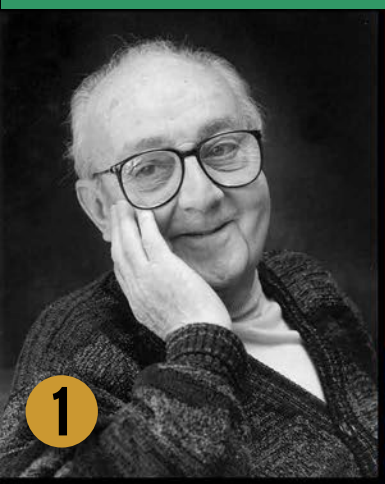
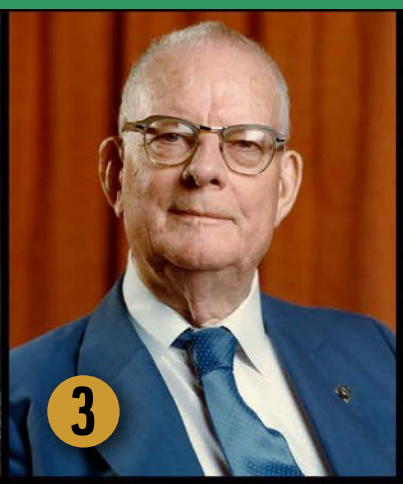
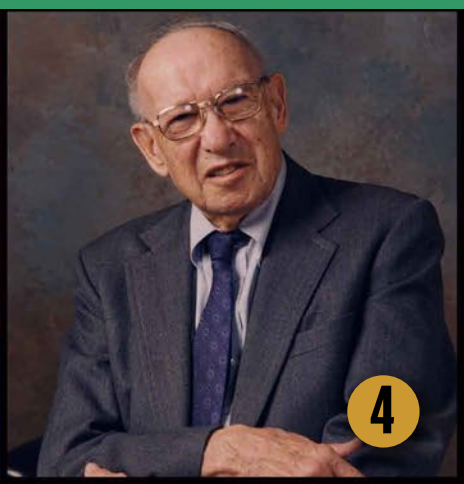
JUNE 2020

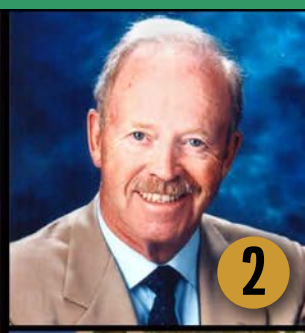
I-Connect007

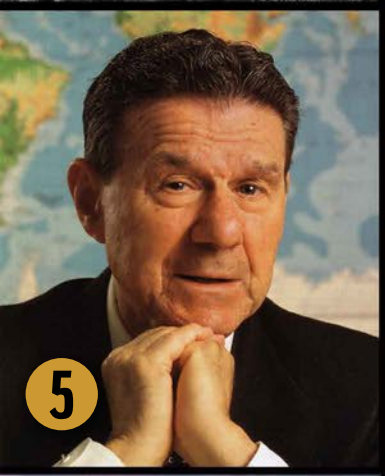
PCB007 MAGAZINE





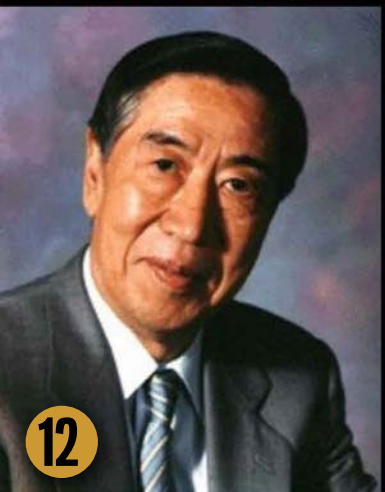






Can you name these fathers of quality?

[click to learn more]



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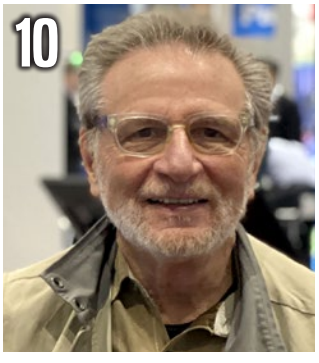
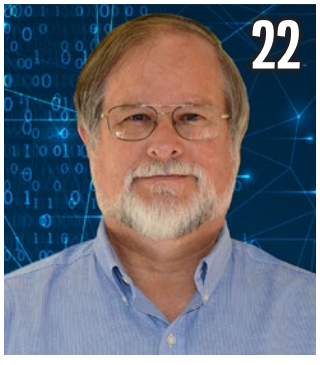
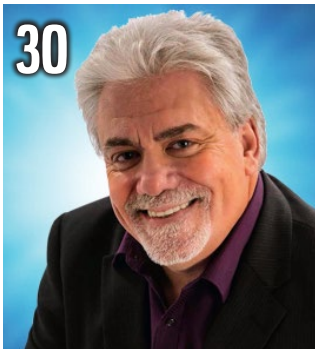
PCB007 MAGAZINE

Are We Back to TQM?

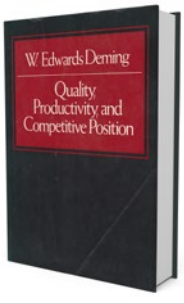
All of the 12 people on the front cover this month were influential in promoting total quality management. TQM is a business management methodology where employees are empowered to improve processes—and therefore, product quality—continuously. In this issue, we discuss TQM as a means to manage change and continuous improvement in your business.







FEATURES:



FEATURE COLUMN:

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Prepreg **R-5680(GN), R-5680(GE)**

(GN):Low Dk Glass cloth type (GE):Normal Glass cloth type

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- Glass transition temperature (Tg): 200˚C (DSC)
- Multi-site production in Japan/China

	Dk	Df
R-5785(GN)	3.4	0.002 @ 12GHz
R-5785(GE)	3.6	0.003 @ 12GHz

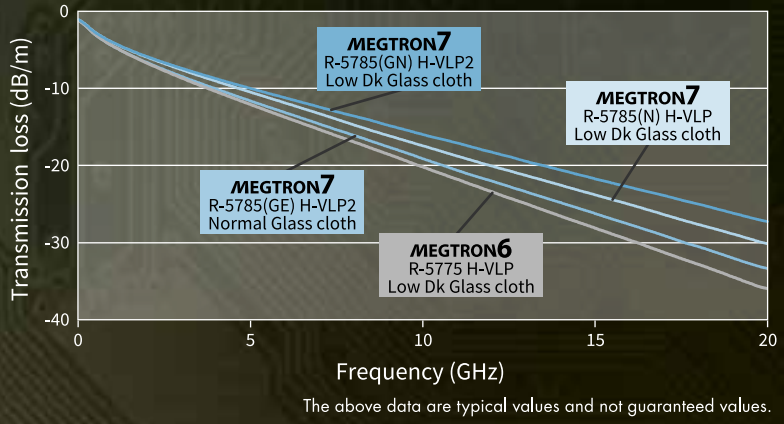
Applications

- High-end servers, High-end routers, Supercomputers, and other ICT infrastructure equipment, Antenna (Base station, Automotive millimeter-wave radar), etc.

