook Report: Economic Data Provides a Mixed View of the Economy ▸

Economic data over the last month is providing a mixed view of the economy per IPC's February Economic Outlook report.

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Package on Package Rework—Skill Required

Knocking Down the Bone Pile

by **Bob Wettermann,** BEST INC.

Editor's Note: Though this may be Bob Wettermann's last installment of Knocking Down the Bone Pile, Bob's column will carry on under the expert guidance of the subject matter experts at BEST.

Package-on-package (PoP) is an electronic component-stacked package type consisting of vertically stacked ball grid arrays most commonly in a two-high stack. The package closest to the board is the logic/CPU component and is more commonly known as the "bottom" package. The "top" package sits on top of this module and is the memory module. These packages are generally found in consumer electronics (mobile devices) such as smartphones, tablets, and netbooks. These packages tend to be high IO count, fine pitch, very thin packages.

The rework and subsequent inspection of such components requires precise control of temperature as well as skilled repair and rework technicians and a broad understanding of a variety of materials that will be of assistance in reworking PoPs.

There are numerous challenges to reworking these components, including but not limited to the following:

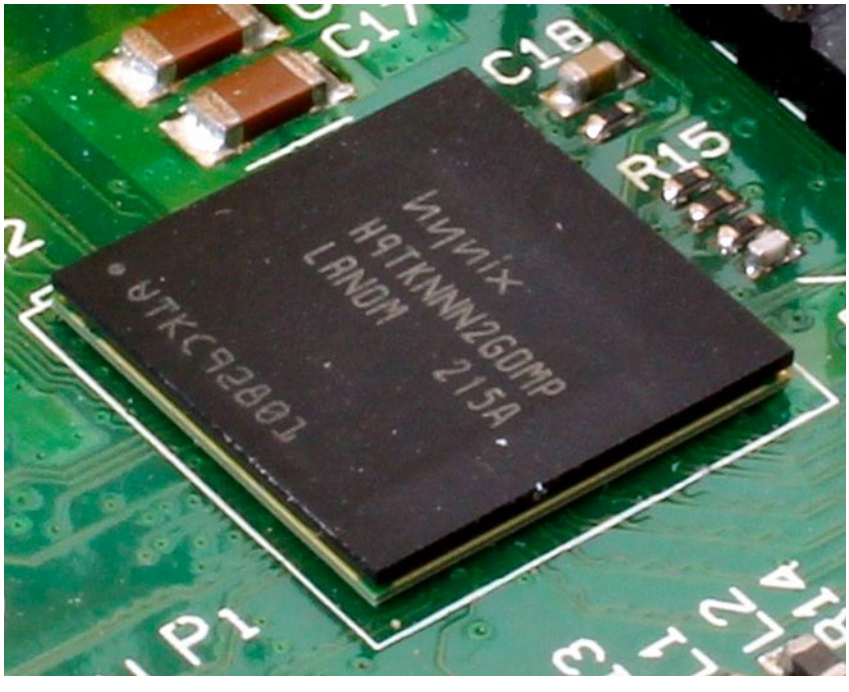

Figure 1: Package on package (PoP).

- Due to the thin sizes of the packages (they have to fit into a slender consumer package in most cases), the thermal stresses of the reflow cycle can cause warping of the packages. This can lead to opens and shorts post-rework.
- Many of these consumer devices are underfilled in order to prevent solder joints from cracking, as the handheld devices are prone to the mechanical shock of being dropped. The removal of such packages using a heat source causes the solder to be pushed around, creating soldering anomalies such as shorts.

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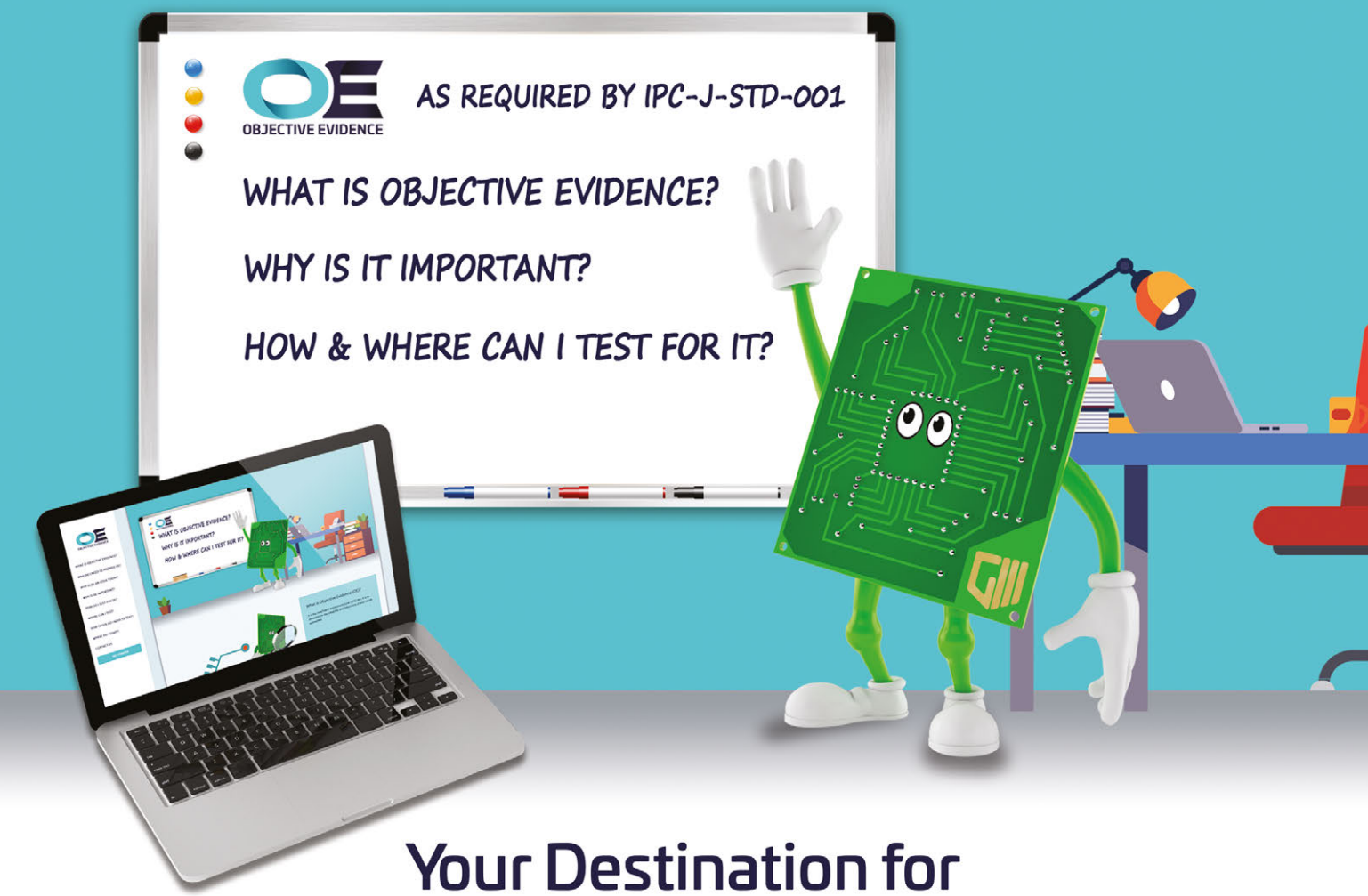

