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PCB007 MAGAZINE

Winning With TQM

A Distinct Evolution from DFM

Look Inside

"In an industry racing against time, MDD is the key to staying ahead."

Ammar Abusham
DFM Integration Engineer (AR EE Team)
Meta Reality Labs

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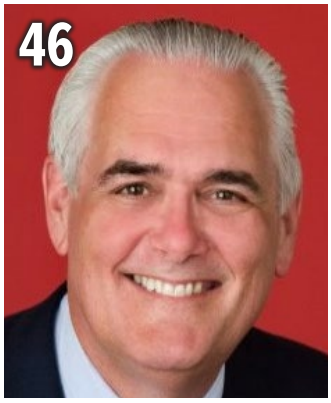
Winning With TQM

Continuous improvement never goes out of style and it starts with leadership. In this issue, we explore how TQM has entered the DNA of continuous improvement disciplines, and the role of leadership transformation. If you've ever competed against a TQM company, you understand their winning advantage.



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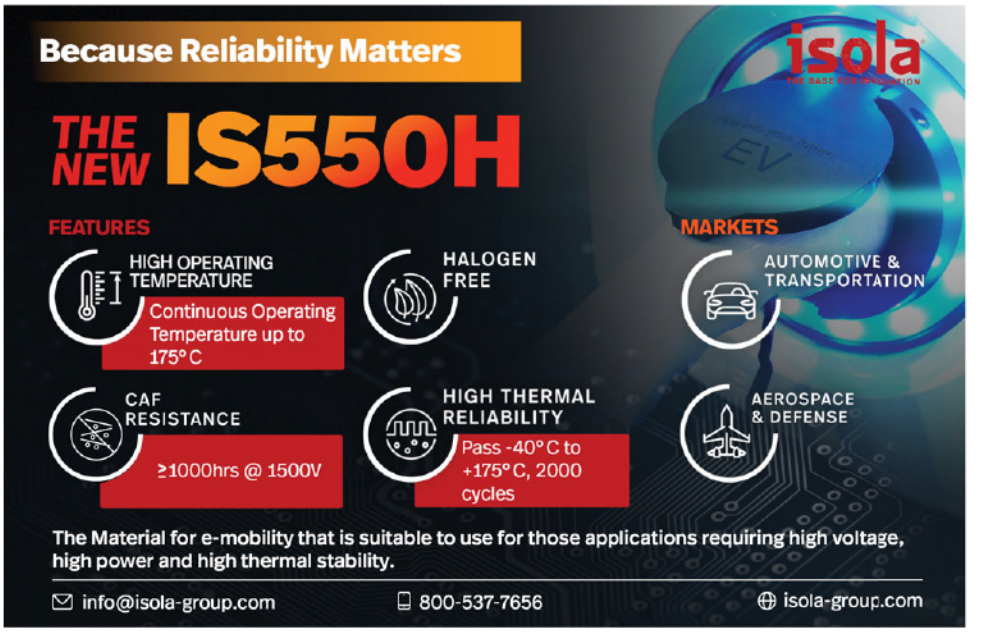

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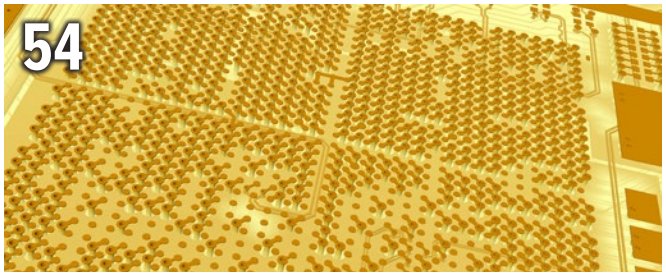

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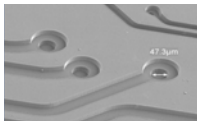

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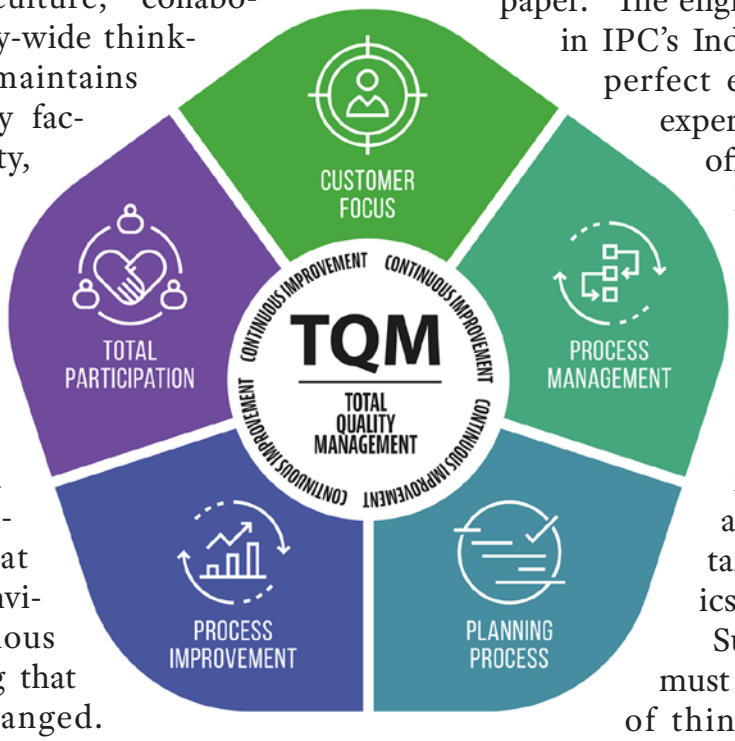
TQM: Always in Style

Nolan's Notes

by Nolan Johnson, I-CONNECT007

A new white paper from IPC titled "Electronic Design and Manufacturing Sustainably"[1] recently caught my eye, particularly because I just completed a podcast series with Siemens on the topic of sustainability as well as our June issue of *SMT007 Magazine* on sustainability in automation.

The white paper mentions common themes we see in discussions about sustainability, namely "leadership culture," "collaboration," and "industry-wide thinking." The author maintains that there are many facets to sustainability, all of which seemingly need to be addressed simultaneously. Furthermore, sustainability work is not a one-and-done sort of project. Have you heard of "greenwashing?" It's a term that means putting an environmentally conscious veneer on something that is otherwise unchanged. It's bad form to issue a press release just because you changed the type of light bulbs in your factory, for example. Sincere work in sustainability is an ongoing process, a prime example of continuous improvement within each of our companies, as well as across company (and political) boundaries. Recently, I saw a public service ad showing the before and after photos of a trash-covered beach, with the tagline, "It's not my garbage, but it is my planet." That is the kind of transformational thinking about our collective futures that sustainability will require.



"So many of our electronics manufacturing industry colleagues are talking more and doing more about sustainability for electronics," says Kelly Scanlon, IPC's lead sustainability strategist, speaking of the Siemens white paper. "The engineers who participate in IPC's Industry Intelligence are perfect examples of industry experts who saw a need to offer helpful resources. Expect to see more industry insights—from industry for industry—from IPC's Sustainability Initiative as we continue to build a community for those who are engaging on sustainability for electronics."

Sustainability is, and must be, an ongoing way of thinking. Sustainability has become a requirement, not an option. Continuous improvement is much the same—table stakes, not a differentiator. In Michael Porter's 1988 book, *Competitive Strategy,* he flat out states that operational efficiency is not a competitive strategy, and that you cannot optimize yourself into a dominant market position. Operational effectiveness is a requirement for being in business at all.

In Chapter 3, "Diseases and Obstacles," of his book, *Out of the Crisis,* organizational strategist Dr. Edwards Deming shares his Seven Deadly Diseases of Management[2]:

1. Lack of constancy of purpose to plan product and service that will have a market and keep the company in business, and provide jobs.
2. Emphasis on short-term profits: short-term thinking (just the opposite from constancy of purpose to stay in business), fed by fear of unfriendly takeover, and by push from bankers and owners for dividends.
3. Evaluation of performance, merit rating, or annual review.
4. Mobility of management; job hopping.
5. Management by use only of visible figures, with little or no consideration of figures that are unknown or unknowable.
6. Excessive medical costs. As reported by Dr. Deming in *Out of the Crisis,* executives shared with him that the cost of medical care for their employees was amongst their largest overall expenses, not to mention the cost of medical care embedded in the purchase price of what they purchased from their suppliers.
7. Excessive costs of liability, swelled by lawyers that work on contingency fees.

His list furthers the point: While still minding today's business, leadership must think long-term, beyond this quarter's results. I find it interesting how Deming's seven points interrelate with not only continuous improvement, but also sustainability and strategy. How much might the decision not to upgrade an old, under-performing piece of capital equipment, for example, have knock-on effects? Delaying that purchase may protect some profits this quarter, but at what expense down the road? Does it contribute too much to line downtime? Does it require more human labor to operate and maintain than a replacement? Does it contribute negatively to employee health and welfare, potentially driving up health care costs?

As I thought about these "diseases and obstacles," all the circles on the Venn diagram of sustainability and continuous improvement shifted toward the center. We can talk about *environmental* sustainability, but continuous improvement methods are *business* sustainability. That's the convergence of all these market dynamics, and where we must think more strategically than ever before. The onus is on leadership and vision.

Continuous improvement, in other words, never goes out of style. And it starts with leadership. In this issue, we explore how TQM specifically has entered the DNA of continuous improvement disciplines, and the role leadership plays in transformation. If you've ever competed against a TQM company, you understand their advantage.

There are so many exciting dynamics in motion right now in our industry. Recently a laminate materials CEO commented, "Our current market is the most dynamic we've seen since the 1970s." He's got a point. There are stories to tell and conversations to have about how we all move this industry forward. Let us know what's on your mind; you might just open a conversation on yet another dynamic inside our industry. I look forward to your email with your thoughts, perspectives, and topic ideas. **PCB007**

References

1. "Electronic Design and Manufacturing Sustainability, a White Paper from IPC Industry Intelligence," ipc.org.
2. Seven Deadly Diseases of Management," deming.org.

Nolan Johnson is managing editor of *SMT007 Magazine* and co-managing editor of *PCB007 Magazine.* Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing. To read other columns or to contact Johnson, click here.

TQM: So Much MORE Than Quality

A Roundtable Discussion with the I-Connect007 Editorial Team

Sit down to a conversation with industry pioneers like Happy Holden and Dan Feinberg, then add TQM proponent Barry Matties to the table, and continuous improvement eventually becomes the topic. In this roundtable discussion, the group turns to the subjects of legacy and the impact of TQM on quality, management, and business operations.

Nolan Johnson: Happy, does TQM matter today?

Happy Holden: Yes, it does. But with TQM, you can't understand how to live it through just one course, a lecture, or even reading a book. We failed with TQM a couple of times at HP. Finally, John Young, who was president of HP at the time, reached out to W. Edwards Deming. Deming said he'd work with HP only if Young and all his VPs and operations managers were in the front row. TQM and Six Sigma programs are inspired by top-down management leadership; they're not pushed up from the bottom.

Deming emphasized that to learn TQM, you had to immerse yourself in it four times. We came up with an acronym, LUTI, which meant "learn, use, teach, inspect." First, you learn with your boss as the teacher. Then, your manager gives you a project for the "use" portion. Next, you teach it to your subordinates, and then you coach each of your subordinates on an individual project. The key was going through it four times.

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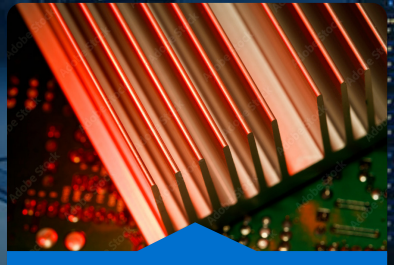

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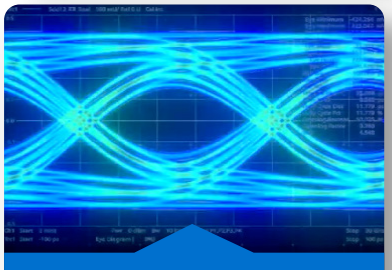

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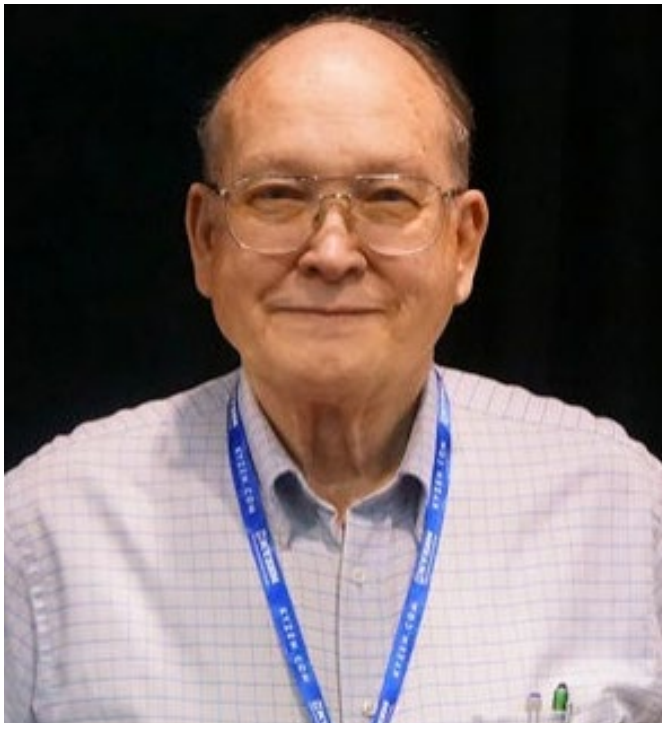

Happy Holden

It's been 45 years and I still believe in the process with TQM.

Eventually, we eliminated the final step of "inspect" by focusing on quality tests. Operators would say, "I don't think this process is working right but I don't have any tools to measure it." So, we invented quality tests that operators could perform on the PCBs as they built them; if the test failed, they shut down the process and got the engineer, because something wasn't working right. It's interesting how few tests are developed for operators to determine the quality of a process.

As we eliminated final inspection and focused on the first pass yield electrical test, we moved everybody to the front of our process. We had to inspect all the artwork coming in because there were so many problems with the DFM portion of the printed circuit board design.

Johnson: This certainly sounds like it could be a contemporary problem as well.

Holden: Forty years after we first embraced TQM, nothing has changed in terms of the need for continuous improvement and measures of performance. We certainly have the Japanese companies continuing to live it.

Dan Feinberg: When TQM was implemented top-down, it worked. When I was a vice president, the president of our company mandated TQM, and it worked. If he hadn't made it a top-down initiative, we'd have heard a few lectures and it would have gone away in a few weeks.

Barry Matties: To your point, Dan, if we go back to the fathers of quality—Deming and Juran and the like—they shared that understanding. If Deming wasn't meeting with the top leadership, he wouldn't even spend his time in your organization because management was a result of leadership.

You can have management by objective (MBO) or you can have total quality management, continuous improvement. But the words are empty if your actions don't match. You can write down all the policies that you want in a handbook of policies. But policies are really defined by the actions of leadership or the people around you. If we always do it this way, regardless of what written policy says, then that's the accepted unwritten policy.

That's the struggle with bringing in these management systems. They turn into fads because it sounds good; it's the flavor of the day. To make it work, we need to change our habits. If our habits still have us doing the old stuff, and if leadership isn't committed, then employees don't buy in, and it never transforms.

Now, back to your earlier question: How do we make TQM contemporary? We have software that will collect data like we've never had before. Back in the day, you had to walk through the factory, and you had to ask each person to get that data. There's still some of that because you still need that communication, but data collection and statistics have never been easier.

When we go back to Deming's 14 points of leadership transformation, management and leadership are two different things. Leadership

is what inspires; it sets direction and tone. Part of the message for this issue is to talk about the commitment to transform leadership into a continuous improvement role.

I will tell you, managing by TQM can be painfully slow. A lot of education must happen. You need to exhibit a lot of patience in helping people learn. Learning is a core foundation in Deming's 14 points. He would come in and he would talk to the top leadership, and then the top would talk to the next tier, cascading the concepts throughout the organization. But it must start at the top.

When you're dealing with a TQM company, it's obvious. The results are phenomenal. Your yields go up, your frustrations go down, your input costs go down. The "red beads" are taken out of your processes, and your upper and lower control limits tend to tighten up, giving you operational competitive advantage. Your output is a predictable, quality product. You don't have to inspect quality in and sort defects out at the tail end.

Holden: Back to your earlier question: What's the basis of TQM? The most important skill to learn is maintaining and gaining that customer satisfaction—whether that's your boss, an external customer, or the next department over. To achieve customer satisfaction, you need data that measures performance. Data measures how you choose to define customer satisfaction, be it price, performance, or profit. You have got to have those measures.

Johnson: Happy, I'm going back to our earlier discussion about TQM being treated like a fad and then replaced by the next fad. Would those follow-on methods be considered derivatives of TQM? Is TQM the foundation for this class of management?

Holden: In the first chapter of my book, *24 Essential Skills for Engineers,* I list more than a dozen quality programs. Elements of TQM can be found in Lean manufacturing, in just-in-time (JIT), and design for manufacturing (DFM, DFX). There's a whole list of them, including Six Sigma, which deals more with the statistics part, but also has a more advanced problem-solving methodology than "Plan-Do-Check-Act."

Dan Feinberg

In the second chapter, I discuss problem solving because it's the second biggest skill you need. The engineer in printed circuit fabrication or assembly will face problems of all types. I think we can turn good technicians or workers into automation experts if they learn some of the skills associated with automating. They don't necessarily need mechanical engineering degrees as much as they need common sense. It will be hard to hire automation engineers because everybody and their brother wants them in well-paid automation jobs. You have to grow your own if you want to get this job done.

Matties: To your point, Happy, even bringing in automation is part of a continuous improvement cycle. It's lowering input cost and upskilling the talent you bring in. You start by understanding your core process. Once you have that process fully understood, then

you can start reducing the steps. Now we can automate, bring in computer technology, or whatever the automation necessitates. It's a journey of first understanding the process, and then improving it. That is the foundational concept. All those acronyms that we're talking about are the foundation for continuous improvement.

Leadership is in control of this whole process. Leaders are the ones who set the tone, decide how much resource to dedicate to it, and what improvements are needed. From Deming's point of view, when there's an error or a quality issue, we don't blame the worker, we always blame leadership.

Johnson: What would Deming think if he'd been doing this type of data collection that we have available now?

Holden: That's why I liked our equation that we came up with last year, X = Xc - 1. Start with changing just one thing. What does your pareto chart say is your biggest yield loss? It's usually handling, and that's why we often misequate automation with mechanization.

Automation is made up of two separate vectors: mechanization and systemization (information). Systemization is system information; mechanization is product action and movement. I advise you to benchmark and analyze the two of them independently in your process. Are you looking at the right information? Do you know what affects yield or do you only understand your yield at a final electrical test when you can't figure out the failure?

Statistics can help you identify what seems to be a random failure, but when it keeps occurring lot after lot then it's not random anymore; it's systemic. You only know that if you do something with the data. Other than that, just let the piece of paper on "pass and fail" go into the trash can and ship the good ones without trying to figure out why you have bad ones.

Johnson: Happy, that's the ongoing question, isn't it?

Holden: You just keep moving it forward.

Matties: Thanks for your insight, everyone. Always informative. **PCB007**

Start Your Smart Factory Journey

Continuous improvement, smart factories, and automation increasingly continue to overlap as trends in the industry. One repeating question of course, is "how to get started?" What is the best way—in a TQM culture—to approach making your manufacturing processes smarter. Well, you're in luck.

In the April 2022 issue of *SMT007 Magazine,* industry pioneer and I-Connect007 technical editor, Happy Holden wrote an article titled "The Journey to Your Smart Factory." In his article, Holden answers these questions about how to get started.

- Who should design it
- What they need to learn
- How to analyze and plan the automation
- How long should it take?
- When is the right time?
- How much will it cost?

Holden also presented this article at the ICT Annual Symposium on June 8, 2022. But readers can refer to the content of his presentation here.

Holden encourages readers to:

- Start your smart factory journey today. Think big, start small, act now.
- Look to staff the automation team with your own engineers plus training.
- Initiate a smart factory assessment, then make it operational with proof of value (ROI). This is a fundamental business transition; align the technology to business objectives.
- Drive toward a smart connected factory with a zero-downtime, zero-defect vision.
- Improve your weak link: people, process, or technology. Benefits only accrue as far as the weakest link.