Transmission Loss

- Construction

Trace thickness(t)	18μm
Dielectric thickness(h)	300μm
Copper thickness	18μm
Inner treatment	No-surface treatment
Core	0.15mm (#1078 x 2ply)
Prepreg	0.15mm (#1078 x 2ply)
Line length	1000mm
Impedance	50Ω



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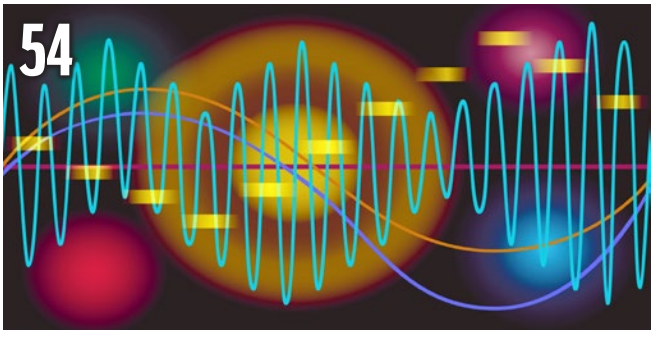

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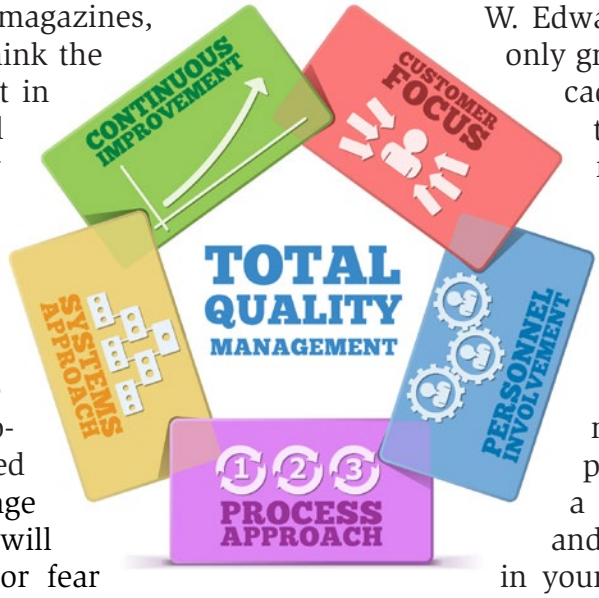
Are We Back to TQM?

Nolan's Notes

by Nolan Johnson, I-CONNECT007

Change is hard. The events of 2020 have certainly made that clear—as if we needed reminding. Though, perhaps we did need reminding that change is inevitable, even if it is hard. 2020 is holding true to that old saying, "You can either choose change, or change will choose you."

As with many of our magazines, we start with where we think the story is and often find out in the process of research and investigation that the story is somewhere else. This month, we began with the idea of emotional manufacturing intelligence, or willingness to embrace change. Susanne Madsen [1] eloquently captures the thesis we started with: "People resist change because they believe they will lose something of value or fear they will not be able to adapt to the new ways."



This conversation on emotional manufacturing intelligence kept leading us away from the philosophical/psychological and toward the application of that knowledge. Like a compass pointing north, these early conversations kept steering our course toward TQM. Our question became, "Why don't we hear much about TQM nowadays? Is it past its time?"

For the uninitiated, total quality management (TQM) is a business management methodology where employees are empowered to improve processes—and therefore, product quality—continuously. Multiple sources suggest that the term TQM was coined in the early 1980s, either within the U.S. Naval Air Systems Command or at the U.K.'s Department of Trade and Industry. Either way, the phrase "total quality control" was in use well prior to 1985 for similar principles. In some of his recent columns, Steve Williams has reintroduced us to a number of TQM/TQC pioneers, including W. Edwards Deming.

W. Edwards Deming's work is not only grouped with the TQM/TQC cadre but is often considered the center of the movement. Deming was widely credited with Japan's move to the top of the quality heap in the 1970s and 1980s, and his work continues to be a foundational resource for TQM methodologies. Thus, we pivoted to discuss TQM as a means to manage change and continuous improvement in your business. In a couple of cases, we didn't have to go very far to find TQM experts.

This issue features an interview with two I-Connect007 technical editors. IPC Hall-of-Famer Dan Feinberg discusses "Lessons Learned From Past Applications of TQM." Happy Holden retrieves some of Deming's lost chapters after uncovering pre-publication drafts of Deming's 1985 book that he received as training handouts at Hewlett-Packard from Deming himself.

But that's not all! Dana Korf discusses focusing on the impact of data, and Steve Williams shares his thoughts on emotional manufacturing intelligence. PCB Norsemen columnist Didrik Bech tackles the issue's theme with his column, "The Importance of Quality Management."

This issue is jam-packed with columnists. Dr. John Mitchell tackles "Problem Solving While Innovating," and George Milad covers "Minimizing Signal Transmission Loss in High-Frequency Circuits." Steve Williams continues with Part 3 of his "Guerilla Tactics to Pass Any QMS Audit" series, and Mike Carano launches a new column series titled "A Process Engineer's Guide to Advanced Troubleshooting."

My personal takeaway from this issue is that embracing change is a given in the world of innovation, and maintaining an emotional appetite for change is a requirement. This leads to the necessity that change be encouraged from all levels of the organization and managed to maximize its benefits. TQM is most certainly worth a revisit during these dynamic and chaotic times.

And remember that the Canadian rock band Rush gave wise advice regarding how to respond to change in their song "Free Will," when Geddy Lee sang, "If you choose not to decide, you still have made a choice." **PCB007**

Reference

1. S. Madsen, "Why Is Organizational Change So Hard?" LiquidPlanner, January 11, 2018.

Nolan Johnson is managing editor of *PCB007 Magazine*. Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing.
To contact Johnson, click here.

From the Cover: Meet the Fathers of Quality

1. George E. P. Box (1919-2013): A British statistician, who worked in the areas of quality control, time-series analysis, DOE, and Bayesian inference.

2. Philip B. Crosby (1926-2004): A businessman and author who contributed to management theory and quality management practices.

3. W. Edwards Deming (1900-1993): An American engineer, statistician, professor, author, lecturer, and management consultant.

4. Peter Drucker (1909-2005): An Austrian-born American management consultant, educator, and author, whose writings contributed to the philosophical and practical foundations of the modern business corporation.

5. Armand V. Feigenbaum (1920-2014): An American quality control expert and businessman who devised the concept of TQC, which inspired TQM.

6. Bob Galvin (1922-2011): A U.S. executive. He was the son of the founder of Motorola, Paul Galvin, and served as the CEO of Motorola from 1959-1986.

7. Mikel J. Harry (1951-2017): A statistician, quality expert, and author who was sometimes referred to as "the father of Six Sigma."

8. Kaoru Ishikawa (1915-1989): A Japanese organizational theorist and professor of engineering at The University of Tokyo who was noted for his quality management innovations.