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- Inspecting the multilayer-stacked packages means that more advanced X-ray systems and more experienced operators are required for inspecting the packages post-rework.
- The thin packages mean the packages have high MSL (moisture sensitivity levels), which requires a high degree of care.
- Many of these packages are underneath or near RF shields, which in and of themselves are challenging to remove and replace without damaging underside or neighboring components. Many times the proximity of underfill or components to the shield wall can cause challenges of neighboring components being negatively impacted during the rework process.

The BGA rework equipment needs to be properly adjusted in order to maintain the proper profile when reworking these stacked packages. If the top package to be singled out is to be removed and replaced, then the rework system must have the ability to precisely control the hot air time-temperature profile in order to reduce the possibility of package warpage. These PoP-capable rework systems need to have a zero force or near zero force removal capability in order to not disturb the lower package if the upper package is the one requiring reflow. Since many of these component packages are small, the optical split vision system—along with the BGA placement system—must be able to precisely place the component. In addition, the BGA re-work system should be equipped with a non-contact scavenging system for more consistent results in terms of site preparation. In the case of underfilled components, the low or no heat "cold" removal machines—which could be lasers or milling machines—will be key to a successful rework program. Furthermore, the X-ray inspection used to check the rework should have the ability for isometric viewing. This allows the rework technician to inspect the PoP and "see" each of the balls on the individual layers. These are some of the critical rework tools for reworking on PoP packages.

Not only does the equipment need to be capable of reworking stacked packages, but the right experienced engineering and technician support needs to be available. Experience in the nuances of time-temperature profile development, along with the experience of using the right paste fluxes or dipping solder pastes, is part of getting to a robust rework process for the PoPs. The technicians need to be experienced in mitigating the effects of component warpage caused by the heating during placement and removal. Furthermore, the rework process technicians should be very disciplined in properly handling the components given higher than normal MSLs. One of the other decisions that needs to be made in the complete rework process is PoP testing. Experience will help guide the functional testing and whether the PoP should be tested prior to being placed or be tested in-circuit to confirm functionality.

In addition to the right equipment set and the right operator experience, the rework supplier must have a deep understanding of a variety of different materials for PoP rework. In many cases, "dippable" solder paste is used for the individual package rework in order to ensure more consistent solder paste deposit volume, which widens the process window. There are a variety of fluxes which can be used to make

Figure 2: Physical damage to PoP will require rework to be performed.

sure that longer rework cycles do not cause the activity level of the fluxes to expire. In some cases, specialty chemicals are required for removal of the underfill materials. Experience in their usage and disposal is important. Finally, the right saponifiers for cleaning underneath and in between the various layers is important for removal of the flux residues. In some cases, the bottom component is temporarily glued to the PCB so as to not have the component shift during reflow cycles. This requires experience with different electronic grade glues.

PoP rework requires the right rework experience in terms of process engineering, the right equipment set to develop a repeatable process with the widest possible operating window, and knowledge of a broad set of materials.

Note: This is my last column on PCB rework and repair. I am fortunate to be moving on to Life 3.0—helping others—and no longer be developing PCB rework/repair processes and products or writing about the same. Thank you to all the readers who have been alongside me in this journey. **SMT007**

Bob Wettermann is retiring as the principal of BEST Inc., a contract rework and repair facility in Chicago. For more information, contact info@solder.net. To read past columns, click here.

Michael Ford: My Best Career Advice

Barry Matties: What do you believe is the best advice you have received over the many years you have been in this industry?

Michael Ford: It didn't seem like good advice at the time, but it was, "Never fall in love with your product." I say "product" loosely, because it can be anything that you have achieved or accomplished. The natural result is that you tend to think that what you have done is brilliant, which may hold up when you measure it against the initial set of conditions that you had, but the needs of tomorrow are always changing, with each small change potentially needing the solution to become completely different. Every achievement we make drives the opportunity for the next. I have found it better to never lament on things gone by, but to always look at things as stepping stones to the next. You have to be open-minded, let go, and reinvent the way you think about things. This involves encouraging input and advice from others, encouraging them to be involved, and to gain a greater context in the ways that things need to be done. Always remain flexible and keep moving forward.

Matties: Did you get that advice early in your career?