— I-Connect007 Editors

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11. *Eliminate numerical quotas for the workforce and numerical goals for management*
12. *Remove barriers that rob people of pride of workmanship, and eliminate the annual rating or merit system*
13. *Institute a vigorous program of education and self-improvement for everyone*
14. *Put everybody in the company to work accomplishing the transformation*

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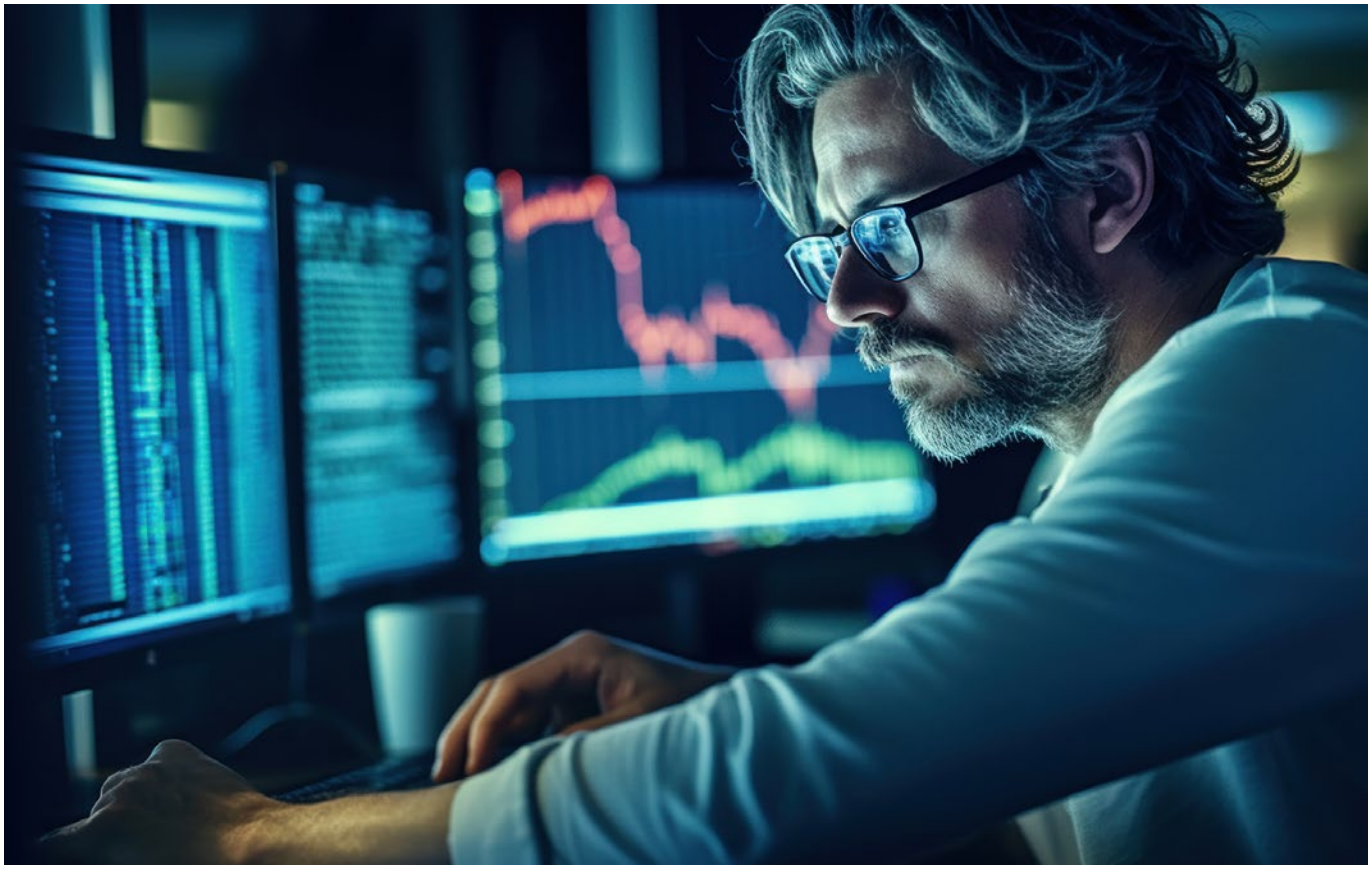

Data, Analysis, and TQM

Feature Interview by Nolan Johnson
I-CONNECT007

Chris Chapman is a Deming management method practitioner and consultant who publishes "The Digestible Deming" blog on Substack. Chris has been a student of Deming's agile, Lean, and related methods since 2007. With his software and data background, he brings something of a 21st century perspective to quality. In this conversation, we explore how data and AI might be changing how we approach quality.

Chris, as we talk about TQM, I'd like to ask you to consider the amount of data that we now have available. Our ability to collect data, implement sensors, get real-time data from the manufacturing floor, analyze it, and make it available to upper management has increased. What would be Deming's perspective on this amount of data? Back in his day, surely, they didn't have this much data to roll up.

There's a fantastic little quip in Dr. Joyce Orsini's book, *The Essential Deming*. Joyce was one of Deming's PhD students and worked with him right up until the end. In one chapter, he comments on the data that was available to management back then. He says, "Tons of figures, no knowledge." It was the idea that, even 30 to 40 years ago, you could have huge amounts of information that would overwhelm management—never mind what we have access to today—without any real methodology to interpret what you were seeing. The key is to distin-

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Chris Chapman

guish signals from noise and gain insight into what the data is telling you about how a system or process is working.

Here's a real-world example from a particular customer of mine in telecom, where they wanted to track the activation of Apple watches as the first versions rolled out. They wanted to know how many people were going onto the network. A senior executive who was very hot to trot on understanding this said, "Gather all the data that tells me the activation and deactivation rates of these watches nationwide."

It took seven or eight hours a day for people to pull together that data from all the systems and roll it up onto a dashboard as a single number. That number was green when it went up, and red when it went down. You can imagine the attendant behavior which that encouraged.

What I suggested to those managers was to present the data in context over time on a run chart with process limits, such that the leadership could see a quarter's worth of activation, perhaps. In that way, you could take some of the temperature, and establish what the estimated three sigma limits are for normal activations. You don't have to explain the math, don't draw them manually; just calculate the limits and report what the picture of normal looks like. We want it to economize our interventions only to when we see very overt signals above or below limits in the activation/deactivation cycle. Only then do we look at the contributory system indications for that.

I don't like the idea, though, of leaving leadership in the lurch for too long, because they're the ones who need to understand this. Transformation to a quality view must begin with them. When leadership is completely overwhelmed by data, they must be able to stand back and say, "Who can explain the most important metrics that we need to know about how our process is working? Because the only real value to me is to know when there are aberrations in the process, so that we can begin to refine it and we can begin a system improvement to reduce that variation."

> "Don't just do something, stand there."

I think Deming had another useful quip, which is a brilliant little inversion: "Don't just do something, stand there." His point was to reduce the inclination to tamper with the system straightaway in reaction to some event. Understand what it's doing first, because your reactions to the figures will produce more harm than good; you could ruin things.

Where do you see AI fitting in the context of turning this data into knowledge? Is this something that has an application within TQM?

I think the jury's still out on that. I've played with ChatGPT in my work, and I find that it

is prone to a lot of mistakes and a thing that they call "hallucinations," where it begins to imagine answers to things that are factually wrong. It's a dangerous tool if you're unable to recognize when it's lying to you.

I had a dialog with ChatGPT about the Red Bead Experiment; you can get into "arguments" with it. It will apologize profusely, and then keep making the same mistake. In terms of how it can interpret the data and draw out meaningful patterns to which leadership can respond, I'm concerned about the innate interpretations which will be built into the models inside of the AI itself. You can train AI on large amounts of data, but you may not be able to train it on large amounts of context.

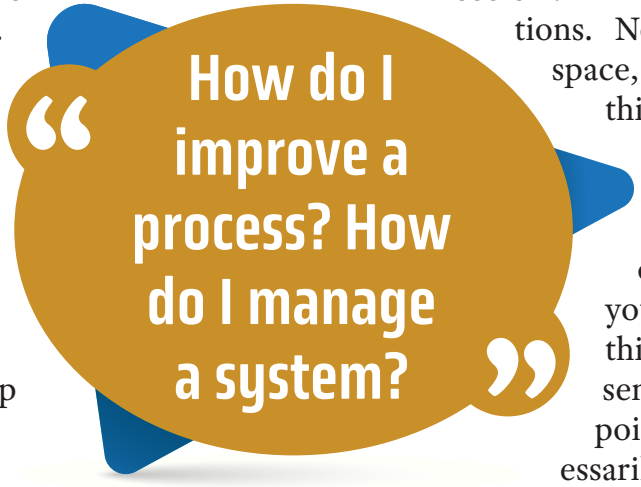
Elon Musk had his visions of a 24-hour dark factory (he called it the "Alien Dreadnought") but came to the realization that humans were being underrated and backtracked. That's the caution I would have about relying too much on what AI can translate data into. It's not necessarily going to give you knowledge; it's still up to the individual to decide. Could I say to ChatGPT, based on current production statistics, "Show me a process behavior chart about how well we are meeting our overall objectives for delivery units per unit of time"? Now, if it could actually do that, that would be remarkable. But I would recommend the same caution as when I teach management about making their own process behavior charts: Don't rely on software, and do it yourself, because then you know the veracity and validity of the calculations being done, whether the picture being presented makes sense in context.

Your point about generative AI, like ChatGPT, is spot on. There's this domain in which the AI engines are really good at analyzing large chunks of data and finding patterns in the data that may not otherwise be obvious. This is very sophisticated pattern matching. Research and development are

making a lot of progress in medical applications, using AI to do pattern matching, diagnosing conditions we never would have seen otherwise. That sort of application could play well in manufacturing.

Oh, yeah. I have been keeping up with what's happening in the medical sciences and that looks interesting. At the same time, they're still cautioning that it takes a human to corroborate and diagnose; there's still some human expertise that's required to validate.

For example, in medical imaging, being able to pick up cancers that even expert radiologists would have missed is interesting. I'm curious, though, what AI is seeing inside of that data. That method is not being shared with a radiologist. Alfred Korzybski, the father of general semantics, said, "The map is not the territory." What is the AI doing that makes it better able to interpret the map? Who's making the map better?



Right. For me that has a direct correlation to what could be happening in manufacturing.

If, for example, you could do scans for defects on traces on PCBs, being able to catch them before they get out, but then you would be able to track that trace back, to ask where the defect emerged. Is it a problem in the manufacturing? Is that a problem in source materials? Is it a problem with people on the production line, or the machines that are doing the assembly?

Do you see any work underway in this space right now?

In terms of using large AI models for interpreting data? Yes, not directly, but I imagine it's coming. We're in a gestational period for that. Experiments are being done within the customer organizations that I've worked with.

How do you think that AI development is going to change TQM?

I keep coming back to leadership. Leadership doesn't yet understand the theory needed to actually change first, and this could lead to depending on AI for answers to system questions.

For example, what I see here in Canada is a system of management used everywhere, irrespective of AI adoption rates, that we imported decades ago from the United States. That management system makes us dependent upon reactionary interpretations of phenomena in our organizations. We don't see or think in systems and interactions. Now, inside the TQM space, I imagine it's like anything. It could make you more reliant on the AI to direct you, and less reliant on your own intelligence. If you haven't shifted your thinking, you will be presented with a lot of data points, and you won't necessarily be able to make the correct interpretations or ask the right questions, such as, "How do I improve a process? How do I manage a system?"

What would be totally cool would be something in AI that could actually help facilitate these questions: "How do I manage my organization as a system?" or "How will this decision affect other parts of the organization?" You want it to be able to provide guidance and waypoints so that you can say, "I'm considering implementing this particular policy in this part of the plant. What are the implications?"

Chris, this has been a really interesting and informative conversion. Thank you so much.

I agree. Thank you, Nolan. PCB007

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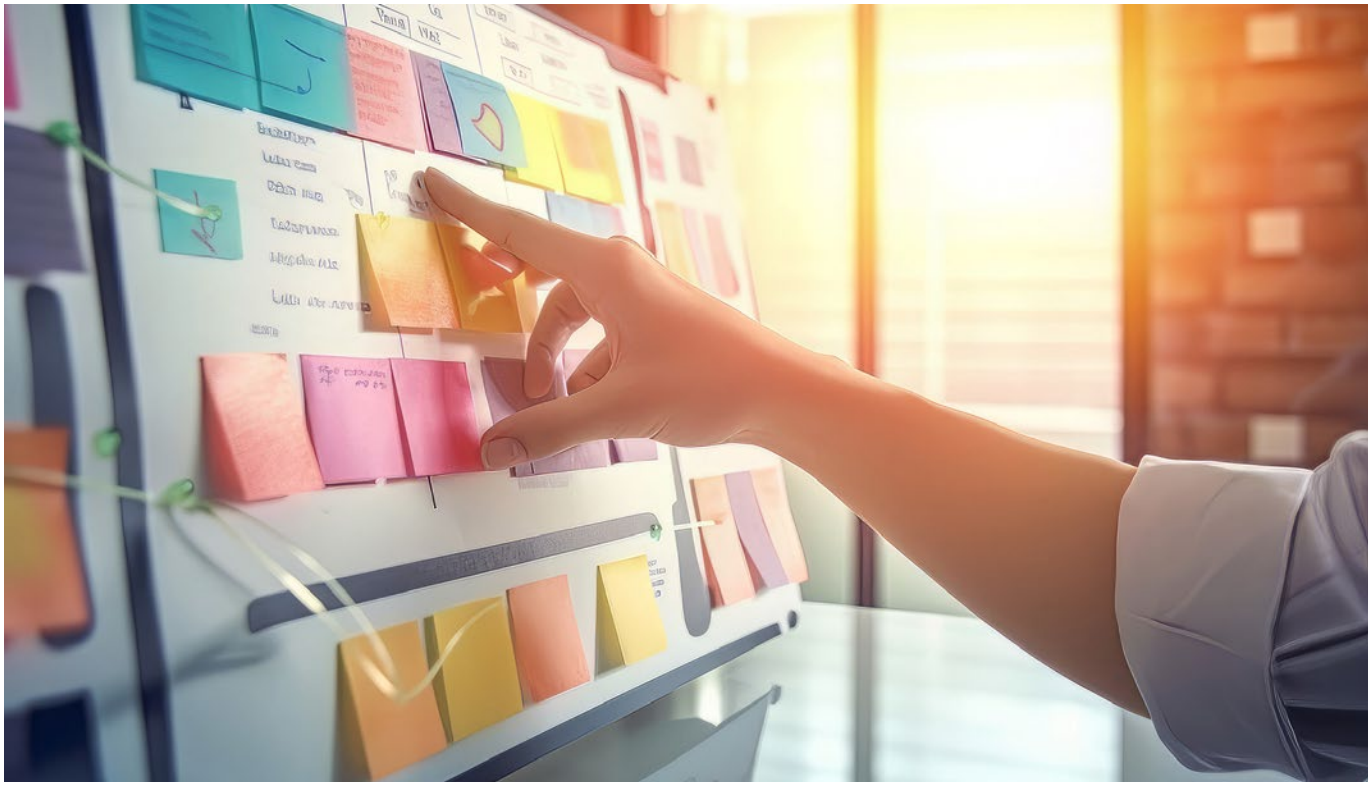

Lean vs. TQM vs. Six Sigma

Feature Article by Steve Williams
THE RIGHT APPROACH CONSULTING

Introduction

Lean, Total Quality Management (TQM), and Six Sigma are three popular methodologies used in business and manufacturing sectors to improve processes, increase efficiency, and reduce waste. While they share some similarities, each approach has its unique focus and: a unique focus and its own set of tools. Here's a comparison of Lean, TQM, and Six Sigma.

The Founding Fathers

Companies like Toyota are often touted (with good reason) as the gold standard for quality system models. Toyota's TPS (Toyota Production System) has been highly publicized and has gained increasing acceptance in American manufacturing operations over the last decade or so. What has not been highly publicized is the fact that many of these concepts originated in America, and quality pioneers like W. Edwards Deming had to take their show on the road to Japan only after being rejected by the leaders of American industry. The contributions of such legends as Dr. Deming, Dr. Joseph Juran, Philip Crosby, Dr. Kaoru Ishikawa, Dr. Walter Shewhart, and Shigeo Shingo had such an impact on the world that they truly are the Founding Fathers of modern quality.

"We strive to decide our own fate. We act with self-reliance, trusting in our own abilities. We accept responsibility for our conduct and for maintaining and improving the skills that enable us to produce added value."

–Excerpt from Toyota Motor Corporation's internal document, "The Toyota Way"


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Lean

Lean is a methodology and philosophy that originated from the TPS and is widely used in various industries for process improvement and waste reduction. The core principle of Lean is to maximize value for customers by minimizing or eliminating non-value-added activities or waste. The primary focus of Lean is on creating flow and eliminating waste throughout the entire value stream, from the beginning of a process to its end. Waste, also known as "Muda" in Lean terminology, refers to any activity or process step that does not add value from the customer's perspective. Figure 1 illustrates the eight types of wastes identified in Lean Manufacturing.

Lean aims to streamline processes by identifying and eliminating these forms of waste, ultimately leading to improved efficiency, reduced costs, and enhanced customer satisfaction. It encourages a continuous improvement mindset and empowers employees at all levels to contribute ideas and suggestions for process optimization.

Key concepts and tools used in Lean include:

1. **Value Stream Mapping:** A visual representation of the entire process flow, identifying value-added and non-value-added activities.
2. **5S:** A methodology for workplace organization and cleanliness, consisting of Sort, Set in Order, Shine, Standardize, and Sustain.
3. **Kanban:** A pull-based system for inventory management and production control, ensuring that items are produced or restocked only when needed.
4. **Just-in-Time (JIT):** A production strategy that aims to produce and deliver items in the right quantity, at the right time, and in the right place, minimizing inventory and waste.
5. **Kaizen:** The concept of continuous improvement, involving small, incremental changes and involving employees at all levels in identifying and implementing improvements.

By implementing Lean principles and practices, organizations can achieve more efficient processes, reduced lead times, improved quality, and increased customer satisfaction. Lean is applicable to a wide range of industries, including manufacturing, healthcare, service sectors, and more; it continues to evolve and be adapted to suit different contexts and challenges.

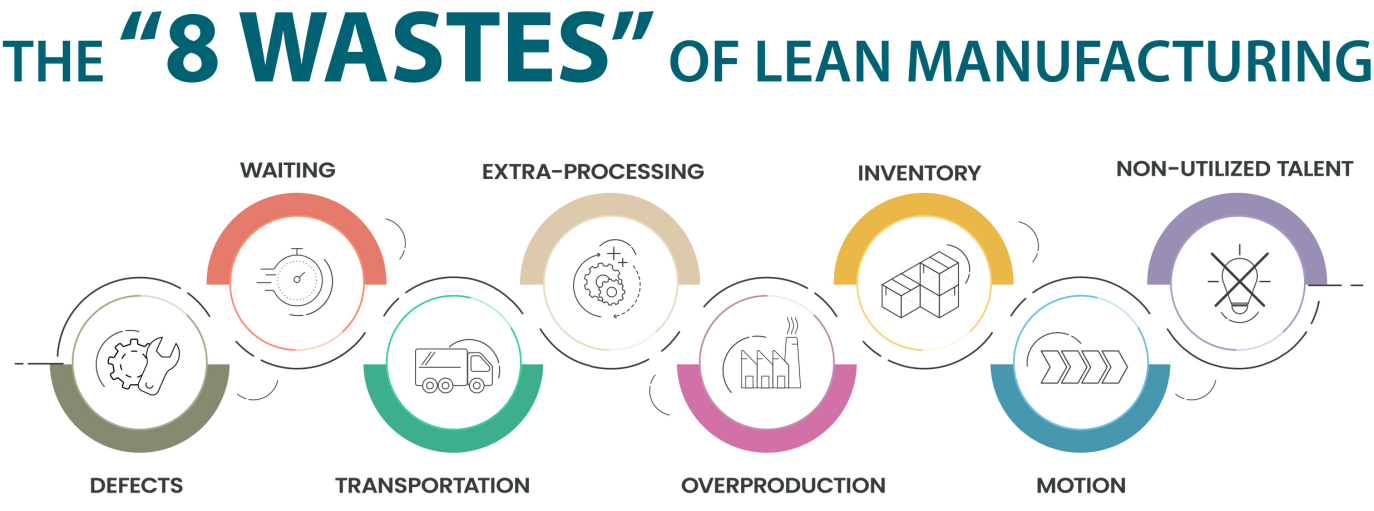

Figure 1.