9. Joseph M. Juran (1904-2008): A Romanian-born American engineer and management consultant. He was an evangelist for quality and quality management, having written several books on those subjects. He and his wife, Sadie, both passed away in December 2008 at 103 years of age. They were married for nearly 82 years.

10. Dorian Shainin (1914-2000): An American quality consultant, aeronautics engineer, author, and college professor most notable for his contributions in the fields of industrial problem solving, product reliability, and quality engineering–particularly the creation and development of the "Red X" concept.

11. Walter A. Shewhart (1891-1967): An American physicist, engineer, and statistician. He was sometimes known as "the father of statistical quality control" and also related to the Shewhart cycle (plan-do-check-act.)

12. Genichi Taguchi (1924-2012): An engineer and statistician. From the 1950s onward, he developed a methodology for applying statistics to improve the quality of manufactured goods. (Source: Wikipedia)

Lessons Learned From Past Applications of TQM


Dan Feinberg

Feature Interview by Nolan Johnson
I-CONNECT007

I spoke with Dan Feinberg about his experiences with TQM while serving as president of Dynachem and Morton Electronic Materials in the '90s. Dan explains how TQM can sometimes be misidentified as a philosophy instead of a set of tools and processes focused on accomplishing business goals.

Nolan Johnson: The principles of TQM are likely to be timeless—perhaps even more appropriate now—for a number of reasons. You embraced and implemented TQM principles back in the '90s at Dynachem. Why?

Dan Feinberg: Dynachem was very successful and grew from a tiny company back in the '60s and '70s. In the '80s and '90s, the company continued to grow pretty rapidly. R&D and sales and marketing expenses went up, total production costs did not come down as volumes increased, and the cost of coating of dry film and manufacturing did not decrease proportionately. Customers were getting bigger and, of course, trying to demand lower prices, and the staff continued to expand as the need for high-quality tech service increased. The company started to lose money. It had gone from a very profitable company to one that was barely breaking even, and then we went through some months of being unprofitable.

I had moved to executive VP at the time, and before that, I was VP of marketing and sales. One late afternoon, I received a call from my boss at the time, the president of Morton Electronic Materials. He wanted to come in to see me, so he asked, "Can you stay at the office a little longer? I want to talk to you." When he got there, he informed me, "I am going back to corporate. I'm not going to be president of electronic materials any longer. I'm going to be taking on something else, and the president of Morton International, Jay Stewart, wants to talk to you on Monday. They're going to make you an offer to become president."

When I met with Jay on Monday, he said, "If you're interested in doing this, there are three goals, and your goal is to achieve one of them. The division is in trouble, so you have to either fix it, sell it, or shut it down. We will consider

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your job done if you do any of those three." We talked about it for a while, and I said, "The only way I'm going to take this on is if you accept that there's only going to be one path, and that is to fix it."

We had a good team of people that were going to work for me. They found out within a few days that I was going to be their boss instead of their colleague, and we decided on a path forward with part of that path being that we were going to continue with TQM. TQM which had already been started by the previous president.

Here's where you have to be careful with some TQM things. TQM itself does not meet your goal, but it is a tool to help you meet your goal. We started to see that in the '90s and made the company meet all of the TQM standards. It doesn't solve anything, not if you're not making money. Instead, we decided to pay more attention to TQM to gain new business and reduce costs. We did that, and it required us to put together a plan that meant we were going to let go of a significant fraction of our employees. The corporation backed us on that plan and we found a way to accomplish it with little pain or suffering for the employees. But to give you an idea, many of the programs that we had put in under TQM were too expensive to continue.

We couldn't have all of these TQM meetings. We had to have meetings on "How are we going to get this piece of business?" At that point, we diverted away from the TQM program and worked more toward meeting the goal of making the company profitable, which we did in about two months. We went from running a significant loss to making huge profits in about 18 months. Then, we stopped even calling it TQM; it was just a way of doing business that met many of the TQM principles and goals.

We treated people well. Senior people had to do their job and let those that work for them do their job. Goals had to be set, and meeting them had to be approved. Overall, we ended up being a very profitable company and continued on for about 10 years until all of Morton International was acquired in 1999 by Rohm and Haas, it's now part of Dow DuPont.

I put one of our senior managers in charge of TQM. Their job was to use TQM to get total high-quality management not to meet the TQM standards but to meet the objectives of the company. Meeting the objectives of the company was the key factor, and it worked.

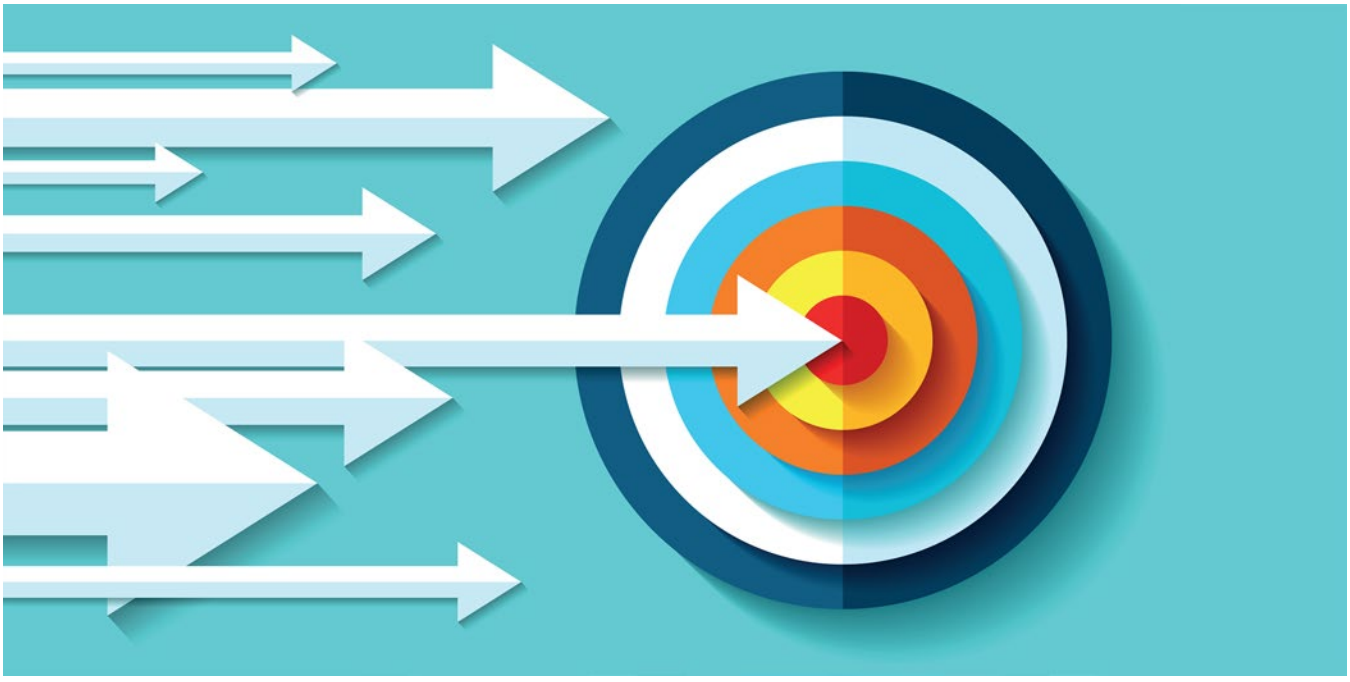
Johnson: For you, TQM was applied to making sure that you were focused on a business objective, not on the philosophy.