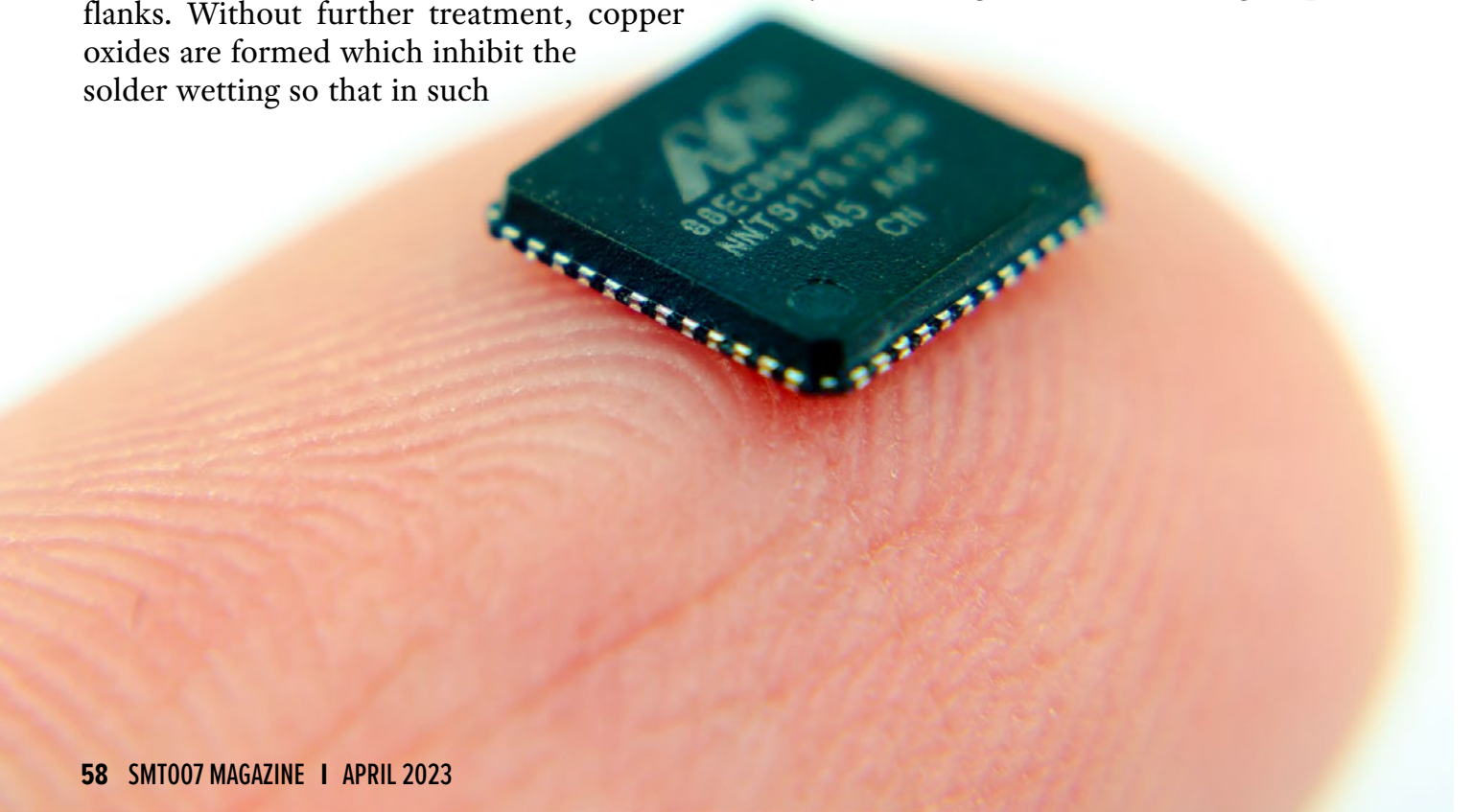
Ford: Relatively so. It was related to the company I was working for, where we self-developed a corporate MES (manufacturing execution software) solution. MES was novel at the end of the 1980s; I think we were one of the first to ever develop such a tool, and it went on to become a semi-commercial product. There comes the time, however, where you can only do so much with a small group of developers within a manufacturing organization who are absolutely brilliant in what they have achieved but were not supported on a proper commercial or professional basis. Without the resources to do that, you learn that all that you've achieved with your team over many years will ultimately be replaced. You must put that in a positive light, but it's tough. It makes you stronger, and more appreciative of those around you. There are many who just don't get the support for making that kind of change. As long as the change happens at the right time, and you take it in the right way, you realize that it is a growing moment, and you move on to the next challenge.

Immersion Tin Plating for QFN Wettable Flank Connections

Article by Britta Schafsteller, Hubertus Mertens, and Gustavo Ramos
ATOTECH

Immersion tin is a surface finish which is well established in the PCB industry and well trusted in the automotive industry due to its high reliability. In the automotive market, the use of QFN (quad-flat no leads) packages become of increasing interest due to their flexible form factors, size, scalability, and thermal dissipation capabilities[1]. One step for success has been the side-wettable flanks, which provide a reliable solder joint connection to the PCB and enable an automated inspection of the solder joint and solder joint quality. The bottom side of the QFN is usually covered with electrolytic tin, and the exposed areas with the copper flanks require additional treatment to enable the solderability of the flanks. Without further treatment, copper oxides are formed which inhibit the solder wetting so that in such cases only two-dimensional solder joints are formed. To achieve a better reliability, the industry investigates solutions to increase the wettability of the flanks leading to the formation of three-dimensional solder joints.

In QFN manufacturing, the final step is a singulation step which can be either dicing or punching. During this step the flanks can get contaminated by tin smear or molding residues which stick on the surface and cannot be removed with standard pre-clean systems for PCBs. Therefore, the cleaner and microetch have to be specifically tailored to remove tin and mold residues and level the copper alloy of the lead frame material. In Figure 1, the copper alloy surface right after the dicing step (a),



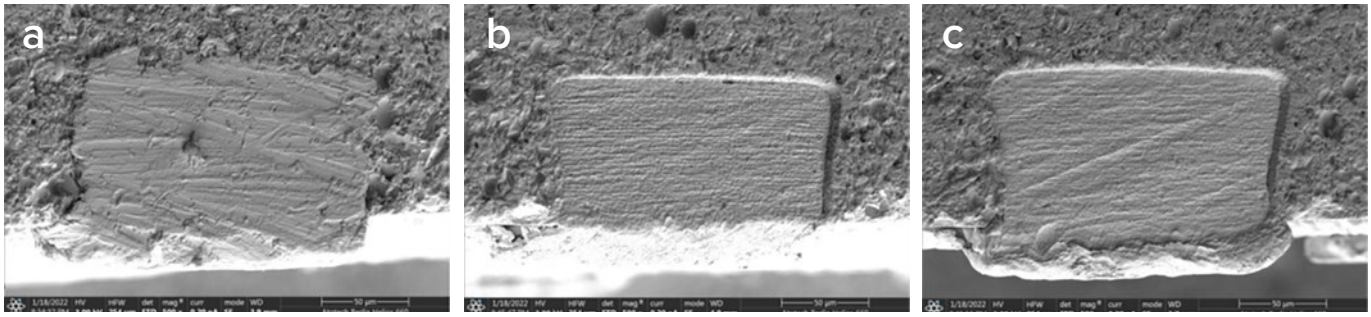


Figure 1: Pretreatment and tin plating of QFN side flanks: a) After QFN singulation; b) After cleaning and microetch; c) After tin plating.

after the cleaning step is shown. The cleaning includes a pre-clean and the microetch step (b). The last one shows the side flank after tin plating (c).

After the precleaning, the copper surface appears even; scratches and smear residues from the separation process are removed. In the immersion tin plating process, the side flanks are covered with the immersion tin forming a dense tin layer covering the full pads on the QFN side wall. After the tin plating process, post-treatment solutions can be applied to prevent any discoloration of the tin layers in the later assembly processes and create a hydrophobic surface for an additional protection of steam aging.