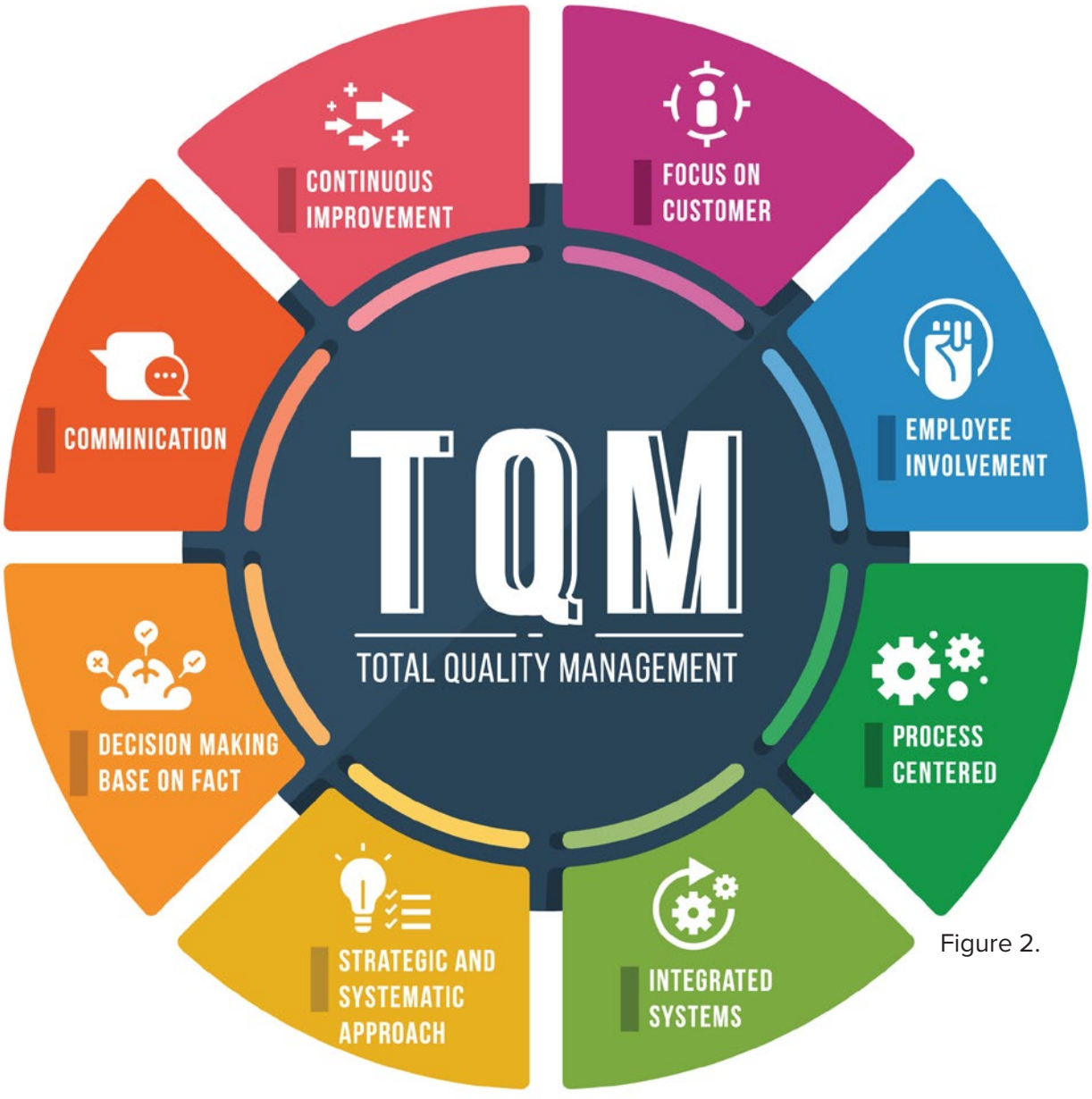

Figure 2.

TQM (Total Quality Management)

TQM is a management approach and philosophy aimed at achieving continuous improvement in quality across all aspects of an organization. TQM focuses on customer satisfaction, employee involvement, and continuous process improvement to enhance overall organizational performance (Figure 2).

Here are key characteristics and elements of TQM:

1. **Customer focus:** TQM places a strong emphasis on meeting and exceeding customer expectations. It involves understanding customer needs, gathering feedback, and aligning all processes to deliver superior value and satisfaction to customers.
2. **Continuous improvement:** TQM promotes a culture of continuous improvement by constantly seeking ways to enhance processes, products, and services. It encourages employees at all levels to identify and eliminate sources of errors, defects, and inefficiencies.
3. **Employee involvement:** TQM recognizes that employees are valuable assets and encourages their active participation in quality improvement initiatives. It fosters a

culture of teamwork, empowerment, and accountability, where employees contribute their expertise, ideas, and suggestions for enhancing quality.

4. **Process approach:** TQM emphasizes the importance of understanding and managing processes. It involves identifying key processes, mapping them, analyzing their performance, and making data-driven decisions for process optimization.
5. **Data and analysis:** TQM relies on data and statistical analysis to drive decision-making and improvement efforts. It involves collecting and analyzing data to monitor process performance, identify trends, and make informed decisions for quality enhancement.
6. **Supplier relationships:** TQM recognizes the significance of strong supplier relationships. It involves working closely with suppliers, establishing clear quality requirements, and collaborating to achieve mutual benefits and improved quality throughout the supply chain.
7. **Leadership commitment:** TQM requires leadership commitment and support. Leaders set the vision, create a supportive environment, provide resources, and promote a quality-focused culture throughout the organization.
8. **Training and education:** TQM emphasizes the importance of continuous learning and development. It involves providing training and education to employees to enhance their skills, knowledge, and understanding of quality principles and tools.

By implementing TQM principles, organizations can achieve improved product and service quality, enhanced customer satisfaction, increased operational efficiency, and greater competitiveness in the marketplace. TQM is applicable to various industries and sectors, and it has been successfully adopted by organizations around the world to drive sustainable quality improvements.

Six Sigma

Six Sigma is a data-driven methodology and quality management approach that aims to improve process performance, reduce defects, and minimize variations within organizations (Figure 3). It was originally developed by Motorola in the 1980s and popularized by companies like General Electric.

Figure 3.

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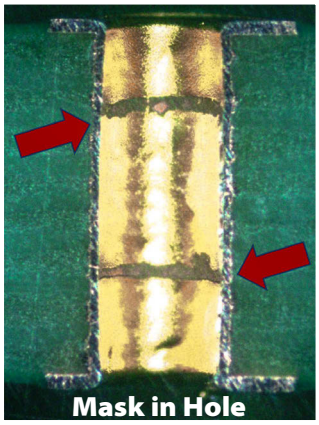
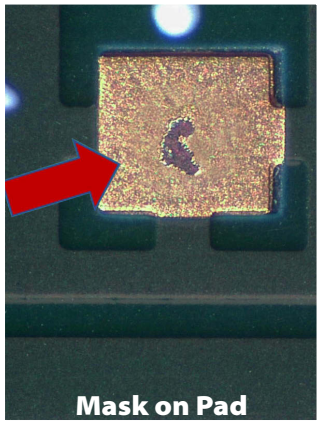
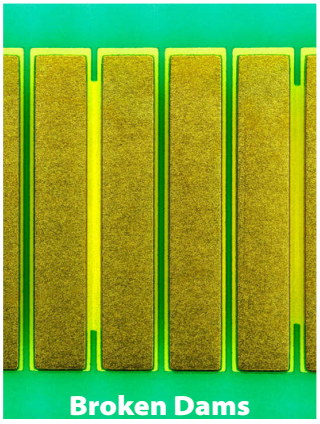

Mask in Hole


Mask on Pad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Key characteristics and components of Six Sigma include:

1. **Focus on quality:** Six Sigma focuses on delivering high-quality products and services by reducing process variations and defects. The goal is to achieve a level of performance where the number of defects or errors is minimal, typically measured as no more than 3.4 defects per million opportunities (DPMO).
2. **DMAIC and DMADV methodologies:** Six Sigma follows two primary methodologies for process improvement: DMAIC (Define, Measure, Analyze, Improve, Control) and DMADV (Define, Measure, Analyze, Design, Verify). DMAIC is used for improving existing processes, while DMADV is applied to develop new processes or products.
3. **Data-driven approach:** Six Sigma relies heavily on data analysis and statistical tools to identify the root causes of problems and make informed decisions. It involves collecting and analyzing data to understand process performance, identify areas of improvement, and measure progress.
4. **Roles and certifications:** Six Sigma uses a hierarchical structure of roles and certifications to ensure effective implementation. Key roles include Champions, who provide strategic guidance and support; Black Belts, who lead improvement projects; and Green Belts, who assist in project execution. There are also Yellow Belts and Master Black Belts who play supporting and leadership roles, respectively.
5. **Tools and techniques:** Six Sigma utilizes a range of statistical and analytical tools and techniques to support problem-solving and process improvement. Examples include process capability analysis, control charts, root cause analysis, hypothesis testing, design of experiments (DOE), and failure mode and effects analysis (FMEA).
6. **Continuous improvement culture:** Six Sigma promotes a culture of continuous improvement and learning within organizations. It encourages employees to actively participate in improvement projects, fosters a data-driven mindset, and emphasizes the importance of ongoing measurement, analysis, and refinement of processes.

By implementing Six Sigma, organizations can achieve significant improvements in process efficiency, quality, customer satisfaction, and financial performance. It is widely applied in various industries such as manufacturing, healthcare, finance, and service sectors to drive operational excellence and deliver superior products and services.

Conclusion

In summary, Lean focuses on waste reduction and process optimization, TQM emphasizes continuous improvement and customer satisfaction, while Six Sigma focuses on reducing process variations and defects through statistical analysis. These methodologies can be complementary and are often used together to achieve comprehensive process improvement in organizations. **PCB007**

Steve Williams is president of The Right Approach Consulting. He is also an independent certified coach, trainer, and speaker with the John Maxwell team. To read past columns, click here.

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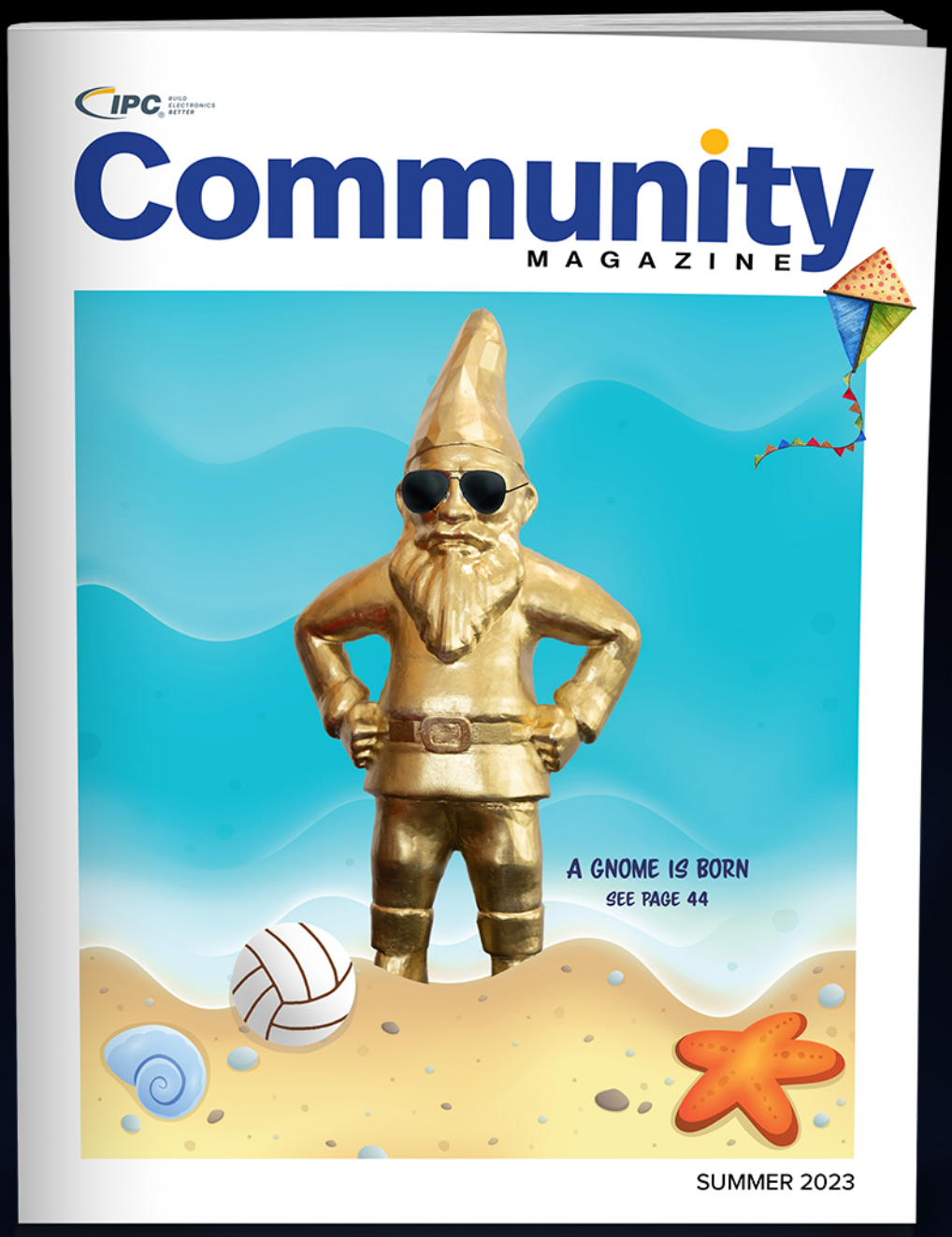

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Developing an Improvement Process

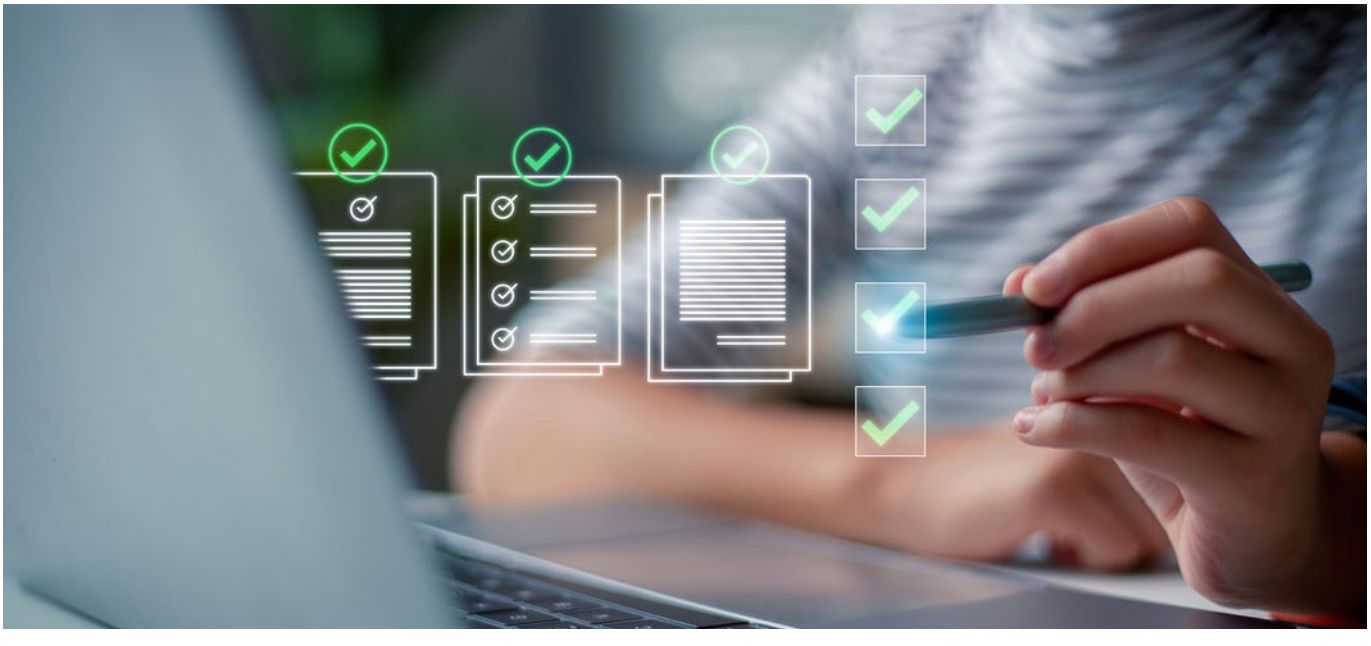
The New Chapter

Feature Column by Paige Fiet, TTM-LOGAN

Just the other day, my colleague and I were discussing the daunting process of creating a quality management system from scratch for a company. He said, "Can you imagine starting up your own company and creating the quality management system? How would you know where to start?" We then began a debate on what processes we would create first and where we would store the database and each of the documents. Thinking about this was, for both of us, overwhelming and fascinating at the same time.

As this discussion progressed, my coworker mentioned that he would begin his TQM with common audit concerns. He claimed this was the best place to start as you are satisfying a customer requirement, and it prepares the company for passing audits with flying colors. I agreed this was the best way to start a new quality management system, but what about an existing system that just needs improvement?

As per typical cubicle chatter, this evolved into a larger conversation among those of us in the quality engineering department. One mentioned customer satisfaction as the best place to focus improvements while another had a firm opinion that it should be focused on employee engagement. We weighed the pros and cons of quality management from our previous employers. How did each of these companies store their quality documents? What sorts of documents exist in their quality system? Toward the end of our less than heated



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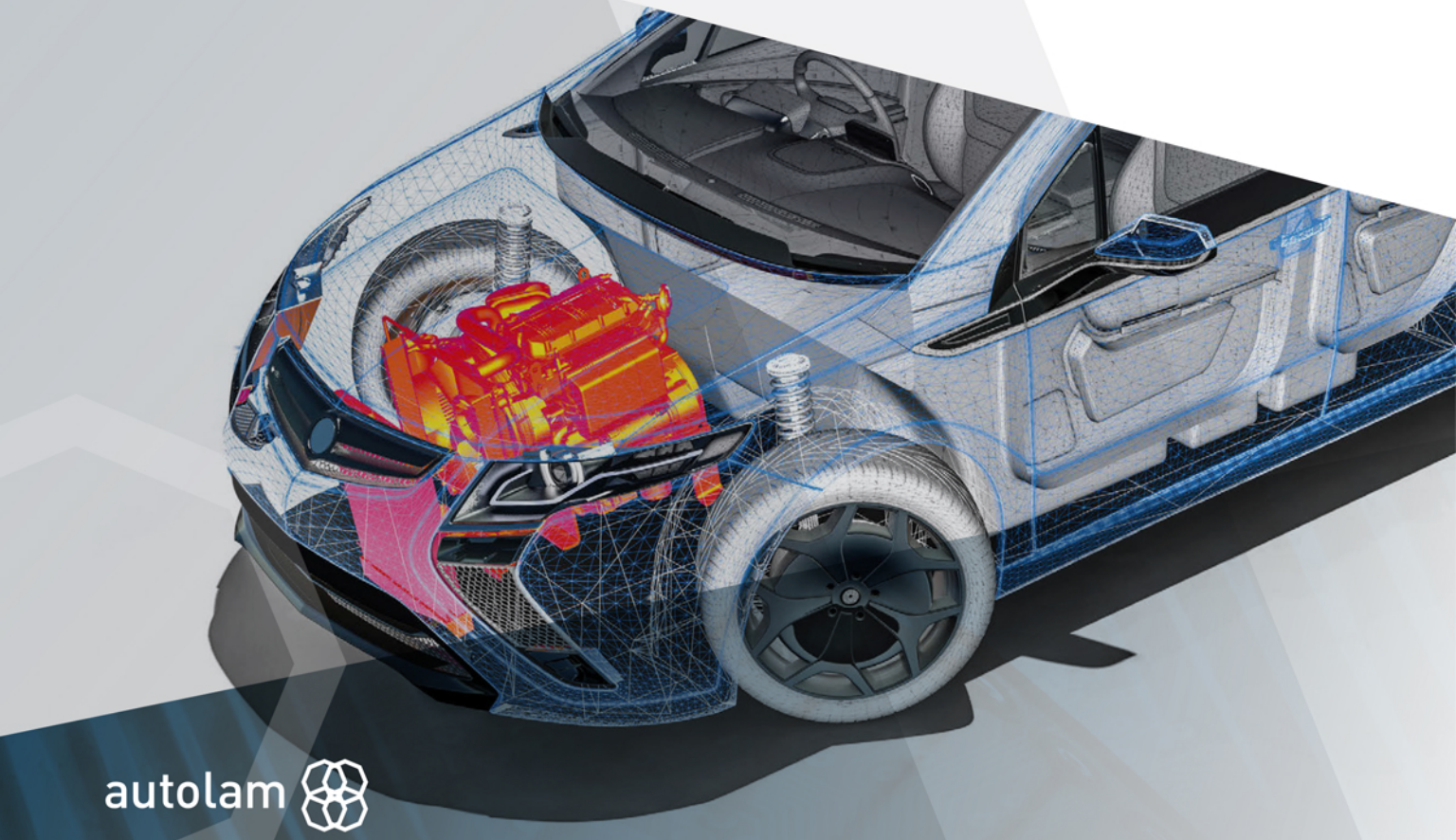

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debate, we agreed: Several factors must be in place when developing the improvement process of any quality management system, regardless of the workplace.

1. Strong Customer Interaction and Satisfaction

The first accepted pillar in the improvement process is through customer interaction and satisfaction. Once we create the foundation of our quality system, it must be constantly updated through customer feedback. They provide a hard look into what's lacking in your systems. Sometimes this looks like a process review or an update to an outdated training document. At other times, the customer can steer the direction into technology and material advancements. Whatever the case may be, a business is in business to make money. In most industries, the money is made by selling products. Why not first listen to those buying the products?

> "Are the employees looking to constantly improve the quality systems around them?"

2. Consider Company Culture

The next agreement we made was that the quality management system should factor in the culture of the facility or company. Is it easy for all the employees to access documents in the QMS? Are the employees looking to constantly improve the quality systems around them? How are the employees able to communicate any ideas they have for improvement to leadership? How willing are the employees to not only present ideas for advancement but for them to follow through with said ideas? A business won't survive without employees (unless AI takes over the world, that is). So, a QMS needs to fit into the everyday culture such that it creates continual improvement at all levels of the business.