Feinberg: Absolutely. And before that, it seemed to many of us who were executives there at the time that we were getting more focused on the philosophy of TQM than the goal of making the business grow profitably.

Johnson: Deming packaged up his work and, for a variety of reasons, took it overseas. Japan was a great case study for TQM; those companies became large, nimble, and profitable. The transformation in Japan was described as "Deming's philosophy made real." As TQM came back to the U.S., it seemed like it was treated as a philosophy rather than a business tool. Does that ring true to you?

Feinberg: We had some partners in Japan, including a joint venture with a Japanese company using TQM as a tool, but not as the major goal of the company. This particular company we did a JV with was making equipment, and equipment was one of the few things we needed that we did not make ourselves at that time. We didn't want to be an equipment company; we were a process chemical company, but we needed equipment to use our chemistry. We'd have quarterly meetings to discuss our goals, and what I saw in them was exactly what we were doing; there was a total focus on the goal of the company. In that case, it was a goal of developing and designing new equipment that would work faster with higher yields and keep the cost constant or keep the cost lower if possible. And they met that goal.

Was it TQM that did it? I don't think we ever mentioned TQM in our meetings. We knew that they used TQM or some of the facets of TQM. And I'm not saying that TQM hasn't helped a lot of companies because it has. But



as I mentioned earlier, it's interesting when we all started talking about TQM recently, or I heard TQM being mentioned in some of our meetings, I thought, "I haven't heard that term in over 15 years."

Johnson: Given what you've seen in the past 15 years, what's your perspective? Has TQM stuck around, gone invisible, or have we lost sight of what TQM was trying to accomplish?

Feinberg: There are a lot of great things about TQM, but it's becoming invisible. It has become a way of doing business and managing a business. If you're good at setting goals and objectives, and have a good management team, it can become invisible. I haven't seen the companies that I've consulted for and the companies I've worked with who are successful slip into lousy management—and there were some pretty bad management practices in the '60s and '70s.

For example, I remember the phrase "three-martini lunches," and that was kind of true. One of the things that TQM wouldn't let you do would be to go out and party at lunch. You have stuff to do, and you must stay focused, and a three-martini lunch wouldn't let you do that. I'm not saying everybody did that, but it did happen. I don't see that much today.

However, are there other key things that may have slipped? Maybe. Sometimes, you meet with senior executives, and they're wearing jeans and T-shirts. That doesn't feel right, but is that anti-TQM? I don't know. It's a case of respect for those with whom you're working. Again, I'm not saying everybody does that, but I do think many of the aspects of TQM have become ingrained in good management practices and habits now.

Johnson: Does it make sense now to revisit Deming's work in 2020?

Feinberg: You'd have to talk about that depending on the status of the individual company. Some companies could revisit it, but others may not need it. If you have a great engineering group, would you want to go back and study engineering 101? No. If you have a lousy engineering group, would you? Probably. That's a pretty elementary statement, but companies have all kinds of extreme differences between them; each company may need something different. TQM means not just following a TQM process but having a high-quality management team that respects those that work with them and for them. It's about setting goals and meeting those goals on a constant basis unselfishly and without trying to gain power. If you set

good goals and continuously meet them, the power will come.

For instance, we used to have raffles once a quarter in the cafeteria. I won once, and it was a nice high-end gift like a good set of golf clubs, but I said, "I can't take this." My secretary said, "Why not? You won it." I replied, "Because there will be some people who think that something was given to me as a special or it was a fix. I cannot take it." Is that TQM? Should I have accepted the prize? I'm not sure. It's one of those things that you're going to get blasted no matter whether you take it or not.

Johnson: Interesting point. That brings up the concept of "manufacturing emotional intelligence." Where TQM has sometimes been misidentified as a philosophy instead of a set of tools and processes, that doesn't mean that there isn't a philosophy to TQM. The philosophy, then, is in how you lead, what sort of a manager you are, and how you create that company culture. For PCB fabricators, they're in an industry inflection point right now. How does an industry—that has not been doing too much to change—navigate a transformational moment in their business?

Feinberg: That's a good question, and it has a lot to do with the fact that the industry of making circuit boards has moved out of the U.S. In the '70s, the percentage of circuit boards made in the U.S. was at least in the mid-60% globally and maybe even higher. But having nonselfish, focused quality carries through the company. If you go to the people that were my direct executive team—people like Walt Custer, Ed Reardon, Dick Chung, Elmer Hayes, and Ted Pauls—they were superb executives and extremely focused. Go down to a level below that to people who were at the management level, not at the vice president level, and there were people like Bob Ferguson and Ken Parent, who are now highly respected executives in the industry.

Many of those people are now 20 years senior, and they're highly successful with other companies doing what they did for us then, but with more experience. I don't mean to leave out people, and I am leaving out people because they're not popping into my head right now, but we had a huge number of people in middle-management who have gone on to be successful in the industry. We were also the only company to have three members of the IPC Hall of Fame at the same company; now, that's true of the I-Connect007 team (laughs). That's because those of us who didn't want to leave the industry have gotten involved with I-Connect007.

For example, I got a lot of accolades from the Morton International Board of Directors for a specific decision. I had to put in a new VP of legal because ours had moved up and into another division. I appointed a woman for that position, Martha Vargas, and I received a round of applause when I came into a board meeting. I said, "What's this about?" They said, "You are the first one to appoint a female executive in Morton. What made you think to do that?" To me, she was the best choice. She was the best lawyer with M&A experience we had in the company—something we were doing more and more of—and she was ideal for the position.

Was that TQM? Yes, but did we do it because it was TQM? No. It has to do with the quality of the management of your company. It's about setting goals, staying focused on them, and not worrying so much about your reward because that will come.

Johnson: A manufacturer, for example, might review changing customer demands and realize that the current facility needs to change. They need to change not only the company culture but also the equipment and skillsets to stay competitive. That's a lot to bite off. That takes some guts and character to lead a company through something like that.