To confirm the capability of the tin layers to improve the solder wetting and enable

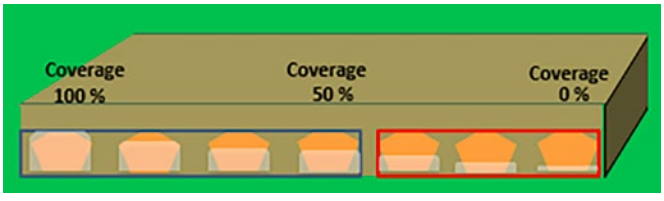


Figure 2: Acceptance criteria for solder wetting of QFN side flanks.

the formation of the three-dimensional solder joints, the solder wetting is tested by immersing the QFN coupons into liquid solder and evaluating the surface coverage of the side pads with solder. The coupons are dipped into the solder with an angle of 45° for five seconds. This test is performed after a thermal pre-aging of eight and 16 hours at 150°C and a steam aging test at 93°C for four and eight hours. Figure 3 shows the performance of an immersion tin

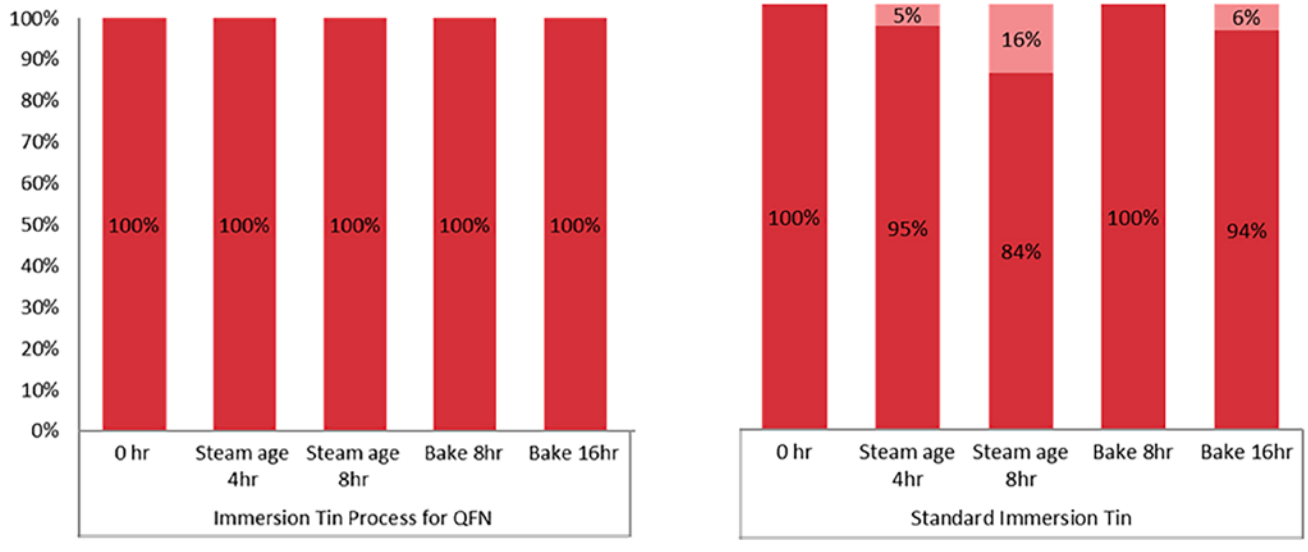


Figure 3: Solder wetting of the QFN side flanks with different immersion tin finishes.

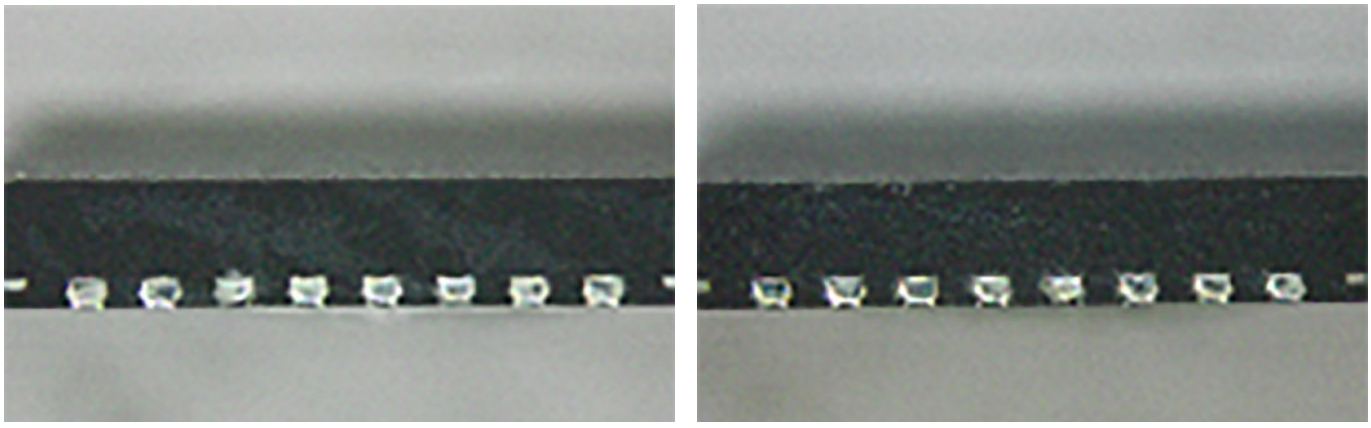


Figure 4: Exemplary images of the solder wetting after 16 hours of baking at 150°C (left) and eight hours at 93°C/93% RH (right).

process dedicated for QFN plating compared to a standard immersion tin process for PCB applied on QFNs.

The pads with a solder coverage of minimum 50% and larger are acceptable, the pads with a coverage of less than 50% are rejectable. Exemplary images of the soldered side flanks are shown in Figure 4. The image shows the soldered pads after 16 hours of baking at 150°C and after storage for 8 hours at 93°C and 93% relative humidity.

The results confirm that the immersion tin process designed for the QFN side flanks can achieve a significantly better soldering performance than an immersion tin process for PCBs adopted for QFNs.

As during the aging of immersion tin layers, the thickness of the intermetallic compound (IMC) increases and leads to a lower content of free tin; this often is considered as critical for the solderability of the tin surface. Storage tests have been conducted to study the growth of the intermetallic compound over time depending on the substrate alloy. For this the tin layer has been plated on EFTEC 64T and C194 alloy. The composition of the two alloys is given in Table 1.

For all conditions, an overall thickness of 1.5 µm tin was deposited and subjected to thermal and steam aging at 150°C and 93°C, and 93% relative humidity. The results of the IMC and free tin thickness are shown in Figure 5—the thickness is stated in µm, where pale blue reflects the free tin and dark blue the IMC.

The results show that the IMC formation is driven by temperature in the first place. The IMC growth is linear over time for the storage temperature of 150°C. After four hours at 150°C, approximately half of the tin thickness is consumed by IMC. The IMC formation is slower for the humidity aging at 93°C where, at the same time, about 40% of the tin layer is converted to IMC. It also shows that even after 16 hours at 150°C, 25–32% of free tin still remains to ensure good solderability. The impact of the alloy material is low and leads to approximately 10% more free tin on the EFTEC 64T material.