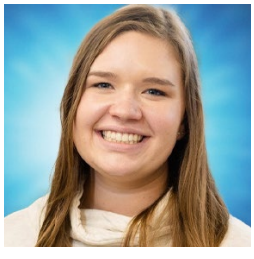
3. Assigning Responsibility

Our conversation then shifted away from the people side of quality and into the system that prompts it. Organization and communication are needed to maintain the documents needed to continue to shape the quality environment. It's important to know who is responsible for the upkeep of each document and when to renovate them as they become outdated. These documents should also have buy-in from multiple leaders in the business.

4. Show Me the Data

The final factor we defined is the use of data. Any company can "feel" that their quality system is robust and gets the job done. But at the end of the day, it's just an opinion. Where are the numbers showing the system is robust? Statistics need to be the driving force, regardless of the continual improvement made. It's what drives the "M" in SMART goals and shows strengths and weaknesses. Data will drive the initiatives worth focusing on.

At the end of our probably too long conversation, my colleagues and I had mostly agreed that we were happy to be on the improvement side of the quality management system and not at the start. We concluded that it's incredibly empowering to be a part of a system that is always trying to revise itself, one in which the best advancements of today will be standard practice tomorrow. **PCB007**



Paige Fiet is a process engineer at TTM-Logan. and in the IPC Emerging Engineer Program. To read past columns, click here.

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Hiring With Leadership Style in Mind

Feature Article by Brian Wallace
HR STRATEGIES NOW

Is your leadership style helping or hurting your hiring results? The influence of a leadership style on hiring practices is often underestimated, yet it plays a significant role in the long-term success of any business. The costs associated with hiring and onboarding a new employee can easily exceed their annual salary, not to mention the future impact their performance can have on the organization. So, prioritizing the hiring process and approaching it with careful consideration is crucial.

Leadership styles are commonly categorized into six descriptors: autocratic, democratic, laissez-faire, transformational, transactional, and servant. Let's explore how each of these styles influences hiring practices.

Autocratic Leaders

Autocratic leaders tend to make decisions in a top-down manner. They believe there is one "best" way to recruit and make hiring decisions independently, without seeking input from others. While this approach may be advantageous in terms of speed, it can negatively impact team chemistry. Bias can easily creep in, as hiring like-minded individuals may become a priority, which can hinder the diversity of ideas and creativity within the team. High-functioning teams are created when members have a personal investment, and that investment is easier when they have the opportunity to influence the composition of the team.

Democratic Leaders

Democratic leaders take a more collaborative approach, actively seeking input from others in the recruiting and selection process. They are open to various recruiting sources and processes to identify high-quality candidates. Panel interviews or a sequence of indi-

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vidual meetings, followed by a debriefing session, are common in this approach. There is greater buy-in and investment in the outcome when you involve team members in the hiring decisions. However, scheduling multiple interviews and managing differing opinions can be challenging.

Laissez-faire Leaders

Laissez-faire leaders excel in delegation. They trust their managers to handle the recruiting process and make hiring decisions. Each manager has the freedom to create their own team based on their perception of performance needs. While delegation is essential, the challenge lies in the variation of what is considered "quality" in the hiring process. Flexibility is desirable, but it can lead to unpredictable results.

Transformational Leaders

Transformational leaders aim to inspire their teams to achieve beyond their perceived capabilities. When it comes to interviewing and selection, they prioritize finding the right candidate and are willing to invest the necessary time. They often seek growth-focused and highly motivated individuals whose values align with the organization's values. The challenge lies in identifying and vetting such individuals, leading to the implementation of rigorous recruiting and interviewing practices.

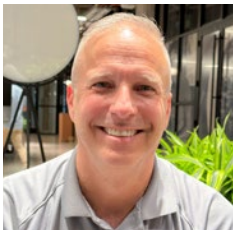
Transactional Leaders

Transactional leaders focus on clear processes and practices. Their priority is efficiently finding candidates who meet all the qualifications and can perform the required responsibilities. They adopt a methodical approach and set clear expectations from the beginning. As a result, candidates have a comprehensive understanding of their role and potential before an offer is extended. Streamlined recruiting and selection processes help maintain quality, but an excessive emphasis on checking boxes can limit creativity and engagement.

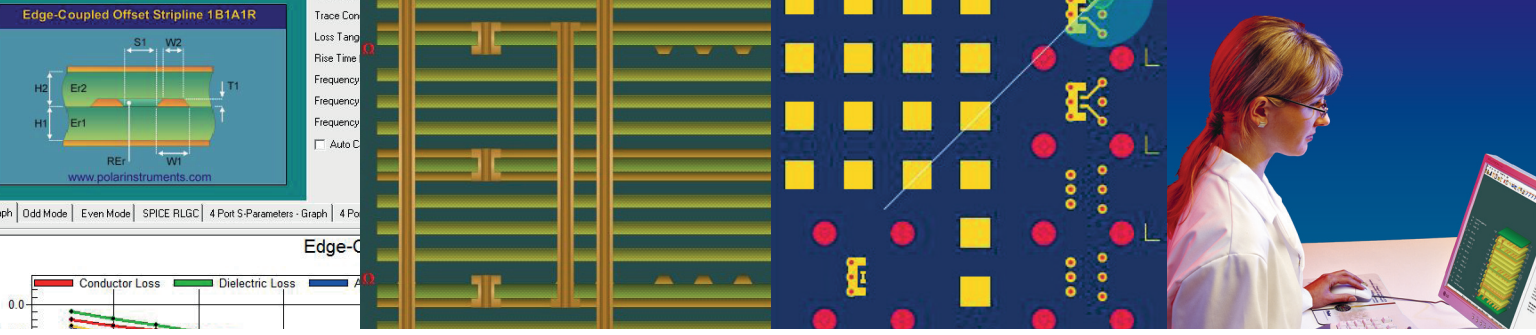
Servant Leaders

Servant leaders are dedicated to supporting the growth and success of their teams. They seek individuals who share this commitment. Recruitment and interview conversations often revolve around commitment levels and potential for growth and development. Trust, communication, and autonomy are also emphasized. Involving the team in the hiring process is paramount to ensuring chemistry. However, challenges arise due to the time required for team involvement, evaluating long-term potential, and managing group dynamics.

The most effective leadership style for recruiting and selection depends on various factors, such as the nature of the business, desired culture, immediate production demands, and the capability level of those working with and for you. In my experience, an emphasis on clearly defined interview processes and team involvement in final decisions leads to the best outcomes. The key is to design and build these practices systematically and continuously drive incremental improvement. Remember, new hires are critical investments for any organization, so conducting thorough due diligence is essential. Happy hunting, everyone. **PCB007**



Brian Wallace is the founder and CEO of HR Strategies Now, a human resources consulting firm in Cypress, Texas. He has a master's degree in management and an SPHR certification from the Human Resources Credentialing Institute. He has led transformative HR initiatives across five industries for more than 20 years.



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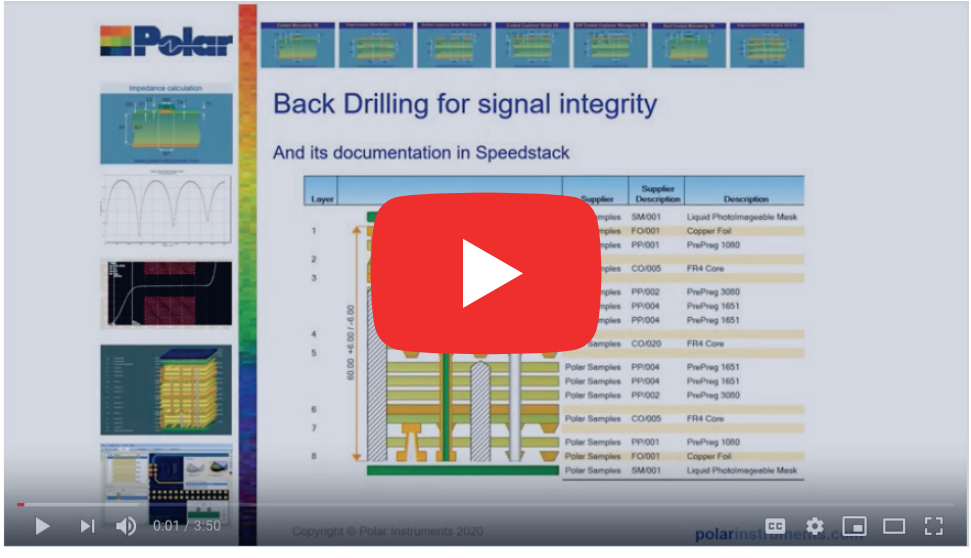

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Recollections on Deming

Feature Article by Mark Wolfe, IPC

In the early 1990s, I was working for EMD Associates, an EMS company (now a Benchmark Electronics operation in Winona, Minnesota), when I became familiar with Dr. W. Edwards Deming. EMD was an early entrant into the SMT provider world, and we were very focused on quality. Deming was one of several experts that we used as a guide for our company.

As part of that journey, I was able to attend a live Deming seminar in Phoenix. There were several speakers as part of his team, but Deming, who was at least 90 years old at the time, spoke in very memorable fashion each day on key topics.

Deming's demonstration of the Red Bead Experiment left the most profound impression on me. You can see a shortened video from the Deming Institute of his experiment online[1]. (In fact, I may even be in that audience.) This experiment involved several "willing workers" (audience volunteers) who were asked to use a dimpled paddle to randomly remove 50 beads from a box of hundreds of white (good) and red (defective) beads. Those "workers" who had fewer relative defects were rewarded and promoted. Those who had more defects were put on probation and dismissed. The company ultimately failed, allegedly because of the workers' inability to produce enough good product. It was, of course, all random and had nothing to do with the skill of individual workers. The system was simply not capable of producing the output they required to succeed

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and the variation across workers was just a normal variation within that system. Deming's colorful commentary was both humorous and sobering, but the impact is etched in my memory. Since then, I have always tried to understand the impact of normal variation on what I think we see.

Now, I recall a more humorous anecdote from that seminar when he reminded the audience that he clearly expected them to pay attention and listen. He had an audience of maybe 300 to 400 people, and at the end of the first session, they had an opportunity to ask him questions. There were microphones on stands in multiple aisles where long lines of people quickly formed behind each one.

Dr. Deming called on the first individual: "First question?" he announced. I don't remember the specific question, but I recall it seemed to be thoughtful and serious. Before answering, Deming paused for what seemed like an eternity; the anticipation mounted. Eventually, he responded back, somewhat loudly, "Weren't you here? Weren't you listening? Next question." I am sure that there was an intentional lesson there, although the waiting lines at the microphones diminished rather quickly. But it taught me to stay engaged and pay even better attention for the balance of the week.

In addition to Deming's 14 points, I frequently credit him with some additional key points that I am likely paraphrasing:

- People generally want to come to work and do the right thing.
- When they don't do the right thing, it is usually the failure of management to provide the tools, training, or resources to do the job properly.
- Don't ever start with blaming the worker; look in the mirror first.
- Trust in God. Have everyone else provide data. Otherwise, it is just another opinion.
- If you put a good person in a bad system, you will still get a bad result.

> "Educators will say that students retain only 10% of what they learn in class."

Educators will say that students retain only 10% of what they learn in class. Over the years, I may not have retained everything I learned from Dr. Deming; those 14 points might be a little hazy, for example. But since that experience, when things did not happen the way I expected, I stopped letting my first response be, "Who did it?" and replaced it with "Why did it happen?" I understood that we needed to look at the system as much or more than looking at the people. Somehow, from then on, it became hardwired into my worldview. It most certainly has had more impact on the past three decades of my life—both personal and professional—than I ever would have imagined. **PCB007**

References

1. "Red Beat Experiment with Dr. W. Edwards Deming," youtube.com.

Mark Wolfe is an electronics industry executive and consultant for IPC.

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Taking the Fight to Capitol Hill

American Made Advocacy

by Travis Kelly, PCBAA

PCBAA hosted its second annual meeting, June 13–14, in Washington, D.C. It was great to see our founding members as well as many new corporate and individual members. On the first day, we heard from senior officials at the Departments of Commerce and Defense, as well as several members of the House and Senate. We spent the second day on Capitol Hill lobbying for the Protecting Circuit Boards and Substrates Act (PCBS). I am pleased to report that several members of the House of Representatives pledged to become cosponsors, and more are sure to follow.

Our guest speakers shared closely related themes that resonate on Capitol Hill:

- There are real risks associated with dependence on Asia
- The Defense Department runs on microelectronics
- We need to bring high-tech manufacturing back to America

They all agreed that the complex microelectronics ecosystem will always be global. They also said the pendulum has swung too far and we are over-reliant on other nations for crit-

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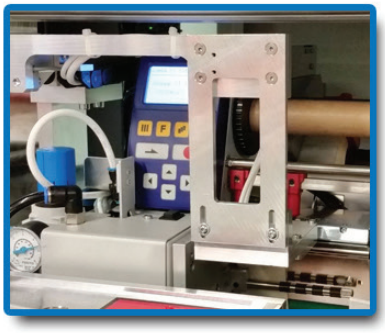

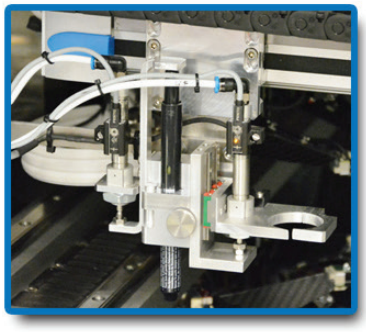

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ical products and materials supporting our national and economic security.

We all know the statistics and they are sobering. We make barely 4% of the world's PCBs and an even smaller percentage of the substrates and advanced packaging. These are risk factors as well as stark reminders of what happened when we took our eye off the long-term consequences of offshoring.

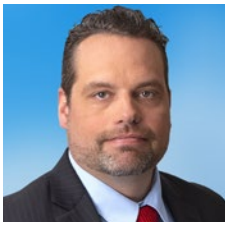
To reverse these trends, our speakers emphasized that it would take a "whole of government" approach. No single agency can solve these problems. Coordinated policy and legislative action is needed.

For example, the Department of Commerce is imposing export controls so that critical technologies don't get into the hands of potential adversaries. The Department of Defense has taken action to prevent the use of microelectronics made in restricted countries. PCBAA was instrumental in getting the right language in the National Defense Authorization Act that ensures the security and resiliency of our Defense Industrial Base.

Our speakers characterized the actions I just mentioned as defensive actions the U.S. can take to stay ahead of peer competitors. However, playing defense alone won't work. Over time, competitor nations will either create better microelectronics or find ways around restrictions.

We need to go on the offense. As we saw in the CHIPS Act, private money followed federal money to invest in all aspects of American semiconductor production. The PCBS Act does the same thing, albeit on a smaller scale. The PCBS Act provides a tax credit for OEMs to purchase American-made PCBs and substrates, and funds workforce development, capital investment, and research and development to innovate and push the state of the art. The PCBS Act is our current vehicle to secure the public investment that will, in turn, attract private investment.

Our speakers also affirmed that numbers matter in Washington. The more members PCBAA has, the louder our voice will be amidst the cacophony of competing interests in our nation's capital. Now is the time to join our team and give our industry the strong voice it deserves. **PCB007**



Travis Kelly is CEO of IsolaGroup and current chairman of the Printed Circuit Board Association of America. To read past columns, click here.

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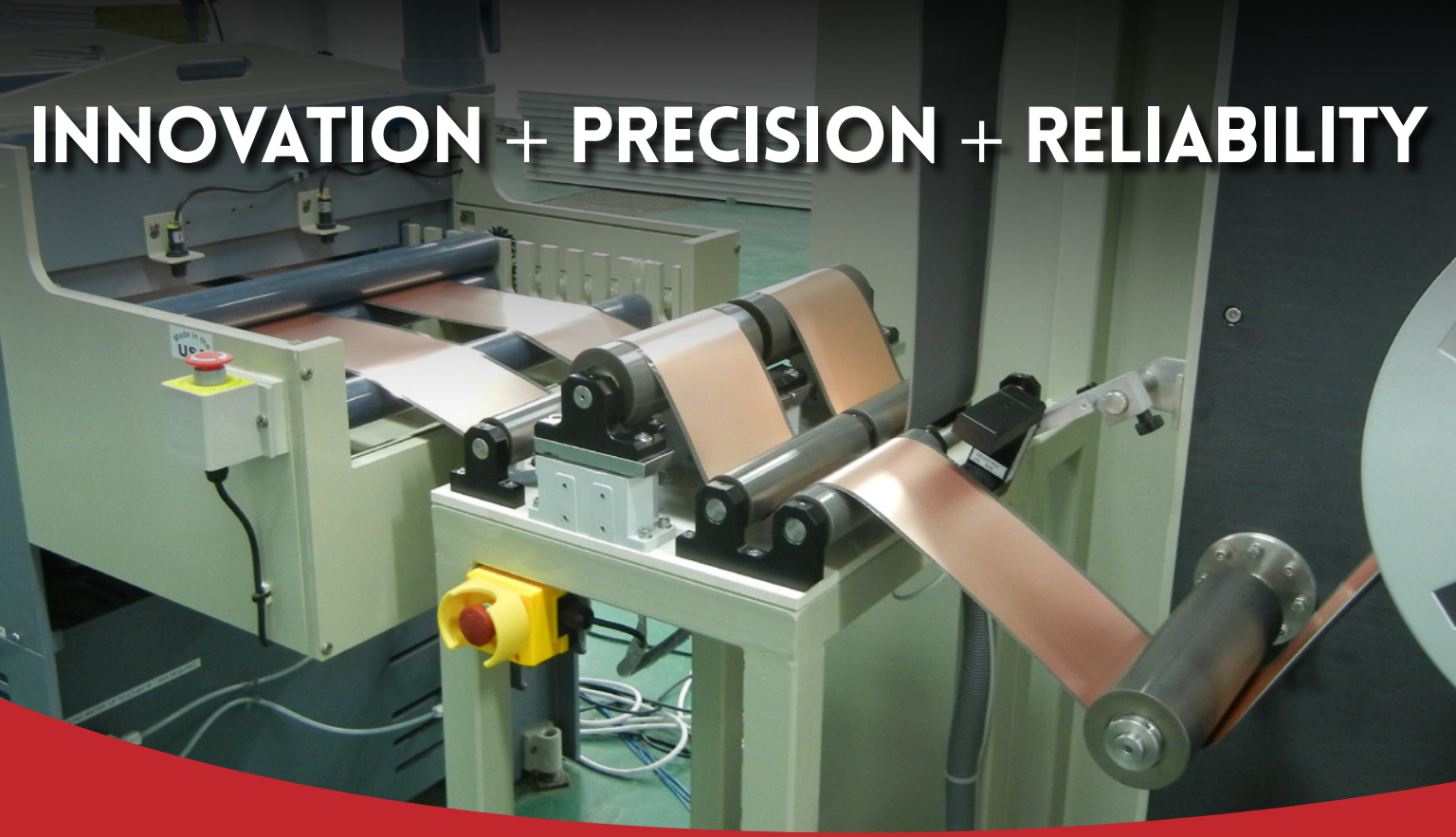

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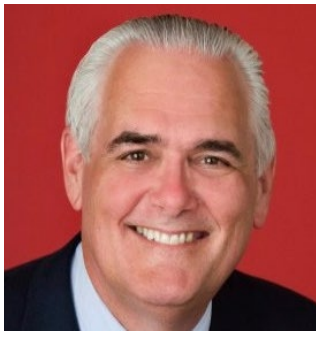
How You Know You're Working With a TQM Company

Feature Interview By Nolan Johnson
I-CONNECT007


Tim Rodgers

We spoke with Tim Rodgers, PhD, a senior faculty instructor at the University of Colorado, Boulder, and an expert in supply chain, about a wide range of topics. In this excerpt, I asked Tim how to determine whether a company in your supply chain follows TQM practices. His well-informed reply leverages his years of experience in the electronics manufacturing industry.

Tim, how can someone tell that they're working with a TQM company?

Everybody is allegedly working on quality but it's hard to demonstrate that quality commitment. Virtually everybody is ISO 9000 certified, so I ask them to tell me about their quality management system. What are they doing to eliminate defects or to prevent them from occurring, not just testing? Don't show me test results or talk about production yields; show me how you prevent defects from occurring in the first place. What investments have you made? What training have you done? This goes beyond ISO 9000.

We used to say that ISO 9000 is doing what you document and documenting what you do. By itself, that does not guarantee quality. I want to hear more about your quality program and your commitment to quality. What did you do the last time you had a quality problem? What actions did you take? Did you shut down the production line? Did you just continue producing bad boards and sort them with a test at the end of the production line?

Is it possible to tell from the outside? How do I know I'm working with a TQM company even before the audit?

I ask them to tell me a story about a quality problem they had recently. How did they respond? Tell me a story about using input from production staff. Tell me about using client input to improve quality and give me some specific examples. What data is being collected? Is that data based only on test results? That's nice, but it's not sufficient. You need to be measuring your processes.