Feinberg: One of the things about Dynachem and Morton Electronic Materials is that many of us were there when Mike Gilano started the company, and it was a case of trying to build the company and hold it together. In the early days, Mike told us, "I can't pay you for six months, and I understand if you're going

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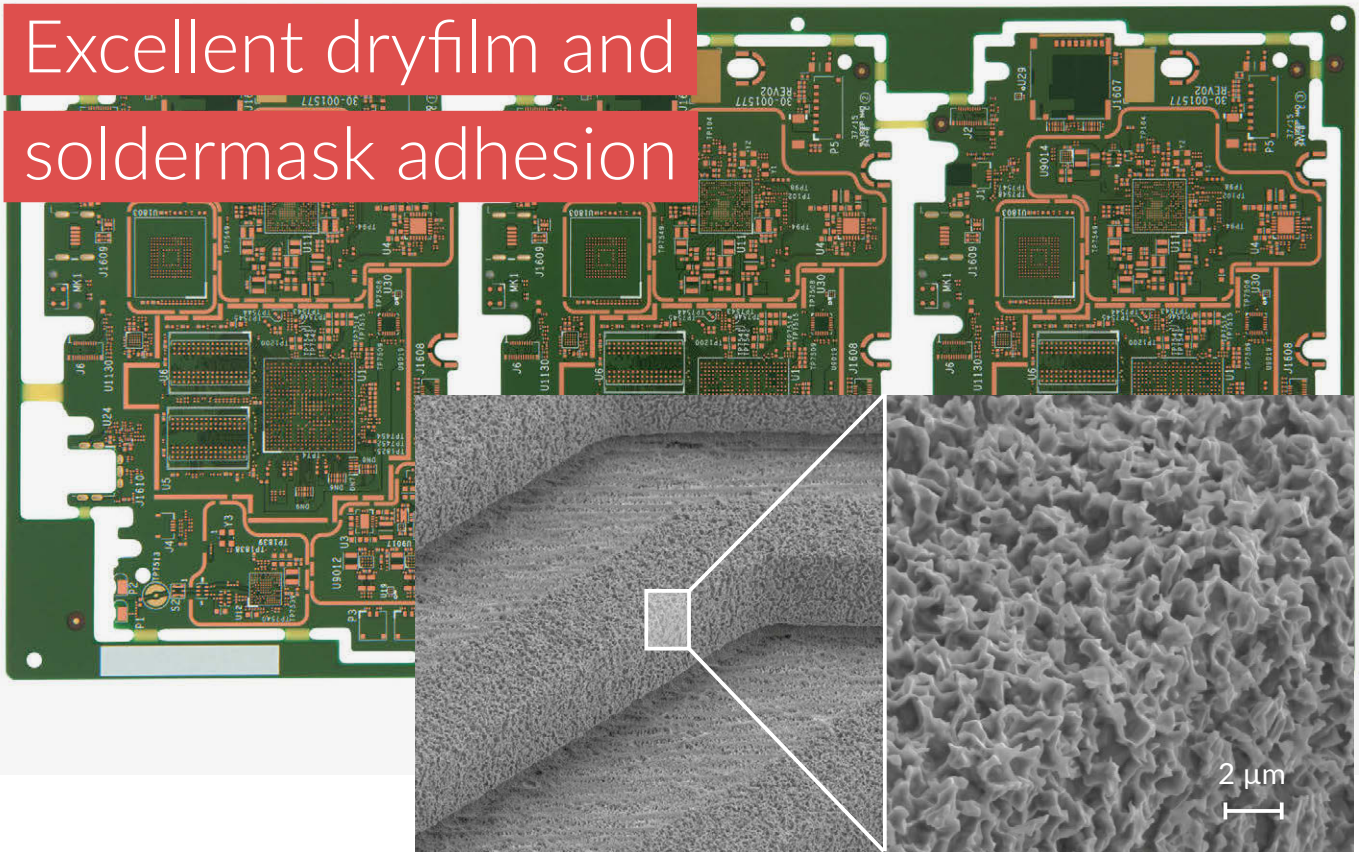

Pic. 1: CupraEtch® SR8000 etched Cu

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to leave." There was not a single complaint. As a part of the sales team, we got some pay, but we didn't get commissions, etc., and these were the people that stayed with the company and built it.

It was a cultural thing. The leadership of the company went the other way for a while, where they brought in some good people from other companies in other industries instead of going with the team that helped start the company. Reverting back to that team may not have caused the turnaround, but it seemed to help.

Johnson: A lesson here may be to ensure you have a team that believes in the mission and has the skillset and emotional commitment to not manage and be tactical, but to buy into the strategy that's required to transform.

Feinberg: Yes. And we can talk about TQM, commitment, and all of these things, but there's another factor that we have to admit—luck. Sometimes, it comes down to being in the right place at the right time and taking advantage of that.

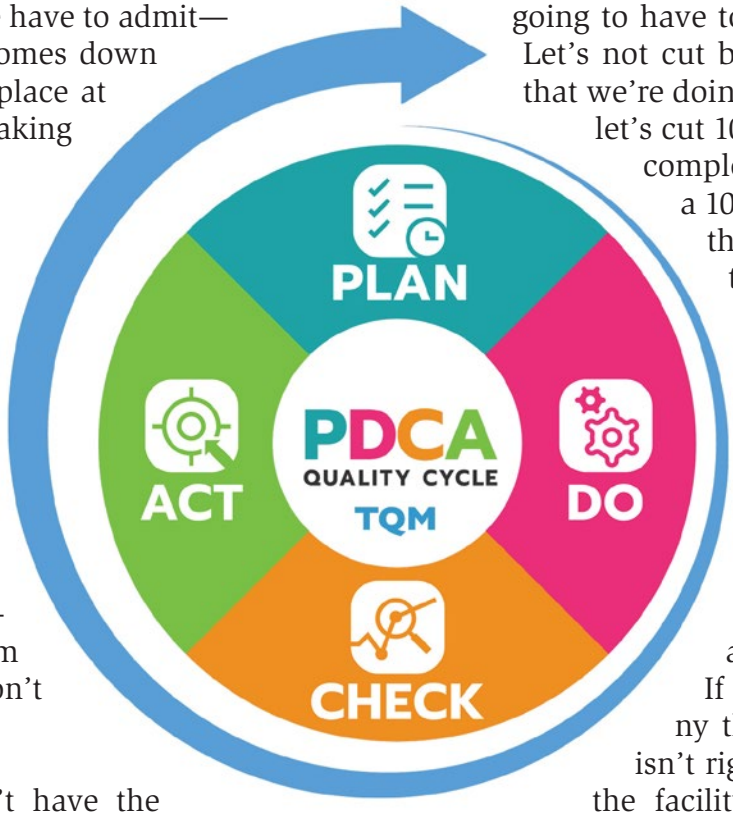
Johnson: It's being able to recognize that you got handed an opportunity and responding to it. What's your advice when a senior management team looks at who they have, what they need to do, and the challenge in front of them and realizes they don't have who it takes?

Feinberg: If you don't have the right team, change it.

Johnson: And if you don't have the right facility?

Feinberg: Let me give you an example that might help and has to do with Dr. Ed Reardon, our VP of research, who passed away about a year and a half ago—God bless. I was VP of marketing and sales, and Ed was VP of R&D, and we didn't get along that well. When I became his boss, he came to me and said, "I know we've had our differences, but we both have the same goal, which is to make this company successful. I want you to know you have my full backing." I thanked him, and we were great friends from then on.

Ed came to me when we decided what we were going to do to fix the company. We had to cut costs significantly. In that situation, he had to cut his budget by 40%. He said to me, "I can't do that and meet all of our goals. It's not possible." I responded, "That's because all of your goals may not be important. What we have to do is prioritize your goals and determine the products and product improvements that are critical to us in meeting our company objective. The other projects are going to have to be put on the shelf. Let's not cut back on everything so that we're doing 50% on 20 projects; let's cut 10 of those projects out completely for now and do a 100% focus on the ones that are important to the company."