The tin deposit on the side flanks provides good solderability even after thermal or steam aging which correlates with sufficient free tin remaining after the IMC formation. The single

Table 1: Alloy composition in % w/w

	Cu	Cr	Sn	Zn	Fe	P
EFTEC-64T	99.25	0.3	0.25	0.2		
C194	Min 97			0.05-0.2	2.1-2.6	0.015-0.15

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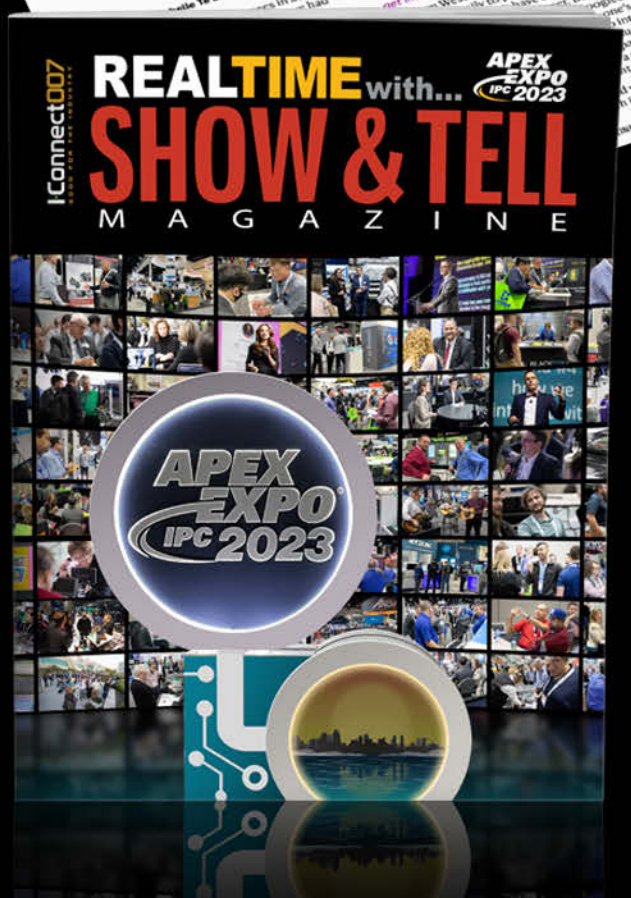

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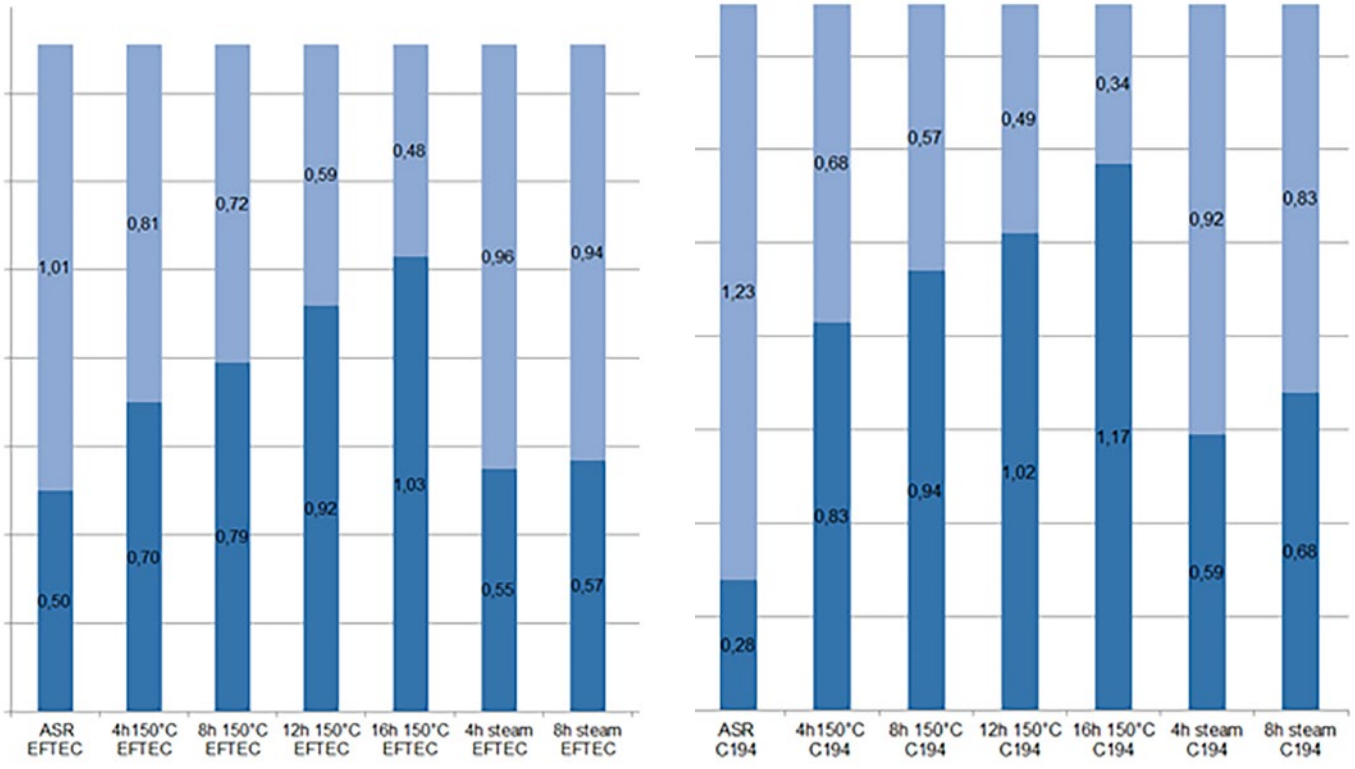

Figure 5: The results of the IMC and free tin thickness (stated in µm.)

process steps were checked for their impact on the electrolytic tin deposit of the QFN bottom pad; no negative impact could be detected. To prevent the formation of whiskers, which are a known risk for immersion tin deposits, an anti-whisker additive is introduced which deposits at the grain boundaries of the tin deposit and inhibits the formation of tin whiskers. **SMT007**

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1. "Side Wettable Flanks for Leadless Automotive Packaging," by M.A. Mangrum, Semiconductor Engineering Whitepaper, Oct. 10, 2020.

Calculating Operating Costs

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. In this episode, Sue and Andy have just returned to the Upper Valley of Vermont and are out for a walk.

"It was really a great idea to take a break and walk through Woodstock," Sue said; Andy replied, "I really like the 1800s New England vibe."

After 45 minutes of walking through this delightful village, they both felt the need for a treat, so Sue said, "Let's go to the Mountain Creamery and get some ice cream."