Does the facility have process control? What are the parameters being tracked? I'll ask about specific areas, lamination processes, or the drilling process. How about imaging processes? What are the characteristics they're looking at? What's been done to reduce variability in those processes?

Behavioral interviewing for your vendor?

When I was working with a major Asian PCB fabricator, we used the PCQRR panels for four years to develop our HDI and other fine-line processes. We even built our own testing machine for it. That kind of attention to quality processes is impressive; it should be impressive to a client. It shows commitment and a willingness to use internal resources to track and improve quality, and to reduce variability not just within a single lot, but lot-to-lot variability as well.

This has been great. Thanks for the insight. **PCB007**

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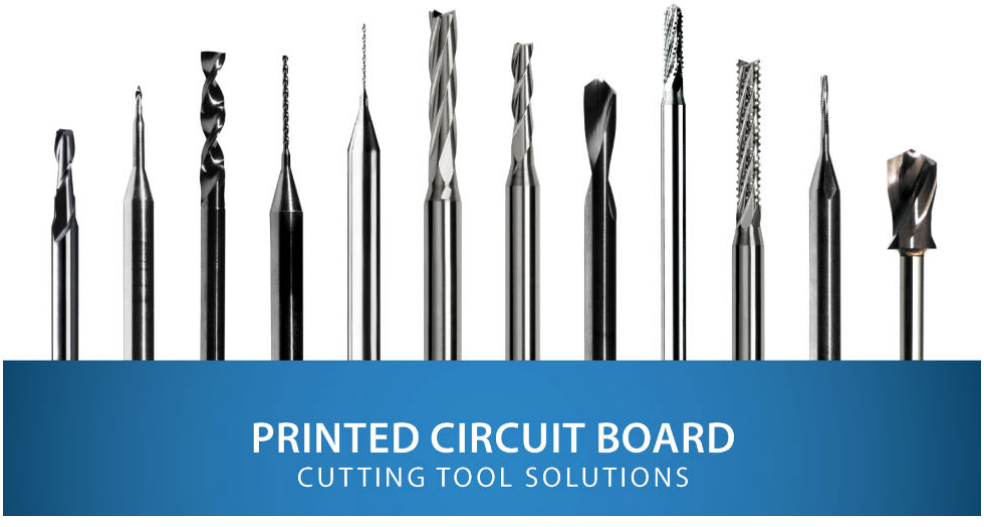

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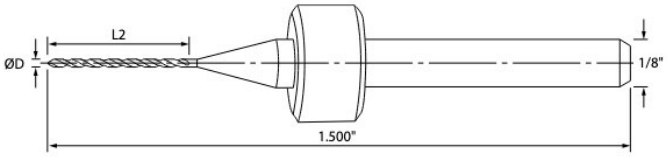

4 Facet Point Geometry

REPOINTING will be a new service offered by Insulectro through Kyocera. The company has recently invested in automated, state-of-the-art equipment and all repointing will be done in Southern California.

Playing the ISO 'Game' for Better Quality

Connect the Dots

Feature Column by Jamin Wilson, SUNSTONE CIRCUITS

If someone asks at your next backyard barbecue, "How is work going?" it might not be gripping to say, "I am improving processes to realize efficiencies based on the ISO 9001 framework." Unless, like me, they are also an ISO nerd. While that's what I'm doing at work, perhaps a more engaging answer would be, "We have turned quality improvement into a game that everyone on the production team can participate in."

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The sum of the scores from each department is tallied at the end of production to calculate a combined score. Each department, shift, and participant are continually challenged to find ways to increase token scores. Our game complements the competitive elements of human nature, whether between different shifts or neighboring departments. The ultimate goal is to improve the system itself, providing everyone with a common goal, and allowing for a friendlier environment, while at the same time improving on-time deliveries and producing higher quality boards.

That's right. We have been gamifying our ISO initiative. Gamification is an extremely useful methodology for companies needing to train new knowledge and skills. It is also used successfully for career development, early group learning, and continuing education. It makes the work more fun and, I believe, makes our business more efficient and our products higher quality.

After 20 years as a lab technician, I moved into administering the quality management systems (QMS). That meant I became the ISO point person. My job is to continue the ongoing improvement that has been integral to our company's success with ISO.

Commitment to ISO Leads to Improved Results

ISO and QMS should be more than a badge on the company website. ISO certification tells the marketplace that your company has created a system that drives continuous improvement of production output.

Even when the QMS functions well and there exists a quality-focused culture, that does not mean it is time to turn on the autopilot. Use the ISO framework to pursue truly continuous improvement. As Jeff Bezos said about developing a space program, we intend to work "step-by-step, ferociously."

Step-by-step is a great model for our work in building custom PCBs for clients. It is a step-by-step process; a PCB board build goes through multiple systems on our factory floor, from masking and plating to drilling and shipping.

ISO 9001 is a lens to look at the work. Each step costs in time and expense. Each team works in a specific area, taking in a job from

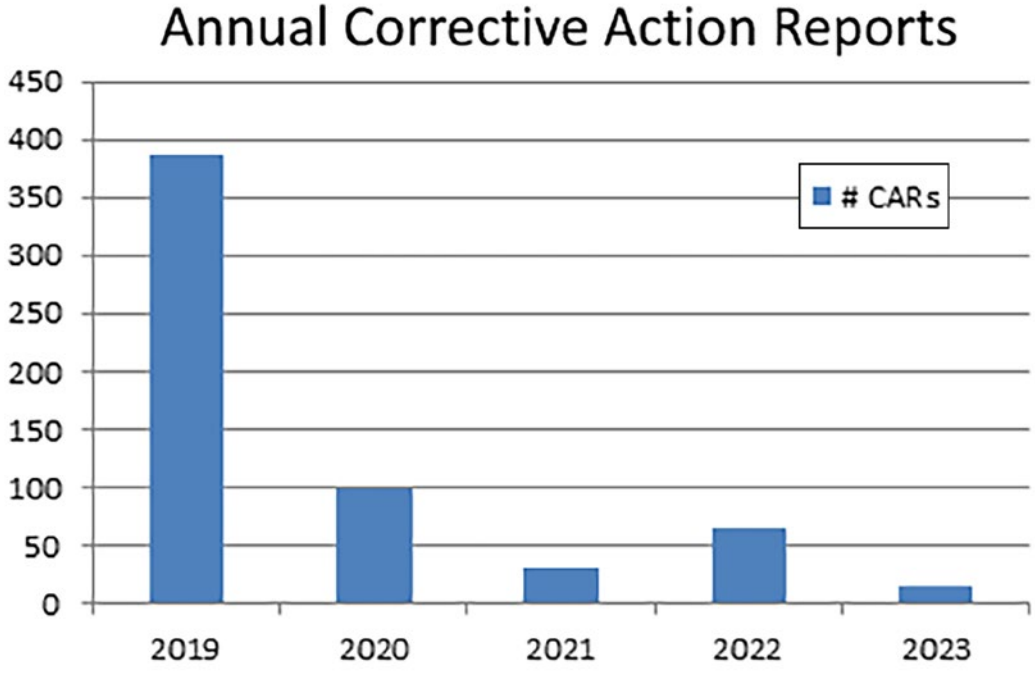

Figure 2: Annual report showing how ISO 9001 adoption led to a reduction in corrective actions. Corrective Action Requests (CARs) are a root cause analysis of a production problem that has occurred.

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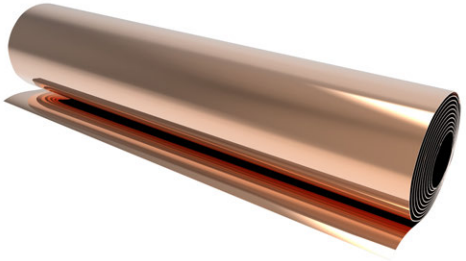

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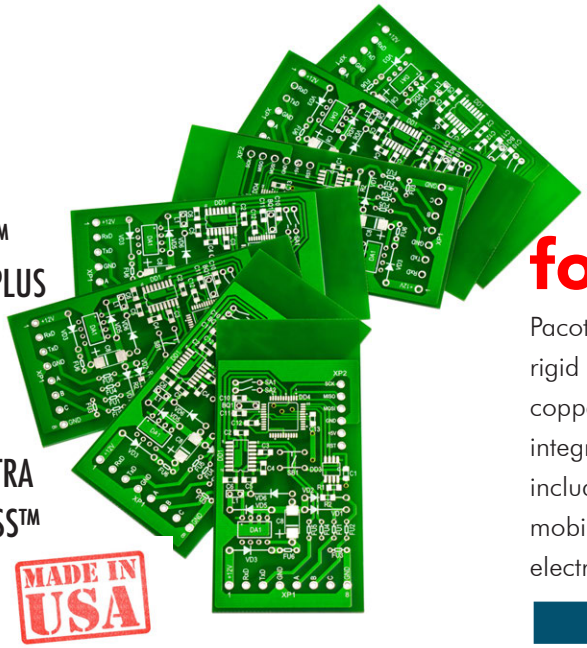

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the previous stage and performing their task, then handing it off to the next.

With ISO, No Cheat Codes

Once we have the systems set up and scored, we bring in the experts. Not outside experts, but the people who work every day on the factory floor on these questions. The teams that operate each process are our experts and have developed all the innovations of our QMS. They are far more familiar with their process than I am. The game helps to train them in ISO and practice in a more engaging way, which helps us as a team consider how changes would affect the process.

For instance, quality checks are a necessary part of manufacture, but they have a high cost. It is expensive to do constant quality checks and does not add value to a functioning board. However, the sooner a failure or error is identified, the less wasted work—tokens—we will spend on that board. Using the game, we can visualize what happens when we move a quality check. The game helps us ask, "Does the increase in time and expense pencil out to more efficiency and better quality?"

> When it comes to generics, there is even more potential for variance.

Visualize, Discuss, and Improve

The game is a way for us to look at our system and see how their expertise can find ways to improve. Are quality checks in the optimal place? Is there redundancy? Could we reduce some of the steps?

Any organization that has been successful with ISO will tell you that this is the key: bringing the team together to visualize and refine their work. The game makes that easier and more fun so we get our creative juices flowing. Not only that, but we can also see the results in a measurable way: more tokens.

We have only been using the game for a short while. It has created more interest and increased momentum in our ISO work. It gives people the buy-in and a global vision of how their work impacts the other aspects of our business. We have animated discussions about maintenance, the supply chain, and the other wraparound efforts that impact the business with the same abstraction of tokens expended. It gives flight to our collective purpose.

Figure 3: An example of our game "tokens."

The accumulated wisdom of the team captured with the game then forces action by leadership. The measure of tokens makes it easy to communicate the impact of proposed changes.

ISO initiatives are ripe for gamification, and we are really happy with how it has energized our initiatives. Maybe soon team members will be working to get on a leaderboard of tokens saved. **DESIGN007**

Jamin Wilson is quality systems administrator at Sunstone Circuits.

Editor's Note: This column first appeared in the July 2023 issue of *Design007 Magazine*.

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Processes to Support IC Substrates and Advanced Packaging, Part 3

Trouble in Your Tank

by Michael Carano, IPC CONSULTANT

Introduction

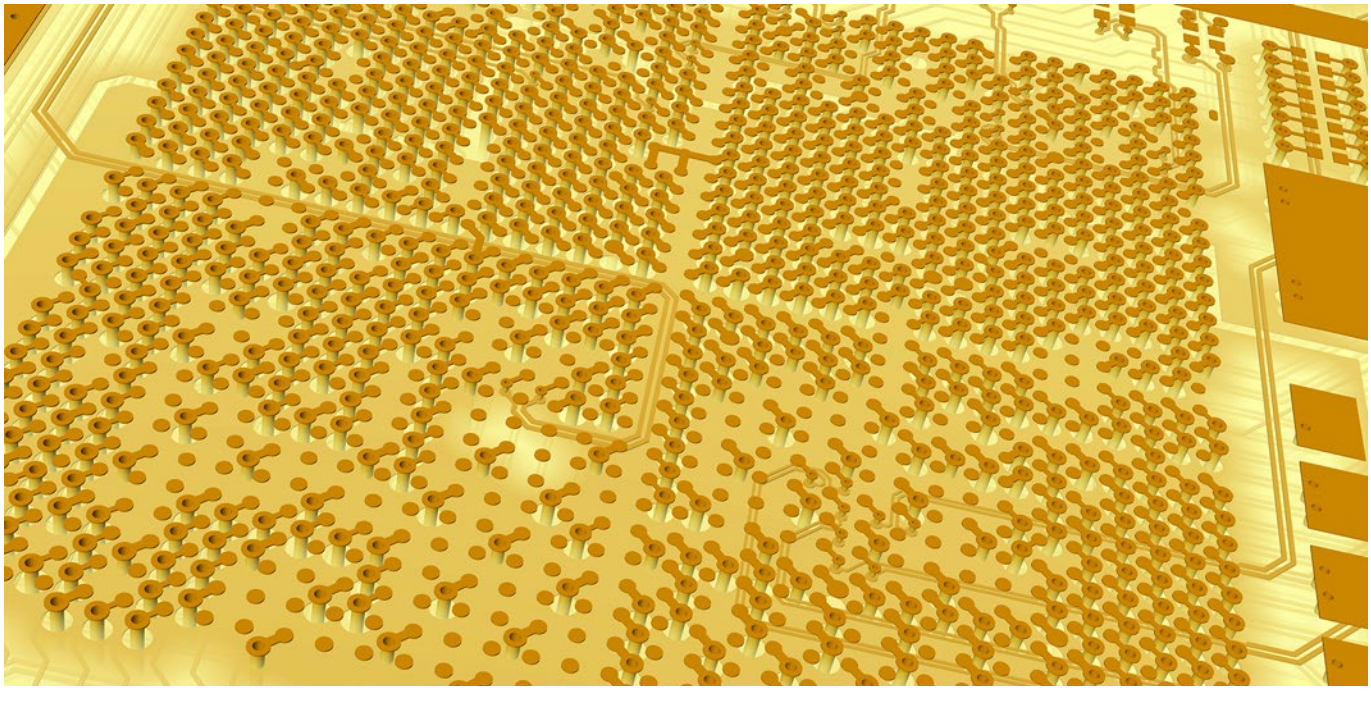
In two previous columns, I explored several of the key competencies and processes required to successfully jump into IC substrates. In this edition, the key process of desmear will be explored.

Desmear: Alkaline Permanganate and Plasma Methods

These processing steps require additional improvements over normal through-holes due to small diameter through-holes and blind vias. Getting process chemistries down into these small holes can be very difficult, especially if they have any trapped air bubbles. If baskets or racks are used in the vertical, there needs to be a way to "bump" the racks to dislodge the bubbles. Installing vibration on the plating racks and frames is critical. Other important considerations include:

- Equipment modifications requiring spray rinsing and flood processing for small diameter blind vias
- Move toward direct metallization to eliminate gas bubble formation seen with conventional electroless copper (more on this in a future column)
- Conveyorized processing as opposed to vertical immersion systems
- Required online process monitoring; everything requires tighter control

Consider processing tools that flip the conventional thinking upside down and instead



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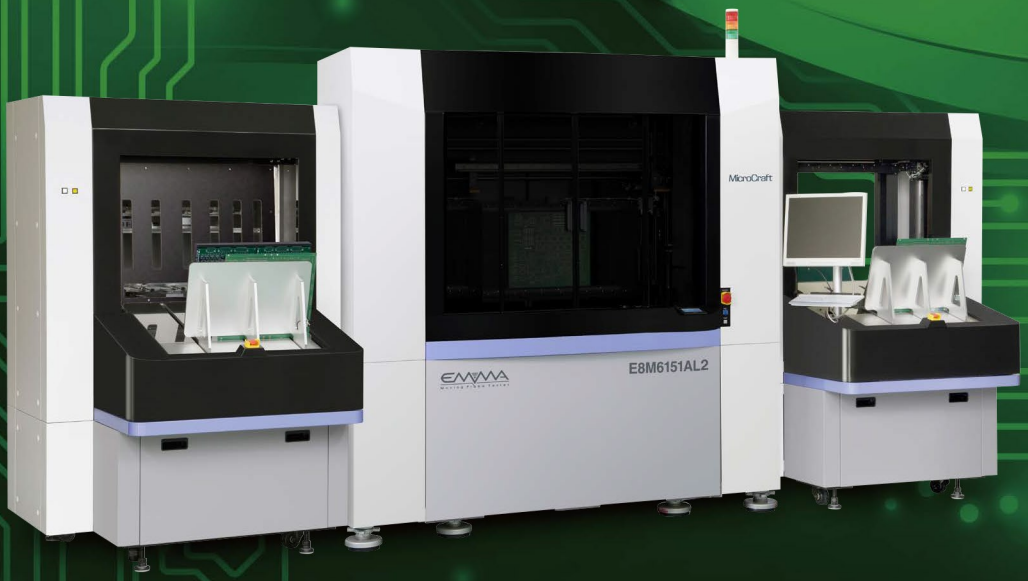

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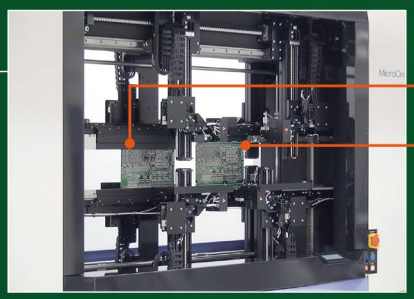

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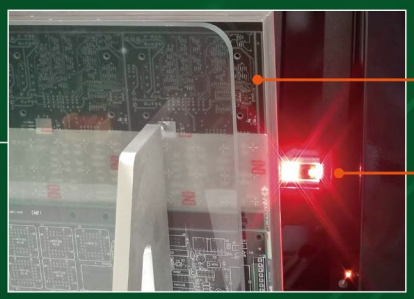

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Let's face it: Things go wrong. Conventional electroless copper has been used in the fabrication of printed circuit boards for more than 50 years. You would think that because we've experienced everything that can go wrong, history will never repeat itself. That is simply not an accurate statement. Chemical processes are dynamic, not static. Ever-changing concentrations, specific gravity, additive breakdown products, etc., influence process and deposit quality. In turn, these affect reliability and should not be taken lightly.

Desmear

It's important to understand the material properties of the resin systems you are using to build your boards. Not all FR-4 materials are created equal. Pay close attention to the Tg and Td of the material sets in question. Review the IPC slash sheets and supplier data packages for further information. Resin blends, the type of cross-linking agents used, and other additives such as fillers, will influence the degree at which resin smear is formed and can be removed by the desmear process.

The SEMs in Figure 1 show the surface conditions of the blind vias as well as the properly filled/plugged via. Figure 2 shows the results

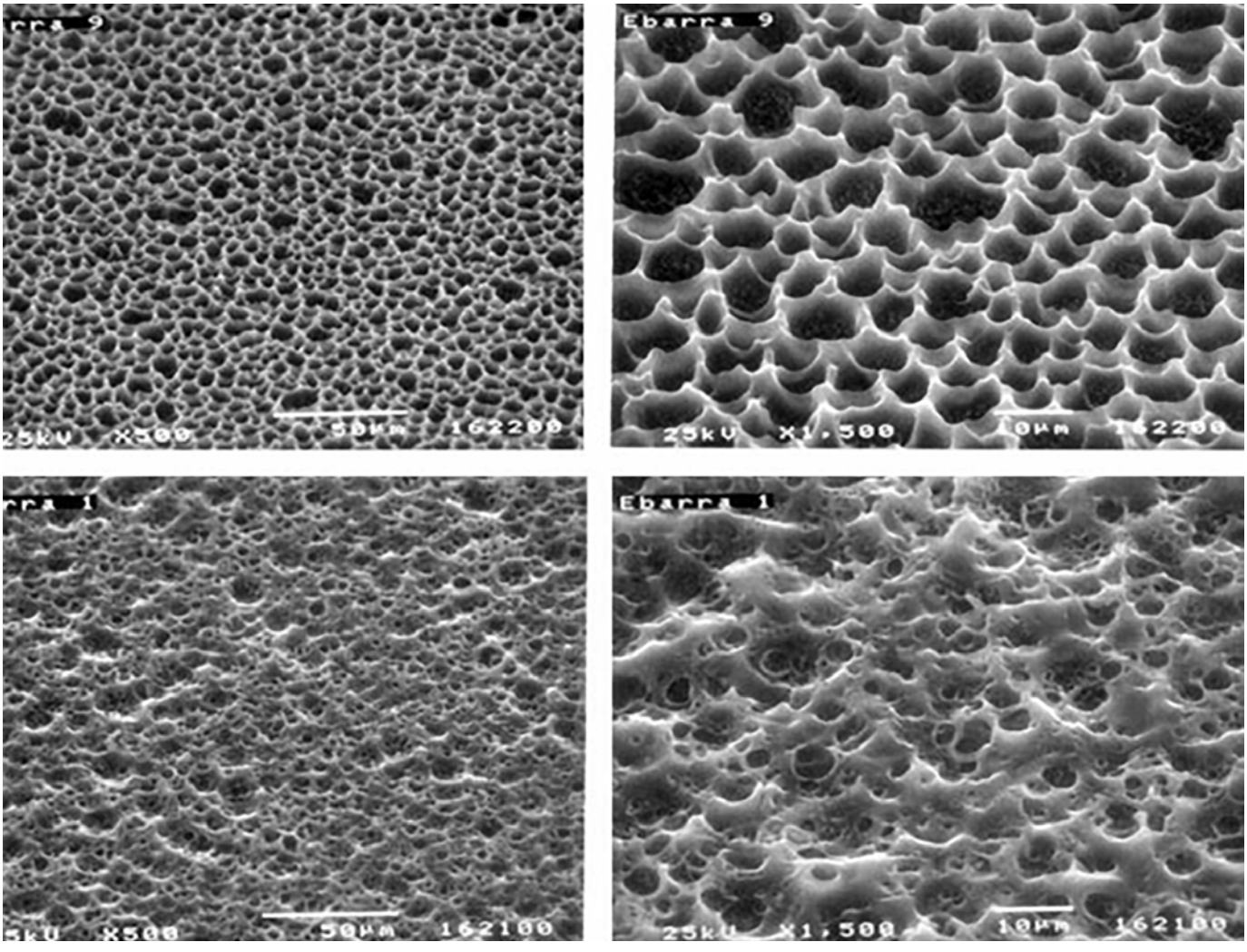

Figure 1: With alkaline permanganate desmear (top row), SEMs for 140° Tg material, and (bottom row) 170° Tg material. Note the difference in the topography of the two resin materials under the same desmear conditions.