Ed gave me kind of a half-smile and walked out. He came back three days later with his plan, and we had to cut his budget, but it was a case of setting the proper goals and meeting them. If you have a company that has a facility that isn't right, then look at what the facility does best and determine if that should be your focus. Many companies are probably trying to do things that they don't necessarily do very well, but they still stick with that stuff. What's your mission? Our company developed and sold new forms of dry film photoresist, sol-

der mask, and electroless copper, and our goal was to introduce new products faster, as well as products that did more for our customers and cost less to use, so we decided not to worry about parts of the facility or plan that did things unrelated to our goal.

Johnson: Based on your experience as far as facing transitions and making changes and pivots—besides looking at your team, facility, and skillsets—what other key things should management pay attention to? For instance, do you have the appetite or fire to be competitive?

Feinberg: That's a factor, and we were pretty good at competing because we had some impressive competitors, and we also gave a decent commission. Our TQM project for sales was that the product is critical, but so are the relationships. Build your relationships with customers not by buying them three-martini lunches but by helping them with their careers. We had a lot of great relationships with some of the major circuit board companies in the world located in the United States at the time. For example, the Western Electric plant in Richmond, Virginia—which was the largest circuit board fabrication plant back then—is now a shopping mall (laughs). Could I have succeeded like that today in a different industry, doing something different? It's not like I had an infinite skill; I didn't. But I was the right person at the right time with the right team who set the right goals and had the right level of commitment. Call that TQM if you want.

Johnson: And then using the right tools so that objectives were effected, measured, and tracked.

Feinberg: Right, and again, look at the team that we had and look at what they've done. We have three members in the IPC Hall of Fame: Gene Weiner, Walt Custer, and me. All of us old folks are still in the industry and involved (laughs).

Johnson: That speaks volumes for Dynachem, its long-lasting effect on the industry, and the reason we wanted to have this talk. Any parting advice around manufacturing emotional intelligence and/or TQM?

Feinberg: My gut feeling is that there's a time and a place for everything. Timing is critical, and the timing for some stuff to come back to the U.S. is happening today. I would not want to be a young senior executive right now, and I consider young in the 50-year age range. I loved it back in the '80s and '90s, but I would not have wanted to be doing it in 2010–2016. On the other hand, now or over the next few years might be a perfect time.

Timing is critical, and the timing for some stuff to come back to the U.S. is happening today.

Some of these companies in the United States can do it, and I'm not saying that we try to conquer the world, but that we need to bring a lot of stuff back and do it successfully to compete on a global basis. We've also talked about the fact that we know that price is critical, but the cost is more critical. You have to think about the difference between price and cost. You can get things at a low price, but the cost may be too high, and we see that right now. For anybody thinking, "Should my company go all out?" if you're committed to doing it, the timing may be good right now.

Johnson: Excellent. Dan, thank you for taking the time to go through this. The old adage, "Those who cannot remember the past are doomed to repeat it," is appropriate here.

Feinberg: That's true. I hope that the older ones of us in the industry are around long enough to see things turn around and come back so that there are more success stories here for the next couple of generations. **PCB007**

Problem Solving While Innovating

One World, One Industry

by Dr. John Mitchell, IPC—ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

How Electronics Manufacturers Are Coping With COVID-19

There is a saying that true character is revealed by the choices we make under pressure, and this is certainly true of this very uncertain time. Those of us in the electronics manufacturing industry are no different from anyone else facing this pandemic; we are not sure of what will happen next, but we are working together to find solutions. We are engineers and problem solvers, after all, and it is in our nature to fix things. As we discover new ways to innovate, keep our employees safe and healthy, and keep our businesses running smoothly, all of these actions are allowing us to move forward.

I am privileged to be the president and CEO of IPC, where I have the opportunity to talk daily to members of the electronics manufacturing industry—a global industry that supports millions of jobs worldwide, contributing to nearly every sector of the global economy.

On frequent calls with IPC members, we offer an open forum to attendees—a place where we can gather online to discuss the impact of COVID-19 on our global industry. We share operational and manufacturing challenges, discuss how our industry can help meet the needs of health care workers and frontline workers, and consider how we can help one another.

These calls and the various discussions I have had with other leaders in the industry have encouraged me in more ways than I could have imagined. It is gratifying to see the way

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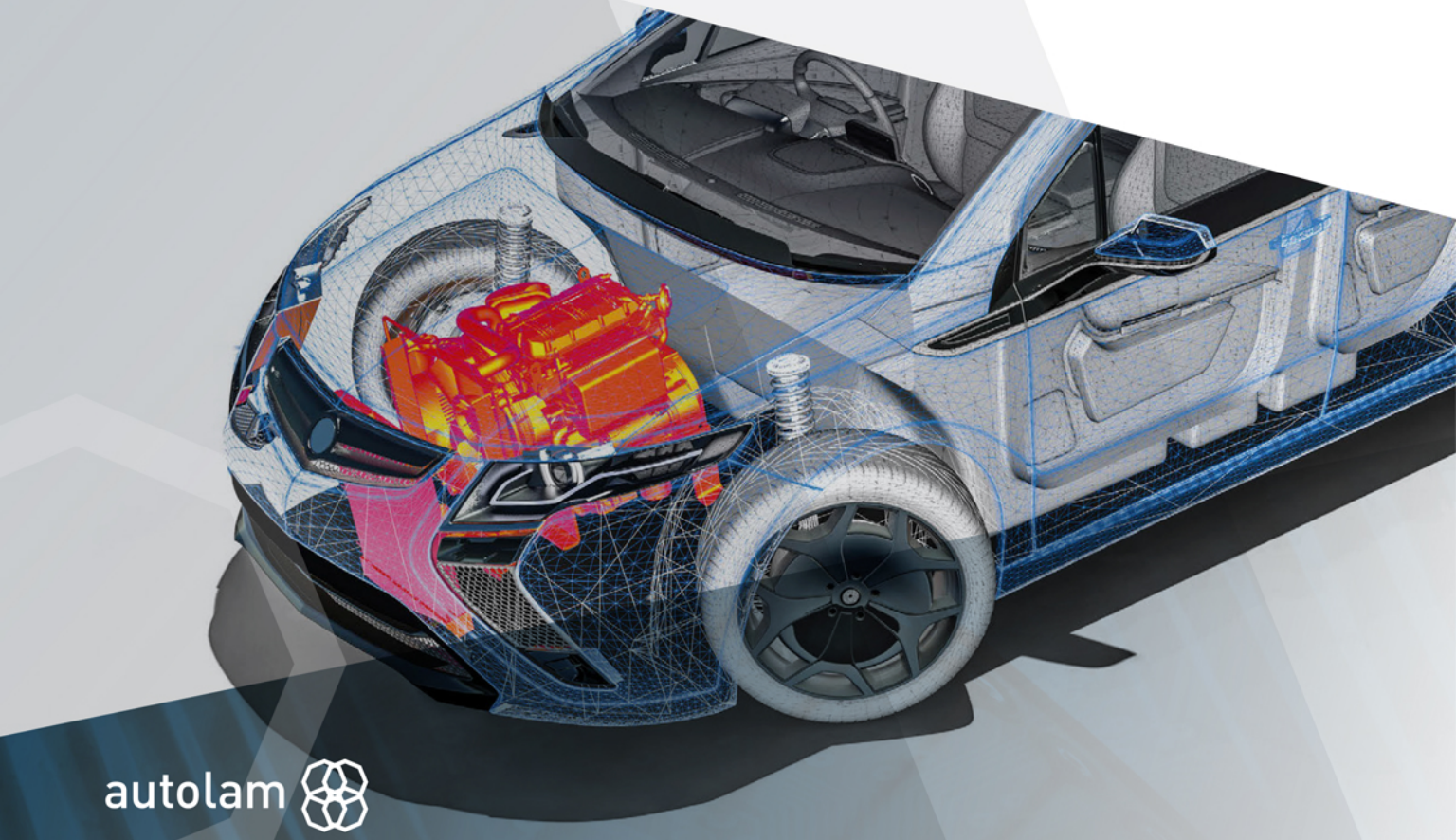