After a short drive to this legendary restaurant, they were served their ice cream by Tina, who started up a conversation with her customers by asking, "What brings you two handsome youngsters to visit us?"

Sue and Andy then regaled Tina with their stories of visiting Castellanos Electronics in Mexico and their need to take an afternoon date to Woodstock for a break.

After they finished their frozen treat, Sue took out her phone and checked her email. Both were surprised that this modest restaurant had good Wi-Fi.

"Hey, we agreed—no looking at phones on a date," Andy teased.

Sue jokingly stuck her tongue out and they both laughed.

"Whoa, we got an email from Professor Coleman," Sue said, feeling a little nervous.

"Yikes," said Andy as he searched for the email on his phone as well.

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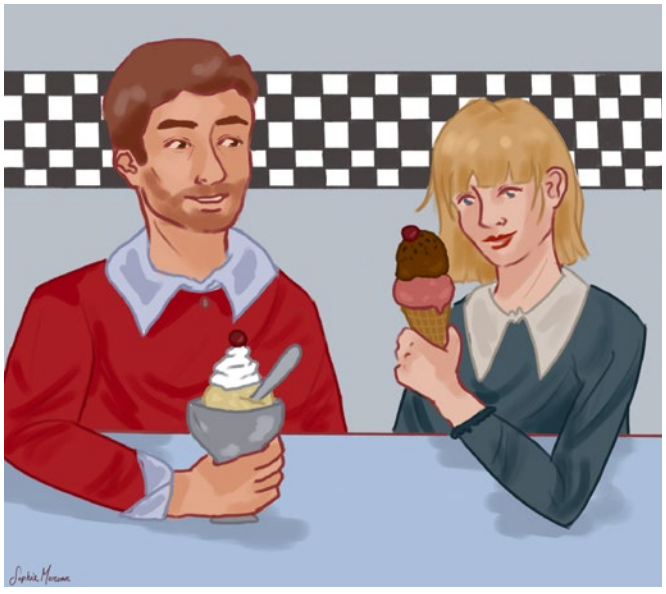


Professor Patty Coleman is widely known as a pleasant and supportive mentor, but when you have just transferred to Ivy University from a two-year community college, you might be intimidated to receive an email from one of Ivy U's most famous profs.

"Well, she says she has an exciting assignment for us if we're interested," Sue said. "Whew," Andy said. "So, what's the next step?"

"She wants to see us," Sue answered.

A few days later, Sue and Andy were on the hallowed campus of Ivy University, walking up the steps of Newton Hall, named after the famous scientist.

Still a little nervous, they knocked on the door of Professor Coleman, who opened her office door, and welcomed them in. "Come in, you two. I've heard great things about your work in Mexico," she said.

After a few moments chatting about their work at Castellanos Electronics, Patty quickly brought up the reason she had asked the pair to stop by.

"One of my friends from my undergraduate days at Tech has just purchased an electronics assembly company, similar to Benson Electronics. His business is a little slow and he found a long-term project wiring some separate modules together. It is a little bit like wiring a stereo system together, but more complicated. The workers also must wire and assemble the components in a larger housing. Because it is so dissimilar to assembling electronic circuit boards, my friend wants to charge for each hour that is spent on the work," Patty explained.

"That seems reasonable," Sue commented, as both nodded in unison. "So, how do we fit in?"

"My friend doesn't know how much he should charge per hour," Patty responded. "You are going to tell him."

"We don't know anything about this topic," Andy said.

"That's terrific," Patty said, chuckling. "So, you have a lot to learn then. And don't worry; I'm going to coach you. To help you develop the right skills for this assignment, I would like you to visit an auto repair shop."

"What does auto repair have to do with wiring electronic modules together?" Andy asked.

"Nothing," Patty said, chuckling again.

The wheels in Sue's head were turning as she began to make the connection. "I think I'm getting it," she said. "It's a successful business that charges for the time that the auto technicians work. The charges per hour should be developed in a similar manner for wiring modules."

"Precisely," Patty answered.

Andy and Sue were young enough that they didn't have much experience in getting their cars repaired, so they didn't know much about repair costs.

"What do you think an auto repair technician is paid per hour?" Patty asked.

"We are paid about $22 an hour at Ivy Benson," Andy replied, then queried, "An auto tech is likely higher skilled than us, so maybe $30 an hour?"

Sue pulled out her phone and did a quick internet search. "That's just about right," she exclaimed.

"So, how much do auto repair shops charge?" Patty asked again, and Andy suggested it might be about $45 an hour.

"Well, we'll see if you're right," Patty said about their intended visit to the repair shop. "Sam Grabowski is expecting your visit. He is very open and will help you to understand why he charges what he does."

Two days later, Andy and Sue were at Sam's Auto Repair and were greeted by a very large, cheerful man with a red beard.

"Sam's the name, but everyone calls me Bubba," he said with infectious enthusiasm. "Professor Patty wants me to help you youngsters understand how a small business develops its labor rate."

"We are curious," Andy said, "how you came to know Professor Coleman."

"My daughter Monica was a student of hers," Bubba said. "Professor Patty suggested that Monica's class do a group project to help understand how a small business is run. Monica offered my shop as a case study."

"I love that idea," Sue replied.

"I never thought I could teach anyone at Ivy U about anything, but I think they learned a lot by studying my shop," Sam/Bubba said. "The students even offered some suggestions to improve productivity. I implemented them and it has helped quite a bit. As a result of that project, I got to know Professor Patty quite well."

"Our main task is to determine how you developed your hourly rate for your auto repair techs," Andy shared.

"Okay, so I need to explain a little about the business and I will not give you the answer. You need to tease it out from our discussions," Bubba replied.

"Sounds like a plan," Sue said.

He began to explain, "I have 20 auto techs and I pay them $30 an hour. We not only repair, but also can replace tires and batteries. We have a small quantity of common tires, batteries, parts, and supplies. I can get most things I don't stock in a couple of hours."

"With benefits, they must cost more like $35 an hour?" Sue said, and Bubba quickly replied, "More like $48 an hour. Medical insurance, Social Security, Medicare—it adds up and they get two weeks' vacation."

"So, you charge about $55 an hour?" Andy asked.

"Don't forget rent for the building, equipment, and supplies for the restrooms, etc.," Bubba said. "Like I said, it adds up quickly."

Sue had been quiet as she contemplated the costs and how much Bubba had to charge. "So, your cost is maybe in the low $50s?" Sue asked.

"How about paying me? I'd like to earn at least $100,000 per year," Sam said.

"So that adds at least $2.50 per hour," Sue suggested.

Bubba was impressed as he could tell that Sue quickly divided $100,000 by the 20 auto techs and then by 2,000 hours in a work year.