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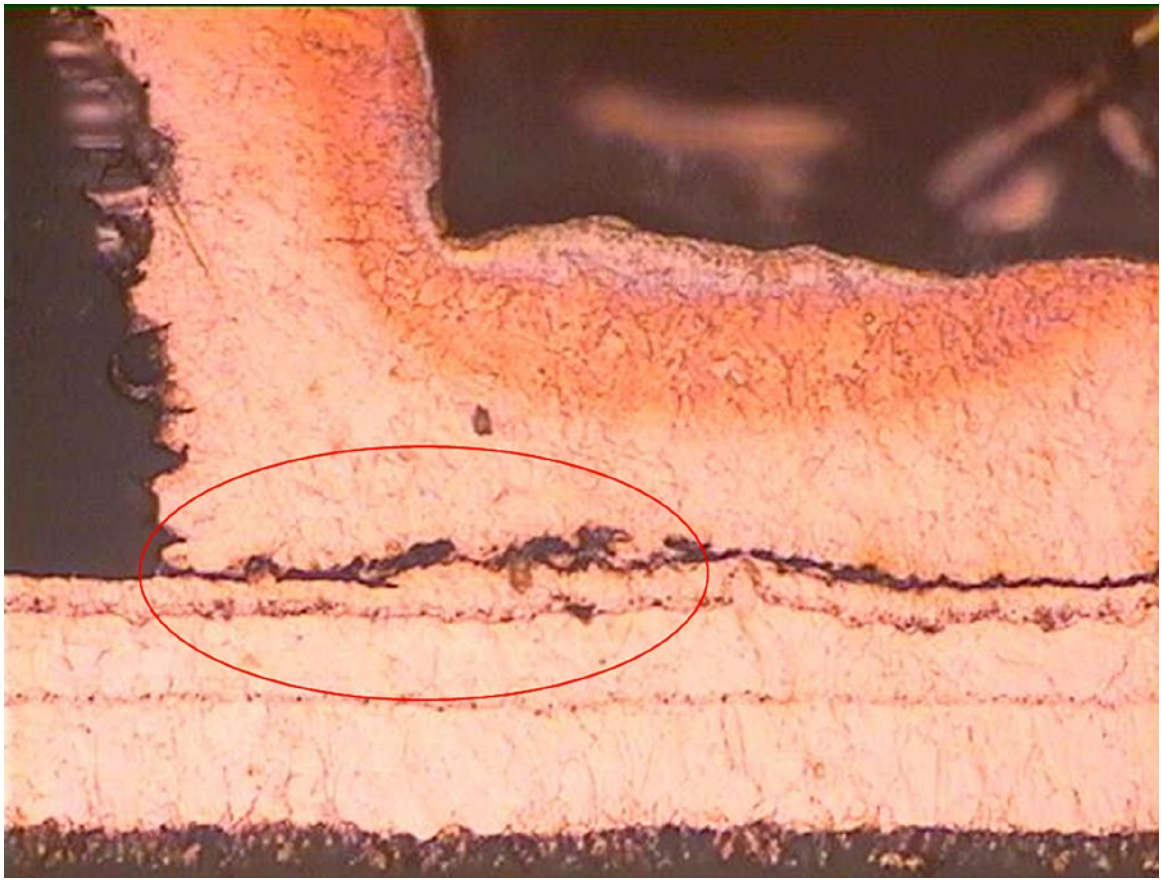


Figure 2: Resin remaining on the pad.

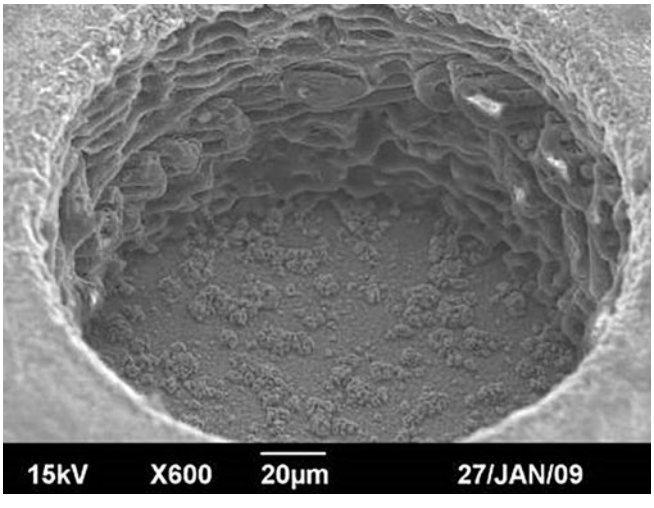


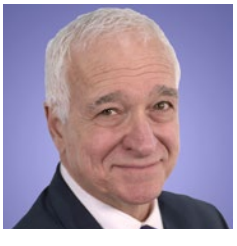
Figure 3: Remaining residues after laser via formation. Residues are clearly evident on the pad.

of an improper or neglected desmear process where residual epoxy from laser drilling is still present and presents an unreliable hole connection.

In Figure 2, one can see the separation of the plated copper from the target pad. A possible solution to this situation would be to employ plasma desmear. Indeed, many firms in the industry today utilize a combination of plasma desmear and chemical desmear (alkaline permanganate) to ensure a target pad free of any organic by-products. Another example of debris is shown in Figure 3.

While this certainly adversely affects long-term reliability, the defect can be remediated with proper attention to the laser via formation process and desmear operation.

In my next column, my discussion will focus on metallization—conventional electroless copper and direct metallization as an alternative. **PCB007**



Michael Carano brings over 40 years of electronics industry experience with special expertise in manufacturing, performance chemicals, metals, semiconductors, medical devices, and advanced packaging. To read past columns, click here.

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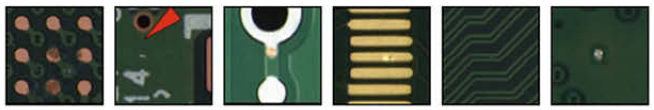
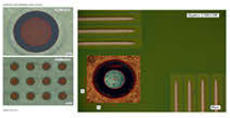


BGA | Missing Legend | Soldermask breakage | Pinhole | Defect Under SM | Soldermask Peeling

PrintProcess



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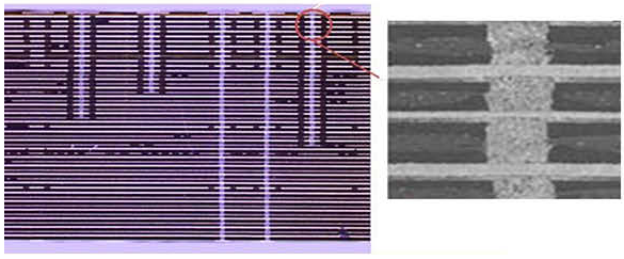

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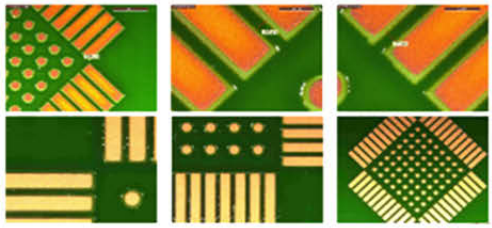

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Last fall, the U.S. Air Force Life Cycle Management Center and Raytheon Technologies successfully tested the Air Force's first palletized high-energy laser weapon during four days of continuous live-fire exercises at White Sands Missile Range in New Mexico.

BAE Systems Unveils NavGuide GPS Receiver ▸

At the Joint Navigation Conference in San Diego, BAE Systems unveiled NavGuide, a next-generation Assured-Positioning, Navigation and Timing (A-PNT) device featuring M-Code Global Positioning System (GPS) technology.

AT&S Wins the Airbus Avionics Supplier Award for 'Best Improvement Project' ▸

AT&S's long-standing customer, Airbus Avionics, chose AT&S's copper recycling project "AERIS" as best improvement project at the 1st Airbus Avionics Supplier Day in Toulouse.

Altium 365 GovCloud Offers Increased Security ▸

Altium recently launched Altium 365 GovCloud, a dedicated platform accessible only to—and managed solely by—U.S. persons. The company says that GovCloud can help customers to be in comply with ITAR, EAR, and other requirements. I spoke with Bruno Blasigh, director of Cloud Security for Altium 365, about the new platform, how it functions, and how GovCloud can help to keep foreign entities from accessing your data.

Lockheed Martin, GlobalFoundries Collaborate to Advance Innovation and Resiliency of Chips for National Security ▸

Lockheed Martin and GlobalFoundries (GF) announced a strategic collaboration to advance U.S. semiconductor manufacturing and innovation and to increase the security, reliability, and resiliency of domestic supply chains for national security systems. The collaboration between Lockheed Martin and GF directly supports the CHIPS and Science Act's objectives of increasing traceability, provenance, and onshore production of critical semiconductor technologies to strengthen national and economic security and domestic supply chains.

CERcuits Wins Second Place in US Army's xTechInternational Competition with it 3D Ceramic Circuits Solution ▸

CERcuits BV, a Belgian technology company specializing in ceramic electronic circuits, proudly announces its achievement as the second-place winner in the prestigious xTechInternational competition organized by the U.S. Army.

Rigid-flex, Rigidized Flex, or Hybrid Flex? ▸

In a recent interview with *Design007 Magazine* managing editor Andy Shaughnessy, he asked me about rigid-flex and its new popularity. This seems like a perfect opportunity to dig into the topic and discuss the differentiation between rigid-flex, rigidized-flex, and what I am calling a hybrid flex.

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Beyond the Horizon: Exploring the Digital Future of Health

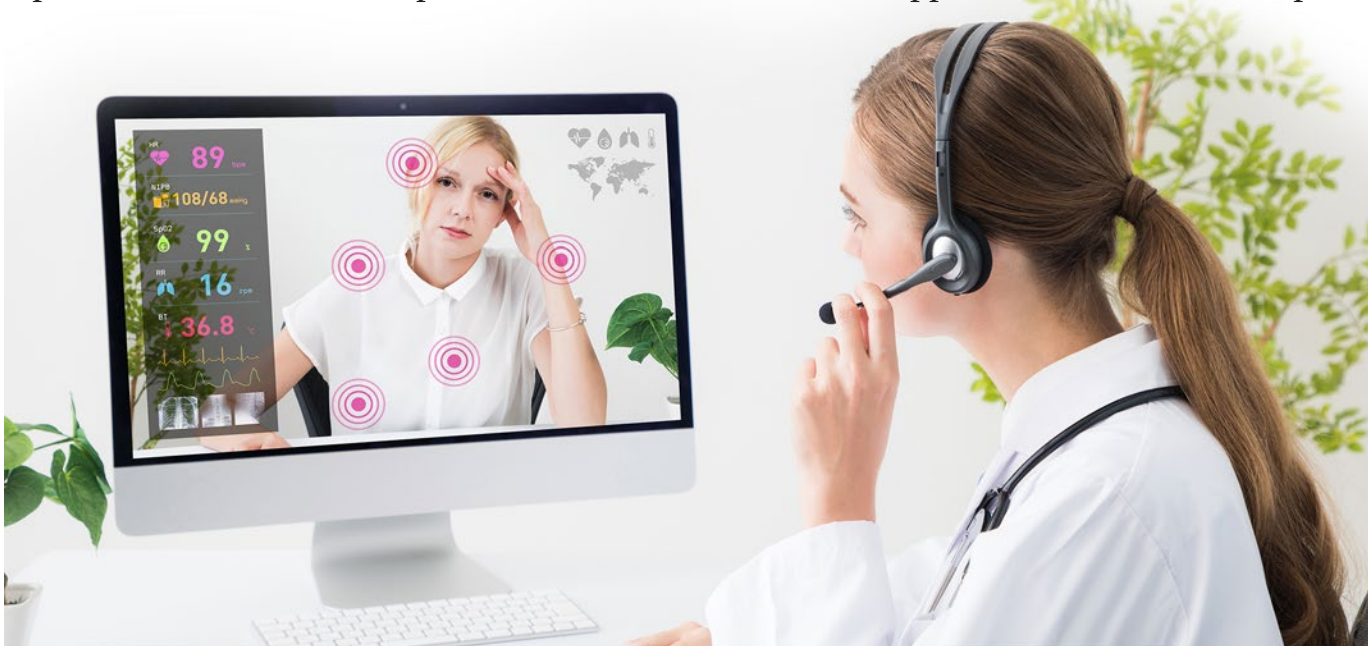
The Doctor's In

by Henry Crandall, UNIVERSITY OF UTAH/IPC STUDENT BOARD MEMBER

In today's fast-paced world, where technology has infiltrated almost every aspect of our lives, it is no surprise that the healthcare industry is undergoing a digital revolution. The convergence of health and technology has given rise to an era of digital health, reimagining how we approach patient care, monitoring, and even medical training. Despite a projected market value of $800 billion by 2030, and an impressive compound annual growth rate of 18%, you may feel that digital healthcare doesn't seem to have reached your local clinic. Stay tuned. This article will walk you through how digital healthcare plans to reform every aspect of the medical landscape.

What Is Digital Health?

Digital health exists at the intersection of healthcare and technology. It entails the integration of digital tools, such as mobile applications, wearable devices, electronic health records, and telemedicine, into the healthcare ecosystem that enhances the delivery of services, improves patient outcomes, and streamlines healthcare processes. From remote patient monitoring and virtual consultations to using artificial intelligence and data analytics for diagnostics and treatment, digital health encompasses a broad spectrum of technologies and innovations that aim to revolutionize how we approach healthcare. It empow-



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ers individuals to take control of their health, provides healthcare professionals with real-time data and insights, and creates a more efficient and accessible healthcare system overall. In short, digital health harnesses the power of technology to transform and optimize the healthcare landscape, ultimately paving the way for a healthier future.

If that definition sounds too fuzzy, here are four specific areas where digital health is already changing the standard.

Remote Patient Monitoring

Picture a patient recuperating at home, miles away from their healthcare provider, yet receiving seamless care and attention. Thanks to digital health, this will soon become a reality. Remote patient monitoring will enable healthcare professionals to keep a close eye on their patients' vital signs, symptoms, and overall well-being, all from the comfort of their own homes. Gone are the days of arduous hospital stays for minor conditions. Now, patients can enjoy the comfort of their own surroundings while still receiving top-notch care. It's like having a healthcare professional on speed dial, ready to attend to your needs whenever necessary.

Wearable Health Devices

Remote patient monitoring would not be possible without wearable health monitors. They have taken the concept of remote patient monitoring to a whole new level. These nifty devices are designed to be worn discreetly and can track various health metrics, from heart rate and blood oxygen saturation to sleep patterns and physical activity. It's like having a personal health assistant right on your wrist. These wearables provide individuals with a deeper understanding of their health and allow healthcare professionals to gather accurate and real-time data for better diagnostics and treatment plans. These tiny gadgets are critical for clinical and consumer digital health.

Virtual Reality Training

Now let's shift our focus to the realm of medical and patient training. Digital health has transformed how we educate and empower aspiring healthcare professionals and patients alike. Through virtual reality (VR) and augmented reality (AR) technologies, medical training has become more immersive and engaging than ever before. Medical students can now step into the shoes of experienced surgeons, practicing complex procedures in a safe and controlled environment. Patients, on the other hand, can benefit from interactive simulations that help them understand their conditions, treatments, and potential outcomes. It's like unlocking a whole new dimension of knowledge and empowerment, all through the power of digital innovation.

Electronic Health Records

Finally, digital health isn't just limited to individual experiences; it's also reshaping how clinics and hospitals operate. Picture a smarter clinic where patient check-ins are seamless, medical records are easily accessible, and waiting times are minimal. By integrating electronic health records (EHRs) and advanced data analytics, clinics and hospitals can streamline their processes, ensuring that healthcare providers have all the necessary information at their fingertips. This not only improves efficiency but also enhances patient safety and satisfaction.

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It's like upgrading from an old-fashioned flip phone to the latest smartphone—everything becomes smarter, faster, and more efficient.

Final Thoughts

The digital health revolution has ushered in a new era of healthcare, bringing with it a plethora of benefits and possibilities. Remote patient monitoring allows for personalized care, wearable health monitors empower individuals to take charge of their well-being, and digital training tools enhance medical education and patient empowerment. Moreover, integrating digital technologies in clinics and hospitals paves the way for more intelligent and efficient healthcare systems. So, even if you still feel frustrated with the current state-of-the-art health services, stay tuned. The wonders of digital health present bountiful opportunities. After all, when health meets technology, the result is nothing short of revolutionary. **PCB007**

Henry Crandall is the IPC Student Board Member. He is a graduate of University of Utah and currently pursuing a PhD in electrical engineering as the Advancing Research in College Scientists Graduate Fellow. To read past columns, click here.

Purdue Engineers Create Continuously Tunable Thermal Regulators for Batteries and Electronic Devices

At Purdue University's College of Engineering, Xiulin Ruan and Amy Marconnet have invented patent-pending, solid-state, continuously tunable thermal devices based on compressible graphene foam composites. The devices can dissipate heat, insulate against cold, and function across a wide range of temperatures. Ruan is a professor in the School of Mechanical Engineering. Marconnet is an associate professor in the School of Mechanical Engineering and a Perry Academic Excellence Scholar.

"As batteries and electronic devices get more powerful, managing heat becomes a more crucial issue," Ruan said. "We all know humans have a narrow range of temperature to live comfortably, and that is why we wear shirts in the summer to keep cool and coats in the winter to keep warm. Similarly, batteries and electronic devices have a narrow temperature range to function appropriately as well, and are even more 'picky' than humans."

Conventional thermal switches, analogous to electrical switches that moderate current flow, tune a battery's heat dissipation pathways only by changing the conduction between on and off states. Ruan said the Purdue-invented thermal regulators improve upon this technology by changing the thickness of the material inside the regulators, which helps batteries continually adjust to different climates and seasons.

The commercially available compressible graphene foam Ruan and Marconnet use is built from nanoscopic particles of carbon deposited in a specific pattern with small voids of air in between. When it is uncompressed, the foam acts as an insulator; air pockets keep the heat in place. When it is compressed, air escapes and heat is conducted throughout. The amount of heat transfer can be precisely dialed in depending on how much the foam is compressed.

(Source: Purdue University)

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Embedded (Flush) Circuits

Happy's Tech Talk #21

by Happy Holden, I-CONNECT007

Introduction

In his Tech Talk series, Karl Dietz wrote several times about embedded circuits[1], particularly detailing flush circuit technology and recessed circuit processes. In his column, Karl outlined two processes that have been used to produce these "flush" circuits:

1. Imprint technology, based on the work of George Gregoire at Dimensional Imprint Technology, Inc.
2. Circuit transfer process, based on Samsung Electro-Mechanics. The transfer process, using polished stainless steel as a conductive carrier, is not new. I was introduced to this plate-post process in 1971, when PACTEL in Westlake Village, California, demonstrated its 50-micron microvias, produced using photoresist and the plated-post transfer process. But as laser technology improved for microvia blind drilling, new applications were developed by Amkor and Siemens for using these lasers to create trenches for circuits and SMT lands.

Flush-Embedded Circuits

The flush/embedded circuit (Figure 1) is compared to the conventional subtractive-etched PCB circuit. It has several advantages as the geometries shrink to under 75 microns:

- Reliability and performance are advanced as adhesion is from three sides.
- In many cases, solder mask is not required because lead-free solder paste will not flow or bridge tight geometries.
- Signal integrity improves at very high speeds.
- For some fab processes, photolithography is eliminated (organo-metallic solder pastes).
- An increased number of insulation materials can now be employed.