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we are coming together without competition, but with a desire for all of us to succeed in keeping our employees healthy, safe, and employed. While we are learning more about coronavirus every day and following the news very closely, we are also implementing innovations that will have benefits long beyond this crisis as we take the opportunity to learn from something so unprecedented. As crisis often does, this is bringing out the best in us as leaders, employees, innovators, and creators.

There are so many stories of how the industry is coming together. A company in Illinois is making free circuit boards for respirators, and a company in Wisconsin is bringing together workers from other states to build ventilators. These stories, along with so many others, inspire me as problem solving takes on global importance, and engineers do what they do best—fix the things that are broken. Out of something catastrophic, we are striving to find the good, the possible, and the best way forward for all of us.

Our job as leaders in the industry has become enhanced and much more critical. We are communicating with our teams by balancing the realism of the situation with the optimism of what innovation we may find in this crisis. We can explain to our staff that what we envisioned six months ago is no longer possible, but perhaps this crisis is opening us to opportunities that did not exist before. We are being tested as leaders, but we are also given a unique opportunity to change our processes not to go back to the way things have always been. By being transparent and helping our teams to understand the situation facing us, we offer them the chance to take on leadership roles themselves, enhancing the work all of us do in problem solving.

We don't have all the answers. But by working together on this enormous, worldwide problem that touches us all, we are leveraging the talents we already have, providing clear communication, hiring good people, listening to them and encouraging them and then getting out of their way.

Only time will tell if we are making the right decisions, but I am optimistic. It is in our nature to take things apart and put them back together in a better way; now, we're doing it on a grander scale with the safety and health of our staff paramount.

For additional COVID-19 updates and to see how your peers are providing support, visit ipc.org/coronavirus. And, as always, feel free to reach out to me personally for any issues, concerns, or solutions you may have. **PCB007**

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

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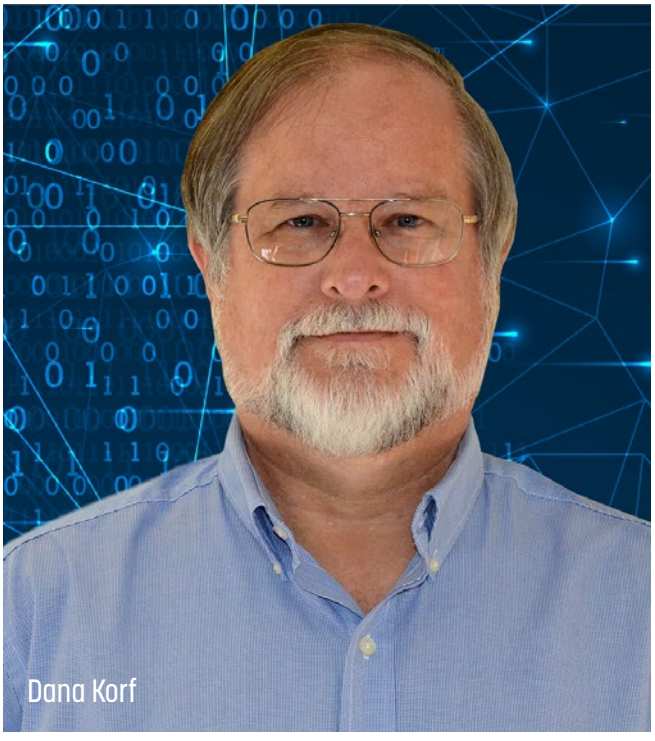
Dana Korf

Focus on the Impact of Data

Feature Interview by Nolan Johnson
I-CONNECT007

I spoke with Dana Korf about his experience with total quality management (TQM) throughout his career. Dana recommends not getting stuck on the process of collecting the data and documenting it, but instead to look at the impact. If you haven't made an impact, then you haven't done a good job.

Nolan Johnson: Dana, our industry, especially on the fabrication side, seems to be at an inflection point. We're on the verge of what seems to be a changing of the guard and even some changes in how fabs are set up where business is done.

First, what is your background, and what is your experience with TQM? Then, we can discuss if the current leadership of these fabrication companies has the emotional wherewithal to effect that change and weather this shift, as well as address how TQM fits in 2020 compared to the '40s through the '80s.

Dana Korf: I've always been on the process engineering side of the business when I worked in board fab shops, implementing all these various quality systems. We were heavily involved within our own department and between departments, trying to maximize the benefit while spending the least amount of money. I've been through many programs, and TQM fundamentally is an excellent concept. I firmly believe in it. Way back when, they taught us in ISO, "Document what you do, and do what you document." All of these systems, including TQM, boil down to that line in my mind.

TQM is the process fundamentally where you make sure you have well-defined processes that are documented. They have quality goals, and you maintain and constantly improve those quality goals for whatever level of detail you want to get down to, from a plant level down to an equipment level. It goes everywhere from how you manage the supply chain to how it gets kicked out the back door.

Johnson: Do you feel like TQM processes and techniques have gone by the wayside, or have they been incorporated to the point that they seem to be invisible?

Korf: If you look at quality management fundamentally, I started in the '70s. It was all human-based. Humans did everything from

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controlling the equipment to minimally integrating automated tracking of defects, etc. You look at it now, and the real transition we're going through over the last 10 years and probably the next 10–15 years is starting to automate more of this.

We're gathering a lot more data, and you can have lots of data and not do anything with it. If you have too much data, it's too much for a human to keep up with. Now, we're starting to get a lot of better-automated tools that run both within a process and within a piece of equipment. Two processes help present the data, analyze the data, and, in some cases, automatically correct based on the data. We've seen a lot more of that in our industry.

Johnson: What are some of the example tools?

Korf: The number one tool that's used is Excel. People gathering data or a piece of equipment will come with embedded software or part of their user interface that will collect the data in a spreadsheet form. Then, you pull that data out and analyze it. Almost all the software tools, in effect, take that data and present it in various ways. They put it on a screen in front of you, show you whether your process is in control or not, and have the system react to that control when it goes out of control and adjusts the process automatically like dosing systems in plating lines.