"So now we are at mid-$50s to even low $60s an hour," Andy said with a noticeable sigh.

Bubba continued to add in more costs: "Who answers the phone, balances the books, makes out the payroll, and orders parts? I have four workers who would be called 'indirects' in a factory that do these tasks," Sam summarized.

"Now it seems like you need to charge somewhere in the mid-$60s," Andy said, and Bubba confirmed that it was actually about $67 per hour.

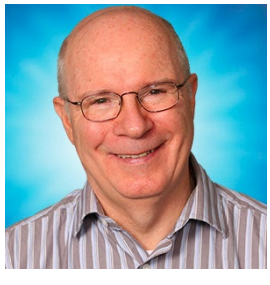
"So, even though you pay your auto techs $30 an hour, each hour they work costs you $67?" Andy said, continuing the conversation.

Who answers the phone, balances the books, makes out the payroll, and orders parts?

"Yep, I charge $78 an hour," Bubba concluded. "The profit goes to emergency and savings funds. I hope one day to buy this building with some of the savings. By the way, without this fund, making it through COVID lockdowns would have been tough." Professor Patty says that doubling what the workers are paid comes close to their total cost. Two times $30 an hour equals $60 an hour. So, that is a little low."

Sue and Andy thanked Sam and headed back to Ivy-Benson.

Now, how does all this relate to the cost of wiring stereo-sized electronic components and housing them? Stay tuned to find out. **SMT007**



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

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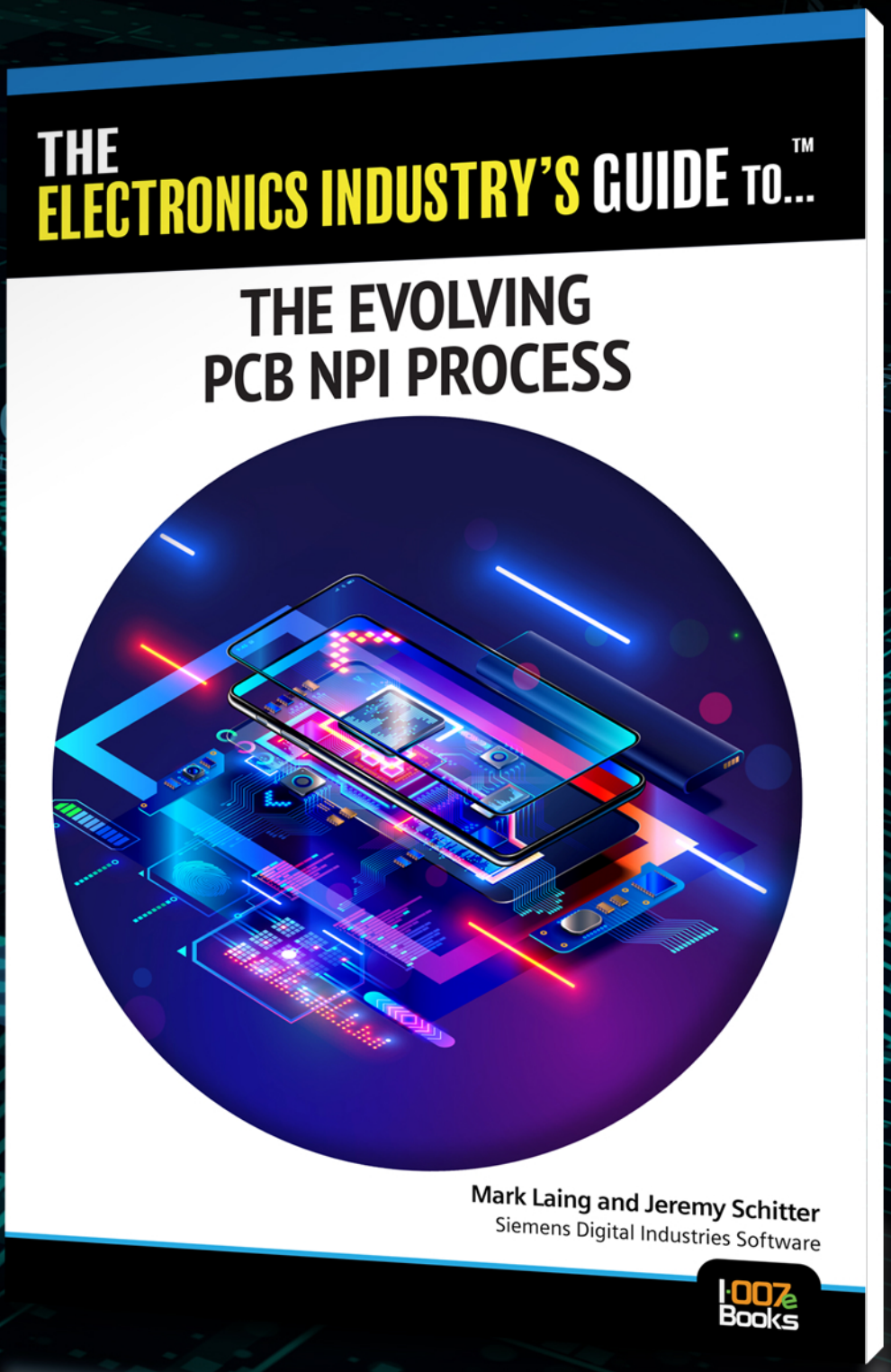

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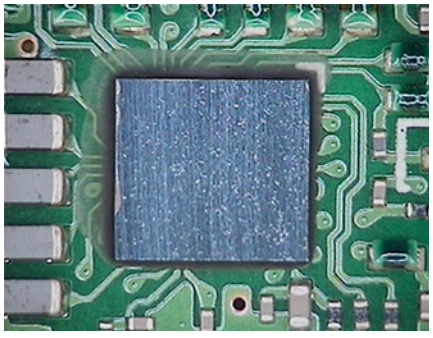


Knocking Down the Bone Pile: 2023's Top Challenges in BGA Rework

Over seven years ago, I put pen to paper to enumerate the top challenges needing to be overcome for a successful BGA rework. With the continued advancement of BGA technology, it's time to apply a fresh coat of paint to that list. Read on to find out my revised take on today's top BGA rework challenges.

I-Connect007 Launches New Micro Webinar Series: 'Smarter Manufacturing Enabled With Inspection Data'

In this engaging, 12-part micro webinar series, Koh Young topic expert Ivan Aduna examines the role inspection systems will play in the next industrial revolution. Viewers will learn about secure data collection, AI-powered solutions to manage and analyze data, and how to leverage IPC CFX-QPL to succeed in the transformation to Industry 4.0.