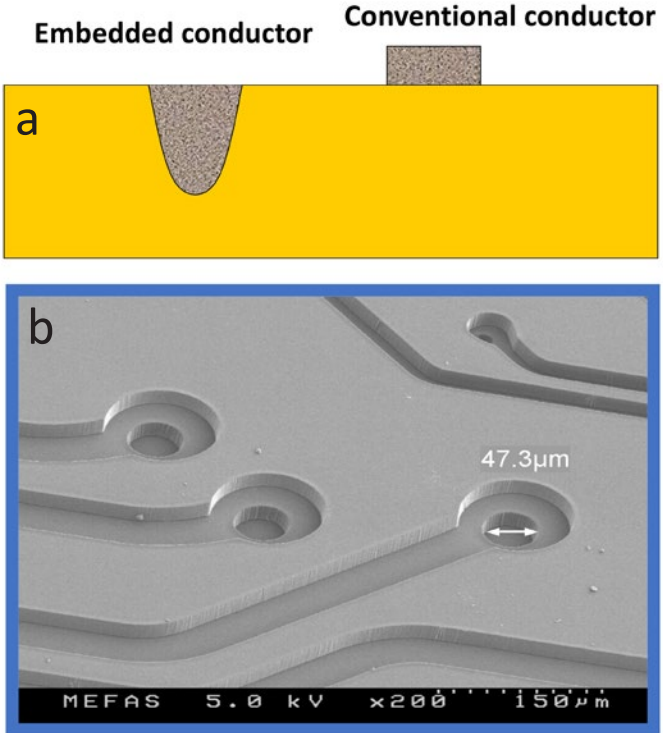
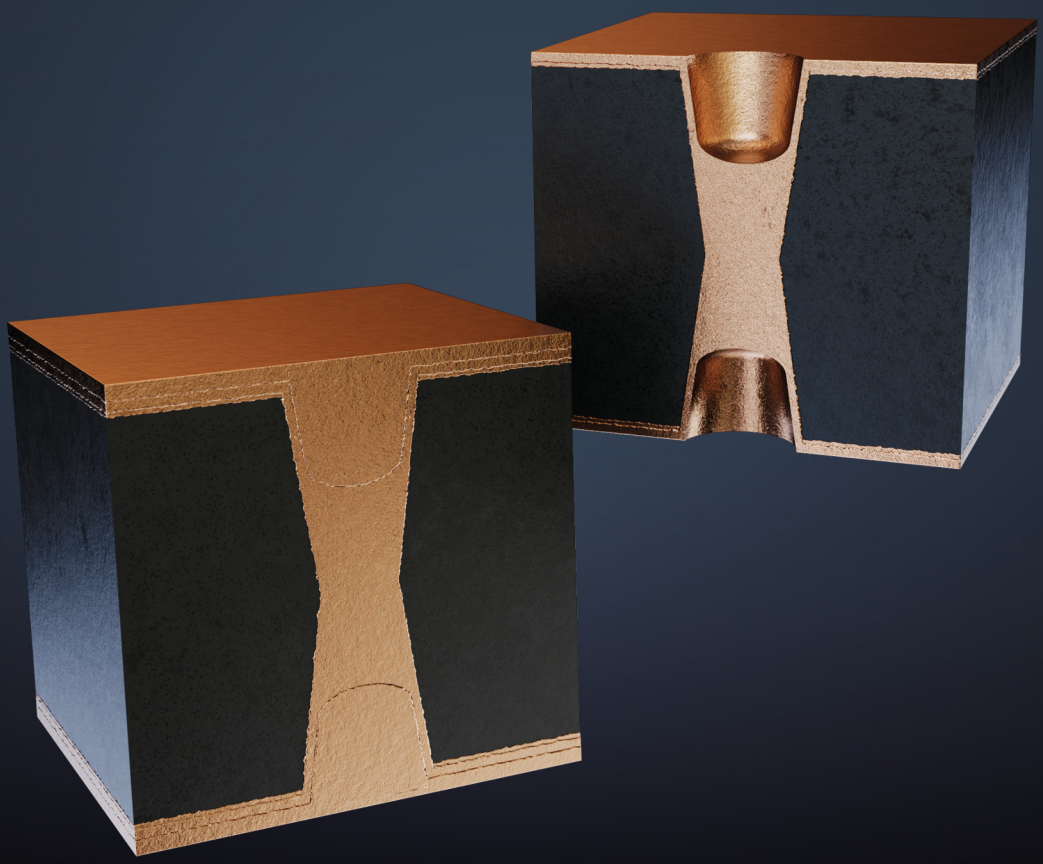


Figure 1: a) An embedded conductor compared to the conventional Cu-foil etched conductor; b) A laser-scribed conductor/land/via path ready for metallization.

Building bridges to higher technologies



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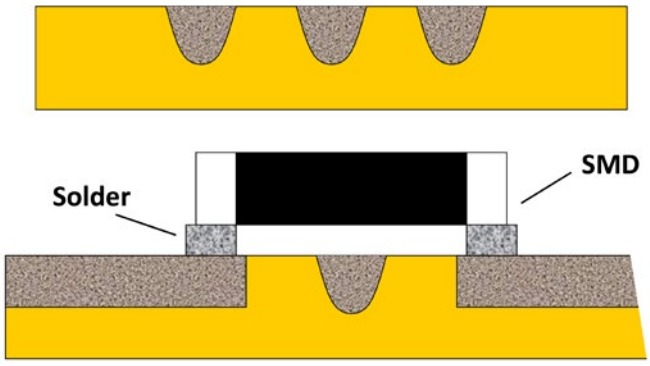

Figure 2: Embedded circuits can provide finer circuitry and flexibility in assembly.

As seen in Figure 2, the embedded traces do not interfere with components assembled over them.

Processes

The transfer process starts with a polished metal substrate that has been coated with a thin conductive release agent. Next, the carrier is coated with a photoresist and exposed to UV light through a mask (or DD imaging) to define the circuit. Once the photoresist is developed, the carrier is cleaned, and metals are plated into the exposed image. Since the carrier will be removed later, the first metal plated (usually gold or silver) will be exposed after fabrication, followed by a plated barrier metal of nickel, and finally copper for conductivity. Following plating, a planarization step provides a flat surface for attachment to a permanent dielectric; then the steps are repeated until the entire circuit is connected. This process is shown in Figure 3.

The Laser Scribing Process

As I described earlier, laser drilling is an integral part of HDI fabrication. Several OEMs have developed processes that use the laser

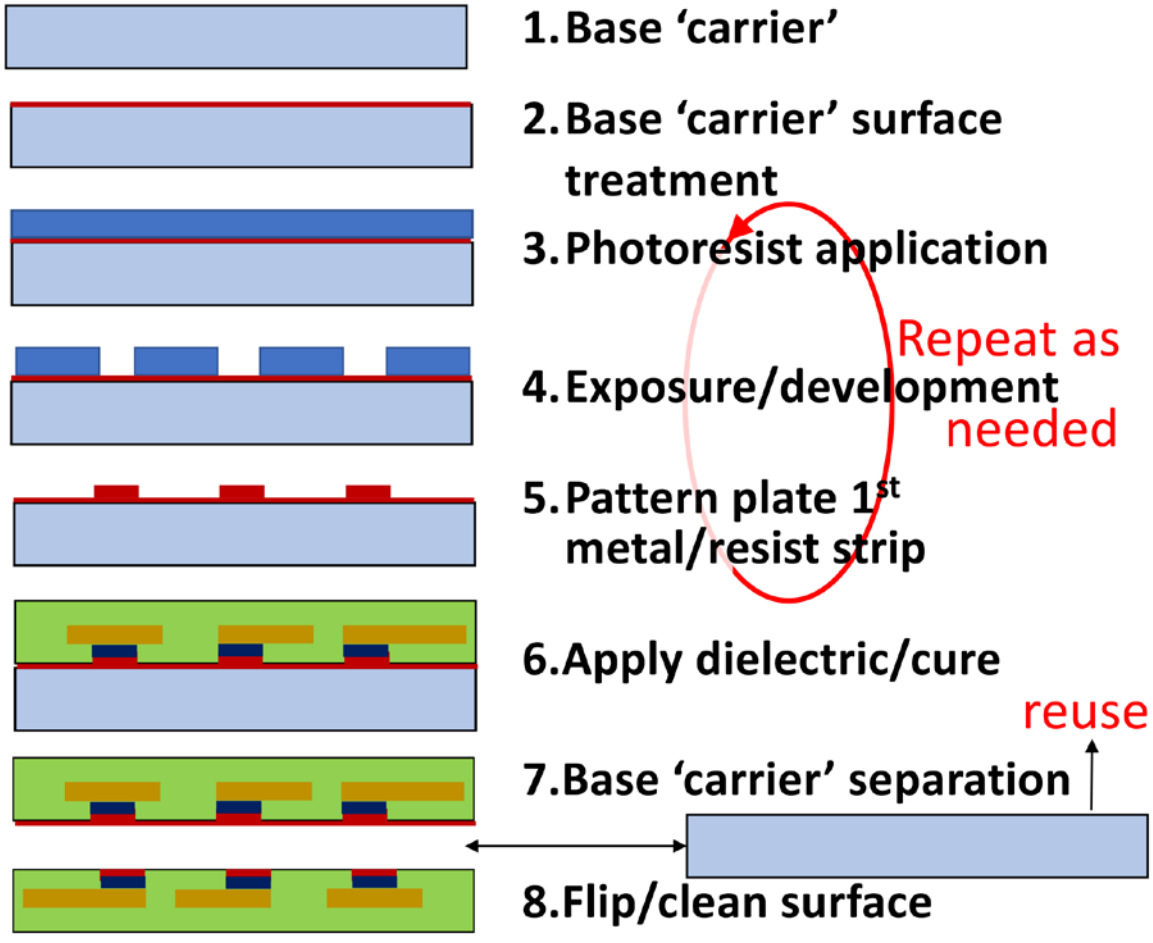

Figure 3: Transfer process using a carrier and photoresist with plating.

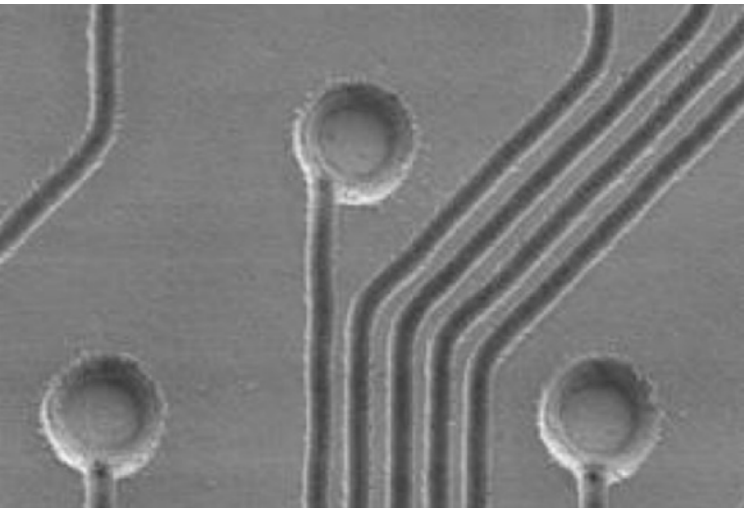

Figure 4: Traces, vias, and pads (near landless) after ablation into the surface of the board[2].

Figure 5: Traces, vias, and pads from Figure 4 now metallized and plated[2].

to scribe the traces and pads into the surface material (Figure 4). After metallization of the substrate and specialized electroplating[2] (damascene fill), the metallization is flash-etched off, resulting in flush circuitry (Figure 5).

Electrolytic Copper Filling Processes

Filling an embedded trench but not the surface requires the new generation of copper plating chemistry.

Vertical and Horizontal Methodologies

One of the new critical process steps which must be mastered in this process is electrochemical deposition (ECD) or electroplating of the trench. Some of the key process specifications, which were transferred from plating wafers to plating panels, include deposition uniformity, substrate throughput, and flexibility for depositing multiple metal layers. Bulk plating, which is used in traditional PCB manufacturing, is not well suited to meeting these specifications.

A new panel-plating tool (racking) was designed to address the needs of advanced packaging on a panel substrate. In place of bulk processing, the tool was designed with a compact series of cells which process a single panel at a time. Using a vertical orientation in the plating cell allows high throughput in a small footprint and enables the inclusion of a set of features which are required for advanced packaging plating applications. The large number of cells and an optimized overhead transport system allow flexible processing with different metals, and a throughput of up to 60 panels per hour. The panels are gripped in a rigid holder during transport and processing, minimizing any issues arising from panel warpage.

Getting to a perfect copper surface required more than just replacing soluble anodes with IrO anodes. It required: [3]

- New membrane technology to isolate the insoluble anode
- Testing and implementing advanced equipment designs
- Understanding the root causes for defects
- Understanding the impact of basic cell design

Shear Plate Agitation

Deposition of metal from a bulk solution involves the transport of metal ions across a hydrodynamic boundary layer at the active surface[4]. The effective thickness and uniformity of this boundary layer is a critical factor in the deposition rate and the quality of the deposit. The vertical cell architecture of the panel plating tool allows the direct application of shear

plate agitation used in wafer plating tools. This style of agitation uses a reciprocating grating near the panel to generate turbulence at the surface and maximize transport efficiency of metal ions and other critical reactants[5].

Vacuum Pre-wet

When the part to be plated includes deep or high aspect ratio features, it is possible for air bubbles to become trapped in the vias or trenches when it is inserted into the plating bath[4]. These air bubbles, held in place by surface tension, can delay or even prevent plating from occurring in those features by preventing the plating solution from making contact with the active surface. The most effective method for eliminating air bubbles is to bring the part under vacuum, and fill the chamber with degassed, deionized water. With no air present, the water fills all the recesses, and now surface tension acts to exclude air as the part is transported to the plating cell[5].

Examples

Many OEMs, PCB fabricators, and OSATs have proposed and created prototype flush circuit ultra-HDI substrates, including Siemens, Samsung, WUS, Unimicron, and Amkor (Figure 6).

Further examples are supplied by WUS in Taiwan[6]. Figures 7 and 8 show the traditional mSAP subtractive process compared to the

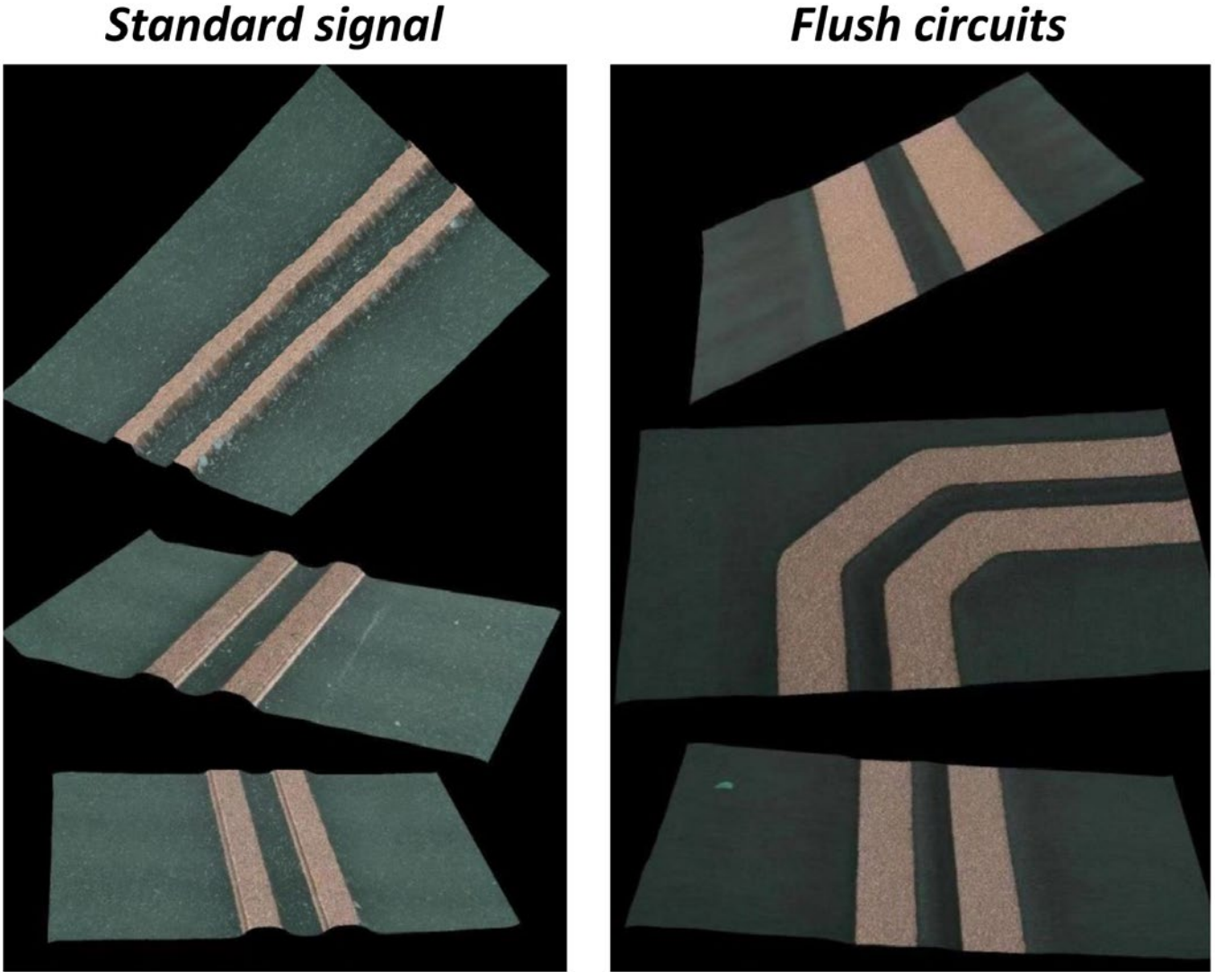

Figure 6: Standard mSAP fine-line circuits compared to the flush circuits.[2]

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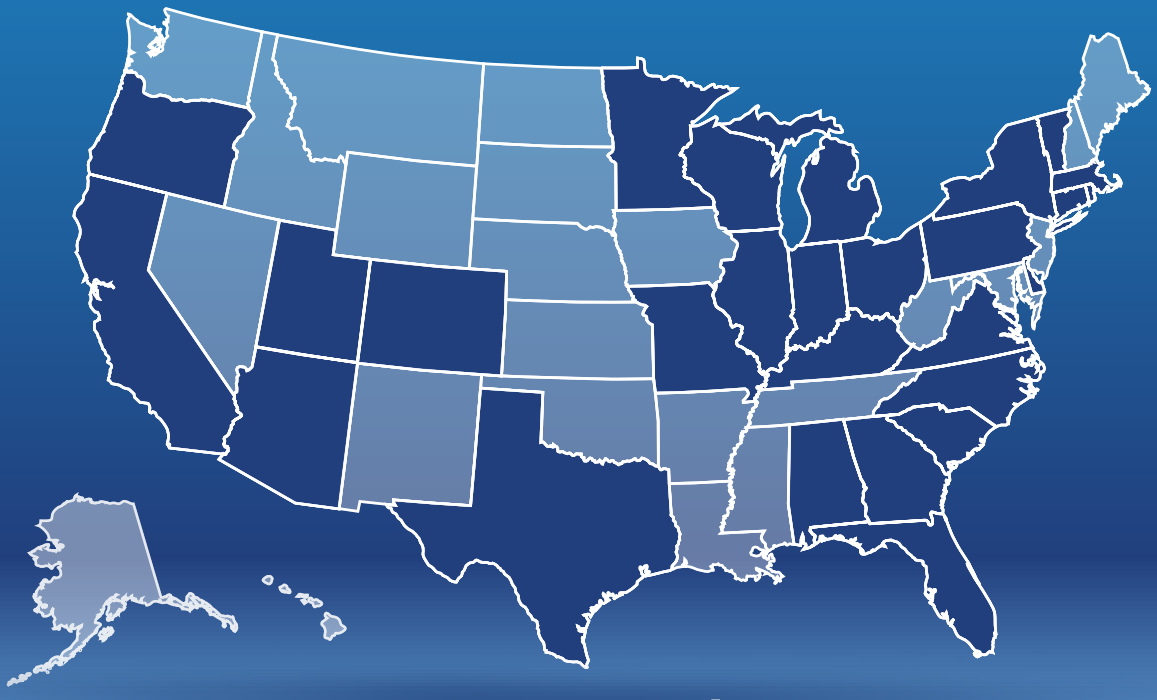

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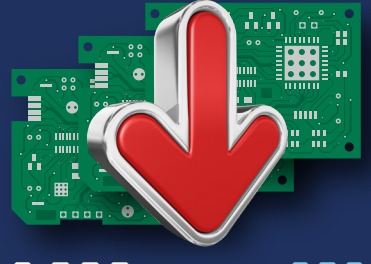

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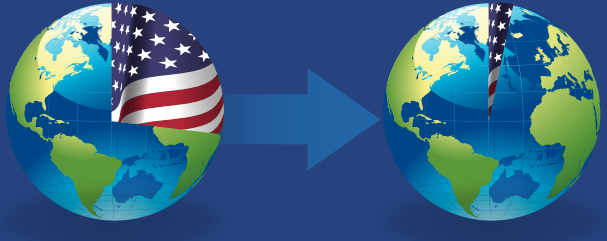

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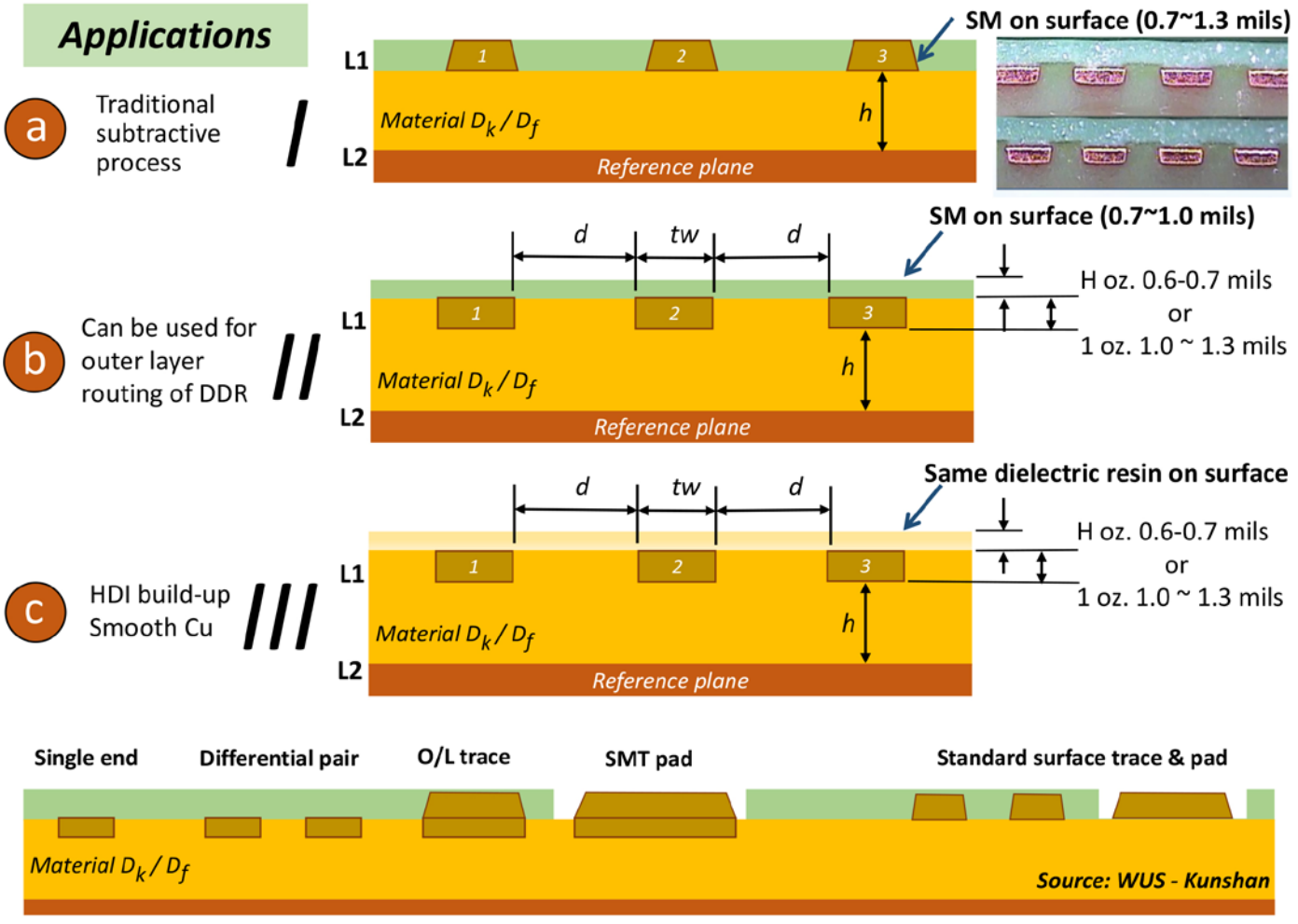

Figure 7: Illustration of three different applications of flush circuits: a) Traditional subtractive circuits as reference; b) Flush circuits as outer layers or inner layer routings; c) Finer-line HDI circuit applications. (Source: WUS-Taiwan[6])

flush process of 1 ounce or half-ounce Cu foil on outer layers or inner layers. Many times, based on density, the flush circuits do not require solder mask to prevent bridging.

Conclusion

As illustrated in Figure 8, the design potential by WUS for RF and high-speed digital circuitry application are apparent in that:

1. There is improved reliability.
   a. Stronger foil-to-dielectric adhesion
   b. BGA ball adhesion to copper pad
2. Improved signal integrity (PIM).
   a. Trace near-rectangular geometry
   b. Smooth copper surface
   c. Minimize crosstalk
3. Other application possibilities.
   a. Selective copper thickness for power or heat dissipation purpose
   b. Very high-resolution outer layer circuit density using conventional chemistry (2.0-3.0 mil or 50-75 µm trace W/S
   c. Same net over two types of materials (patch antenna)[6] PCB007

References

1. Karl Dietz devoted two columns (#125 and #184) to flush circuit technology, but only one went into details about recessed circuit processes (TT#184), *The PCB Magazine,* May 2011.

2. "Selective Copper Metallization for Advanced Packaging," by Rashid Mavliev and Robert Rhoades, Proceedings of the International Wafer-Level Packaging Conference 2020, San Diego, Calif.

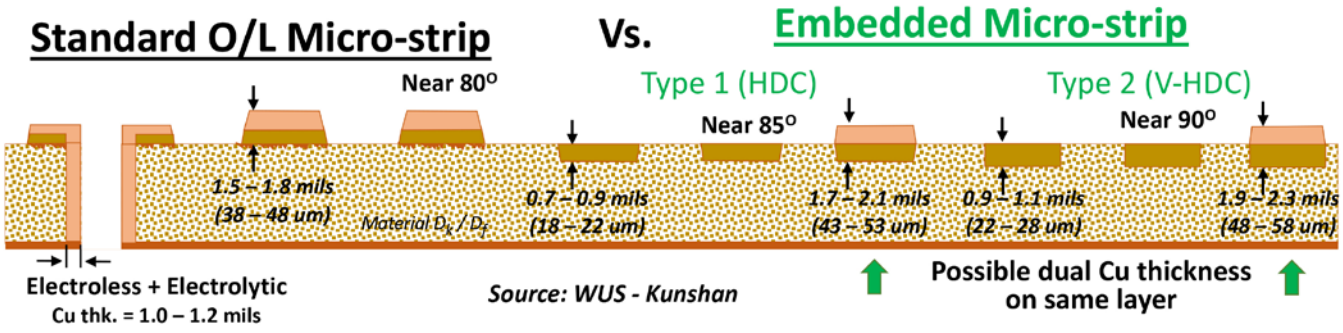

Figure 8: Illustration of high-speed O/L microstrips in standard subtractive process compared to the embedded micro-strip process with optional dual Cu thicknesses. Trace and spacing down to 75/75/75 µm (2.0/2.0/2.0 mils). (Source: WUS-Taiwan)

3. "Unveiling the Next Generation in Substrate Technology," by Ron Huemoeller and Sukianto Rusli, IEEE ECTC, January 2008.

4. "Innovative Panel Plating for Heterogeneous Integration" by R. Boulanger, J. Hander, R. Moon, R. Hollman, SMTA International, Minneapolis, November 2019.

5. These techniques are illustrated in Happy's Tech Talk #19: *"Next-generation Electroplating Systems," PCB007 Magazine,* May 2023.

6. This is from a conversation with WUS Vice President Joe Dickson, 2022.

Happy Holden has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa Westwood, Merix, Foxconn, and Gentex. He is currently a contributing technical editor with I-Connect007, and the author of *Automation and Advanced Procedures in PCB Fabrication*, and *24 Essential Skills for Engineers*. To read past columns, click here.

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TOP TEN

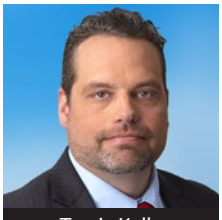
EDITOR'S PICKS

Bill Wilkie

An Exclusive Review of the Institute of Circuit Technology's Annual Symposium

After a long crawl through heavy traffic on the M42 motorway, it was a great relief to exit at Junction 6 and arrive at the National Conference Centre for the 2023 Annual Symposium of the Institute of Circuit Technology on June 6. The conference center is co-located with the historic National Motorcycle Museum and situated in the heart of the UK midlands, a stone's throw from Birmingham International Airport.

Isola Changing With the Times

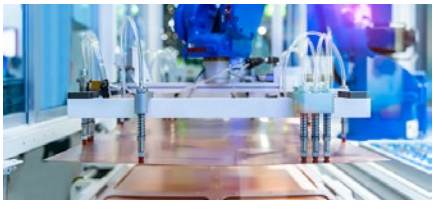


Travis Kelly

Changing market conditions require changes in approach. I-Connect007's Barry Matties and Nolan Johnson speak with Isola's Travis Kelly, Sean Mirshafiei, and Kirk Thompson about Isola's recent responses to market conditions. In this interview, Kelly, Mirshafiei, and Thompson outline recent changes to Isola senior leadership, optimizing manufacturing to meet the needs of the global market, and the strategic importance of advanced packaging to the global economy, and to the U.S., in particular.

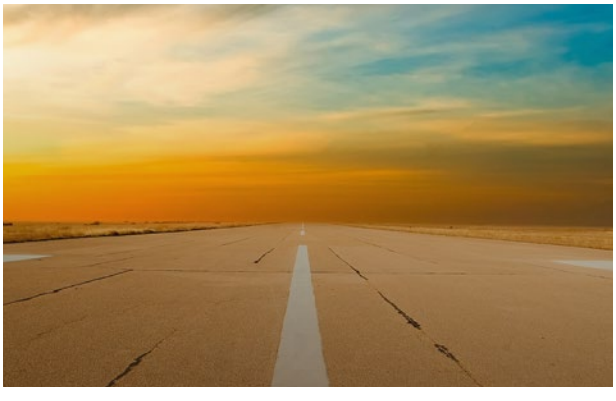
The Chemical Connection: The Challenges of Thin Material

In wet processing, the transport of thin materials and substrates (less than 1 mil in thickness) can be a rather tricky process. These materials are vital in manufacturing flexible circuits, but often this flexibility adds new challenges. Most of these materials are easily damaged, and in some cases require well-trained personnel to handle them.



The Journey to IPC-1791 Validation

How does a company protect its most valuable electronics manufacturing information? How can designs and processes be kept safe? IPC-1791 is an industry-driven and industry-written standard that focuses on protecting two things: controlled unclassified information (CUI) and controlled technical information (CTI)—the information that would be devastating for a company to lose.



Brian Kamradt

Summit Interconnect Welcomes Brian Kamradt as New Chief Financial Officer

Summit Interconnect today announced the appointment of Brian Kamradt as chief financial officer. Kamradt brings over 20 years of finance, accounting, merger and acquisition, and IT experience to Summit's leadership team. He will succeed Tom Caldwell, Summit's initial CFO, who will be retiring after leading the company's expansion for the past four years.

Insulectro Announces New Partnership With Laminate Suppliers Arlon Electronics Materials and EMC

Insulectro, the largest distributor of materials for use in the manufacture of PCBs and printed electronics, has announced it will become the exclusive distributor for North America of Arlon copperclad laminates beginning Sept. 4, 2023. Arlon is also the master distributor for Elite Materials Company (EMC) based in Taiwan bringing both product lines to Insulectro.

Ventec to Strengthen Global Supply Chain and Logistics with New Factory in Southeast Asia

Ventec International Group Co., Ltd., has announced plans to open a new manufacturing facility in Southeast Asia by 2025-26 to extend its manufacturing capabilities beyond China and Taiwan and enhance global supply chain resiliency.

Reduction Assisted Immersion Gold for ENEPIG Surface Finish

RAIG was introduced a few years ago to meet the requirements of newer designs. Since its inception, more gold finishes are finding RAIG to be a viable alternative to standard immersion gold.

PCB Market Poised to Grow at a CAGR of 5.1% and Reach $104.8 Billion by 2033

In 2023, the size of the global printed circuit boards (PCBs) market is anticipated to be US$ 63.5 billion. The growth of the market is being driven by the expanding application in the various end-use industries.

Averatek Names New CEO

Averatek is pleased to announce Scott Meikle, Ph.D. as CEO. Dr. Meikle has more than 30 years of experience in the semiconductor industry.

Scott Meikle

For the latest news and information, visit **PCB007.com**

Hiring for Soft Skills in Technology

Article by Brian Wallace
HR STRATEGIES NOW

In the age of digital transformations and disruptions, many technology companies continue to amaze us with ever increasing capability and the breakneck speed of development. But beneath the surface, nearly every one of those organizations is made up of teams of employees who are tasked with delivering better results year after year. Technical capability is no longer enough to achieve long-term success. Soft skills are now a key factor in distinguishing high performing organizations from those that struggle, and their effect is far reaching.

In this article, I'll explore the role of soft skills as they relate to technology-focused positions and investigate strategies for integrating these skills into the hiring process.

Many technology companies create a major challenge for themselves in that they focus so heavily on identifying and honing the technical skills that they lose sight of these soft skills. This can lead to information disconnects, dysfunctional behavior, and broken chemistry within the team. Missed opportunity often follows.

Initiatives that move the needle for an organization don't happen within a vacuum. They require interdisciplinary teams to work together effectively and efficiently. Soft skills like communication, collaboration, emotional intelligence, and problem solving (among many others) are the capabilities that an individual possesses that enable them to do so. They are central to high team performance and the ability to create raving fans as customers.

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At one level or another, technology employees must interact with internal and external clients and stakeholders who may not have technical backgrounds. Soft skills such as empathy, patience, and the ability to explain complex concepts in non-technical terms are crucial in building rapport, managing expectations, and ensuring their satisfaction.

In the face of unexpected challenges or changes, employees must possess crucial skills such as critical thinking, analytical reasoning, and adaptability. These skills enable them to effectively assess problems, think creatively, and adjust their approach to discover innovative solutions.

The fact is that soft skills directly influence teamwork levels; operational quality; client, stakeholder, and employee engagement; project execution results and, really, the general culture of the organization. Given that level of impact, it pays to focus on these during your hiring process.

Here are five recommendations to consider, specific to soft skills identification, that may help you improve your hiring quality.

1. Analyze the soft skills required for success.

How will the incumbent be interfacing and collaborating with others? Will they be required to translate technical information and concepts into non-technical terms? Will they be working across the organization, or will they be focused on supporting their own close-knit team? How will they be expected to influence the work of others? What are the skills that, if lacking, could be detrimental to the team?

2. Pay close attention to the way they handle and respond to the interview process itself.

Remember that candidates typically put their best foot forward during an interview. Have they prepared? Are they able to present their thoughts clearly? Are they willing to speak up or do they appear timid? Are they proactive in their communication or are you having to draw answers out of them? Does their body language convey confidence? How well are they able to articulate their experiences? If you notice red flags along the way, they may be a perfect fit in some environments but not in others.

3. Move beyond the technical questions.

Ask about their experience in team settings, the role they played, how they responded to challenges, and how they supported the team even when it was uncomfortable. Ask questions that help you identify their ability to handle ambiguity and respond to change. Consider their working preferences and ensure that their values align with those of the organization.

4. Think two steps ahead.

If they are successful in this role, will they have the soft skills required to move into the next? There is a strong temptation to place top performing technical employees in leadership roles over their peers in an attempt to replicate their performance. Remember that leadership is a different skill set. I've seen technically brilliant performers promoted only later to destroy the dynamic of the team because they were not cut out for leadership.

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5. Use an assessment test to identify strengths and weaknesses.

Several assessments are available today that can help identify strengths and weaknesses in a candidate's soft skill set. DISC, Myers-Briggs Type Indicator, and StrengthsFinder are just a few. Depending on the nature of the position, these can be invaluable in establishing and protecting the chemistry of a team.

If the role requires a heavy emphasis on influencing team members (project management) and communicating across organizational lines, consider including others in the interview process to gain a more well-rounded perspective. Conducting interviews in different settings (within the office, over lunch, out for coffee, etc.) can also help you identify how they present themselves to others. It's amazing how much you can tell about a person by observing how they interact with others.

Technology projects thrive on collaboration and teamwork. When soft skills are strong within the team, higher levels of collaboration are possible, knowledge is shared, quality tends to improve, and innovative ideas are given the opportunity to breathe.

Soft skills play a pivotal role in fostering an environment where creativity thrives, challenges are conquered, and customer loyalty is cultivated. By valuing and nurturing these skills during the hiring process, tech companies pave the way for continuous improvement, adaptability, and disruptive innovation. **PCB007**

Brian Wallace is the founder and CEO of HR Strategies Now, a human resources consulting firm based in Cypress, Texas. He holds a master's degree in management and an SPHR certification from the Human Resources Credentialing Institute. He has led transformative HR initiatives across five industries for more than 20 years.

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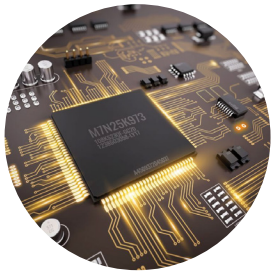

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Sales Engineer SMT North Mexico

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- This position is responsible for expanding our customer network and maintaining existing customer relationships in the Northeast Mexico region. The Sales Engineer would work closely with the German headquarters and the General Manager Rehm Mexico to implement the sales strategy.
- A candidate's proximity to Monterrey, Mexico, is a plus.

Qualifications:

- An Engineering degree or comparable qualification with a strong technical background is required.
- Sales-oriented attitude, good communication skills and willingness to travel frequently within Mexico is essential.

We offer innovative products, a great dynamic work environment and exciting training opportunities in our German headquarters.

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Please send resumes to: Mr. Luis Garcia at luis.garcia@rehm-group.com.

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Europe Technical Sales Engineer

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

PRIMARY FUNCTION:

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

ESSENTIAL DUTIES:

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

QUALIFICATIONS / SKILLS:

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

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

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BLACKFOX
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IPC Instructor
Longmont, CO

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

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

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

Salary: Starting at $30 per hour depending on experience

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

Schedule: Monday thru Friday, 8–5

Experience: Electronics Manufacturing: 5+ years (Required)

License/Certification: IPC Certification–Preferred, Not Required

Willingness to travel: 25% (Required)

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Prototron Circuits

Sales Representatives

Prototron Circuits, a market-leading, quick-turn PCB manufacturer located in Tucson, AZ, is looking for sales representatives for the Southeastern U.S. territory. With 35+ years of experience, our PCB manufacturing capabilities reach far beyond that of your typical fabricator.

Reasons you should work with Prototron:
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- Excellent quality
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- MIL-PRF- 31032
- ITAR
- Global sourcing option (Taiwan)
- Engineering consultation, impedance modeling
- Completely customer focused team

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

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Career Opportunities

KYZEN
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Regional Manager

West Region — Two Positions

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

DETAILS OF FUNCTION:

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

QUALIFICATIONS:

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

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

fernando_rueda@kyzen.com

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EMA Design Automation®

Technical Marketing Engineer

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

Requirements:

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

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

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MACHINES FOR PRINTED CIRCUIT BOARDS

Field Service Engineer

Location: West Coast, Midwest

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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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KOH YOUNG AMERICA

Technical Service & Applications Engineer

Full-Time — Flexible Location

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

Responsibilities

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

Skills and Qualifications

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

Benefits

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

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

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

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

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

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Career Opportunities

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Field Service Technician

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- Performing preventive maintenance
- Providing virtual and on-site training
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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.

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- Soldering and/or electronics/cable assembly experience
- IPC certification a plus, but will certify the right candidate

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Career Opportunities

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Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

The CAD/CAM Engineer is responsible for reviewing customer supplied data and drawings, performing design rule checks and creation of 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 Orbotech/Genflex CAM tooling software.

PHYSICAL DEMANDS

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

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APCT, 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.

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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.

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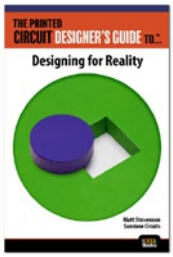


Designing for Reality

by Matt Stevenson, Sunstone Circuits

Based on the wisdom of 50 years of PCB manufacturing at Sunstone Circuits, this book is a must-have reference for designers seeking to understand the PCB manufacturing process as it relates to their design. Designing for manufacturability requires understanding the production process fundamentals and factors within the process. Read it now!

Thermal Management with Insulated Metal Substrates, Vol. 2

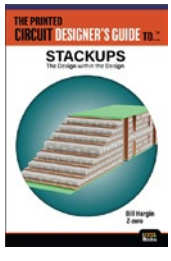
by Didier Mauve and Robert Art, Ventec International Group

This book covers the latest developments in the field of thermal management, particularly in insulated metal substrates, using state-of-the-art products as examples and focusing on specific solutions and enhanced properties of IMS. Add this essential book to your library.

High Performance Materials

by Michael Gay, Isola

This book provides the reader with a clearer picture of what to know when selecting which material is most desirable for their upcoming products and a solid base for making material selection decisions. Get your copy now!



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by Bill Hargin, Z-zero

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