Smart Factory Insights: Differentiation, Community, and Composability


Michael Ford

Are progress and evolution in the industry driven by collective hive minds, business opportunity, and thought leadership, or is it just through random events? I believe it's all the above. The real question about progress is better related to the strategy of how we balance differentiation with our contribution to common industry goals that bring about business opportunity, and then how we apply that same strategy to the tools and services that we use.

Alpha Takes the Greenfield Route

Given that the launch of a new PCB fab is a rare occasion these days, we caught up with the senior team who is guiding the buildout of Alpha Circuit's brand new 44,000 square foot facility. They discuss what goes into equipment selection and line design, and the timing couldn't have been better.

Maggie Benson's Journey: The Finishing Touch

In our last episode, Sue was working on solutions to minimize solder defects that have been categorized in a Pareto Chart, whereas Andy was working on creating a training program to develop some process engineers and implementing an

improvement plan developed by Chuck Tower and José Castellanos.

Standard of Excellence: The Rise of NPI

There is no doubt that innovation is on the rise. The number of new products being developed post-COVID is staggering. Our OEMs are not only upgrading their current products, making them better than ever, they are also developing new products at a very rapid rate. But what does that mean for us? Will we continue sending our products overseas? Will be willing to join forces and find solutions? Anaya Vardya gives this idea some thought.

Darwin AI Evolving the Islands of Automation

When Canadian artificial intelligence company Darwin AI was founded in 2017, machine learning and deep learning were still relatively new terms. In the past five years, CEO Sheldon Fernandez and his team have been working with this technology to develop some foundational IP to simplify implementation.

A First Look at IPC-CFX Box for Legacy Equipment

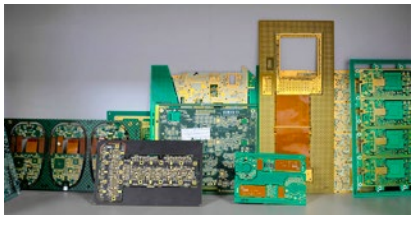
An A-Team under the IPC-CFX Standard Task Group spent the past year working on a project that provides simple, readily available IPC-CFX hardware with supporting SDK that can act as an IPC-CFX endpoint for existing legacy equipment.

NEOTech Recognized by Northrup Grumman for Supplier Excellence

NEOTech was recognized as one of the top suppliers for 2022 in Northrop Grumman Corporation's global network of more than 10,000 suppliers. They have earned the Strategic Excellence Award as part of Northrop Grumman's Supplier Excellence Awards to recognize top supplier partners.

The EMS 'State of the Union'

We recently heard President Biden's State of the Union address, and it got me thinking that perhaps now is a good time to look at our own post-pandemic "state of the union" in the electronics manufacturing services industry. I will describe several key issues that our customers around the world are facing as we move forward into a new normal.



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Mid-Atlantic Region

General Summary: Manages sales of the company's products and services, Electronics and Industrial, within the Mid-Atlantic Region. Reports directly to Americas Manager. Collaborates with the Americas Manager to ensure consistent, profitable growth in sales revenues through positive planning, deployment 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

pluritec®
MACHINES FOR PRINTED CIRCUIT BOARDS

Field Service Engineer
Location: West Coast, Midwest

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

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

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

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

Valid driver's license is required, as well as a passport, and major credit card for travel.

Must be able to travel extensively.

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ventec
INTERNATIONAL GROUP
騰輝電子

European Product Manager
Taiyo Inks, Germany

We are looking for a European product manager to serve as the primary point of contact for product technical sales activities specifically for Taiyo Inks in Europe.

Duties include:
- Business development & sales growth in Europe
- Subject matter expert for Taiyo ink solutions
- Frequent travel to targeted strategic customers/OEMs in Europe
- Technical support to customers to solve application issues
- Liaising with operational and supply chain teams to support customer service

Skills and abilities required:
- Extensive sales, product management, product application experience
- European citizenship (or authorization to work in Europe/Germany)
- Fluency in English language (spoken & written)
- Good written & verbal communications skills
- Printed circuit board industry experience an advantage
- Ability to work well both independently and as part of a team
- Good user knowledge of common Microsoft Office programs
- Full driving license essential

What's on offer:
- Salary & sales commission--competitive and commensurate with experience
- Pension and health insurance following satisfactory probation
- Company car or car allowance

This is a fantastic opportunity to become part of a successful brand and leading team with excellent benefits. Please forward your resume to **jobs@ventec-europe.com.**

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Career Opportunities

Technical Service & Applications Engineer

Full-Time — Midwest (WI, IL, MI)

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

Responsibilities

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

Skills and Qualifications

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

Benefits

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

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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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Career Opportunities

INSULECTRO

Are You Our Next Superstar?!

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

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

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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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Career Opportunities

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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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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Career Opportunities

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

YOUR JOB AD HERE

For information, please contact:
BARB HOCKADAY
barb@iconnect007.com
+1 916.365.1727 (PACIFIC)

I-Connect007
GOOD FOR THE INDUSTRY

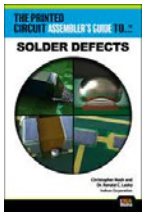
NEW WEBINAR! **On Demand: Free 12-part Webinar Series**

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.

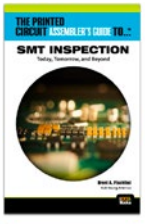
I-007eBooks *The Printed Circuit Assembler's Guide to...*



Solder Defects

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

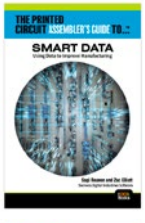
This book is specifically dedicated to educating the printed circuit board assembly sector and serves as a valuable resource for people seeking the most relevant information available.



SMT Inspection: Today, Tomorrow, and Beyond

by Brent Fischthal, Koh Young America

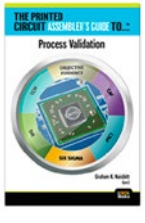
An in-depth insight into new and exciting true 3D inspection technology is provided in this book, along with a look into the future of leveraging big data management and autonomous manufacturing for a smarter factory.



Smart Data: Using Data to Improve Manufacturing

by Sagi Reuven and Zac Elliott, Siemens Digital Industries Software

Manufacturers need to ensure their factory operations work properly, but analyzing data is simply not enough. Companies must take efficiency and waste-reduction efforts to the next phase using big data and advanced analytics to diagnose and correct process flaws.



Process Validation

by Graham K. Naisbitt, Gen3

This book explores how establishing acceptable electrochemical reliability can be achieved by using both CAF and SIR testing. This is a must-read for those in the industry who are concerned about ECM and want to adopt a better and more rigorous approach to ensuring electrochemical reliability.

I-007eBooks *The Electronic Industry's Guide to...*

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.

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