Johnson: It doesn't necessarily mean that you must have an enterprise management system or sophisticated quality management software. A two-dimensional tabular database program like Excel can go a long way.

Korf: I've been through lots of those specialized systems. They run for a while, then the new type of system comes in the next year, and they switch to another system. The next year, another system comes in, so you switch to another system, and they don't tend to gather traction. People lose interest. They start gathering data and putting it on charts to present at a meeting, and it dies. The intentions are all well. In most companies, the quality department will manage the process and push people to follow the process and react to the data that you're getting. But fundamentally, you have to take people off the line to react to the data or have them focus on improving versus pushing product out the door. That has always generated conflict. How do you get enough people assigned to react to the data?

Along with that, you tend to shotgun the data. You get data from every process, even ones that don't need to be improved as much. You get data overload instead of having the teams focus on one particular area until that gets better. A good example from many years ago was we had companies that merged together, and our front-end processes were all competing against each other to have the lowest defect rate, which was great. It worked out well, and we all had great pride in our processes. Every month, we got together, compared the metrics, looked at the defects, how we reacted to it, and we all learned from each other.

But then we got down to a point talking about scrap produced. We were down to having people chasing on the floor, trying to get $5 of scrap off of our list because another site was going to have $3. We were a one-billion-dollar company at that time. We all looked at each other and said, "This is nonsense. We're wasting money trying to save, in effect, nothing." We drew a baseline and said, "If we're below this defect level, we'll call that zero and focus on something else that's bigger." That was a huge transition point of getting us to improve our processes so we could focus on the bigger problems versus the chart data, per se.

Johnson: The moral of the story is don't take "total" too literally in TQM.

Korf: Yes. You get focused on creating the process and paperwork versus the impact. I see this in quality improvement, Lean teams, everything. People get so enamored of making sure the paperwork is correct, and at the end of the day, you don't have any impact. All the paper is completed, and it looks like you're doing something good, but in reality, you're not. Board shops, as you know, do not have unlimited profits. There's very tight profitability. You have to assign your resources very succinctly and make the most money with what you have. You need to work on the bigger projects, and everyone knows what the biggest areas are, meaning the biggest scrap areas or those with the highest defects. They can focus on that, and those types of programs tend to get better results from a bottom-line standpoint versus having 100 departments compete against each other.

Johnson: It needs to be a means to an end. Ultimately, the reason for TQM is to increase your profits to run more efficiently and make more money. If it's not achieving that, it's not working.

Korf: And be careful that you do not get such a low cost that the quality of the end product to the customer suffers. You can save a lot of money by doing things you don't normally do that could affect the reliability in such a way that the customer may have more problems, which is the worst thing that can possibly happen. There's a balance there. If you have good engineers, which most shops do, you know which processes you shouldn't cut corners on, or how far you can go before you're putting in some acceptable risk or an extreme amount of risk in the shippable product. TQM's goal is not to negatively affect PCB performance.

Johnson: If you're serious about what you're doing with TQM, you identify areas that need to change, whether those areas are your processes, business methods, staffing, or even the equipment in your facility.

Korf: Change is interesting. I've always said there are two factors. First, the senior management of the business department needs to be fully supportive of what's going on. In other words, they can't say, "I don't like it because I didn't put it in myself," or, "I'm going to lose interest after a month." If that happens and employees see it, they lose interest.

Second, humans fundamentally hate change. It's fundamental to how we were raised and how we're born. There are ways to implement change such that the people will support it. The first fear is, "We're trying to reduce costs to lay people off." Sometimes that's valid. You're trying to reduce resources, but you can show how you can get more out of the current resources so that you don't have to hire more people, which you can show. I've done this multiple times. You can make more money because you now have more value to the company.

Humans fundamentally hate change. It's fundamental to how we were raised and how we're born.

The other key item is documentation. Everything needs to be documented. The initial reaction is to write tons of procedures. You might have several hundred procedures written down, and you'll pass every single quality audit from a customer because they say, "You have a procedure for everything. You're good." I took over one group's point in an audit one time. They were struggling on a quality basis and throughput. I sat down with one of the operators one day and said, "How many procedures apply to you?" They didn't know even though they were fully trained theoretically. I also asked, "How many procedures do you have?" and they didn't know.

I started digging through the system. There were 120 procedures or portions of procedures they were expected to understand and be fully trained in. That's not possible. We said, "Let's make it so each person has one procedure to

understand with sub-elements to it that can be trained easier." Their quality went up because previously, they couldn't even give you the number of any of the procedures, let alone know what was in the procedures. You can make this overly complicated. But from an audit standpoint, it looks like you've done well, but you haven't.

Johnson: That's a good point. Be efficient and effective, but don't micromanage.

Korf: These days, lots of good software is being developed for the "factory of the future," the fourth generation of factories. We see a lot more automation. The human has to understand less. Like any system that gets automated, now your operators and engineers need to be at a little bit higher level. They need to be able to understand the data, including good versus bad data, to ensure the automated systems are reacting effectively. There are very good examples of this both as a sub-process and in entire factories in our industry all over the world that have done a very good job of using data. They have made it cost-effective to maintain a good TQM system.

Johnson: Do you see investing in a better understanding of their processes and analyzing the data to find improvements as a cost of doing business at a fabricator? Is this something they need to do to survive?

Korf: I would suggest that every person that runs the business does this already in some shape or form. If you let everything run wild, you're going to be out of business fast. Everyone's doing something to ensure their quality and that they have a good quality system. That means it produces less scrap, rework, and returns. Everyone has this in some form. It's a matter of how intelligent and widespread is it, and what's the real bang for the buck with whatever they have installed.

If you look at higher level businesses, they do more of it better and see a real financial result. I tell people, "Everything we do in a company is to make money. If the company doesn't make money, you don't have a company." That's always the bottom line. If you're working on something that doesn't save or make money, you're working on the wrong thing. That's how you have to look at all these things. Am I spending my money and getting the biggest effect on the bottom line? This indirectly shows that your customers are happy also because they want to continue buying from you; that's a subliminal message.

Everyone has TQM in some form or fashion by default. It's a matter of how much they do, how well they do it, and the lower your scrap is in a process means that your process is tuned better. Generally, it indicates you can get a little bit higher technology or a little bit higher throughput out of the process. This indirectly allows you to grab more business because you're now confident you can do a higher technology without having to spend capital funds to buy equipment you don't currently have. They teach you in the theory of constraints that production that gets thrown away is wasted capacity. You never get it back. That's how you have to think about it. If I build something and scrap it, I can no longer make that money back because I threw away the panels that I spent money on. I now have to spend more money to get that same amount of revenue back.

Johnson: I guess it all boils down to the fact that everybody does this. It's a matter of how good you are at doing it.

Korf: Correct. As you know, in board fabrication, the process is so complicated. The chemistries and all the equipment need to be tuned right to effectively build something. This is not a trivial product to build; it's relatively complicated. You have to have some level of controls, or you're not going to be in this business.

Johnson: Does Deming's original work or inspiration still have a place, or has TQM moved beyond that?

Korf: That's a good question. If you look at the function, purpose, and goals, those have never

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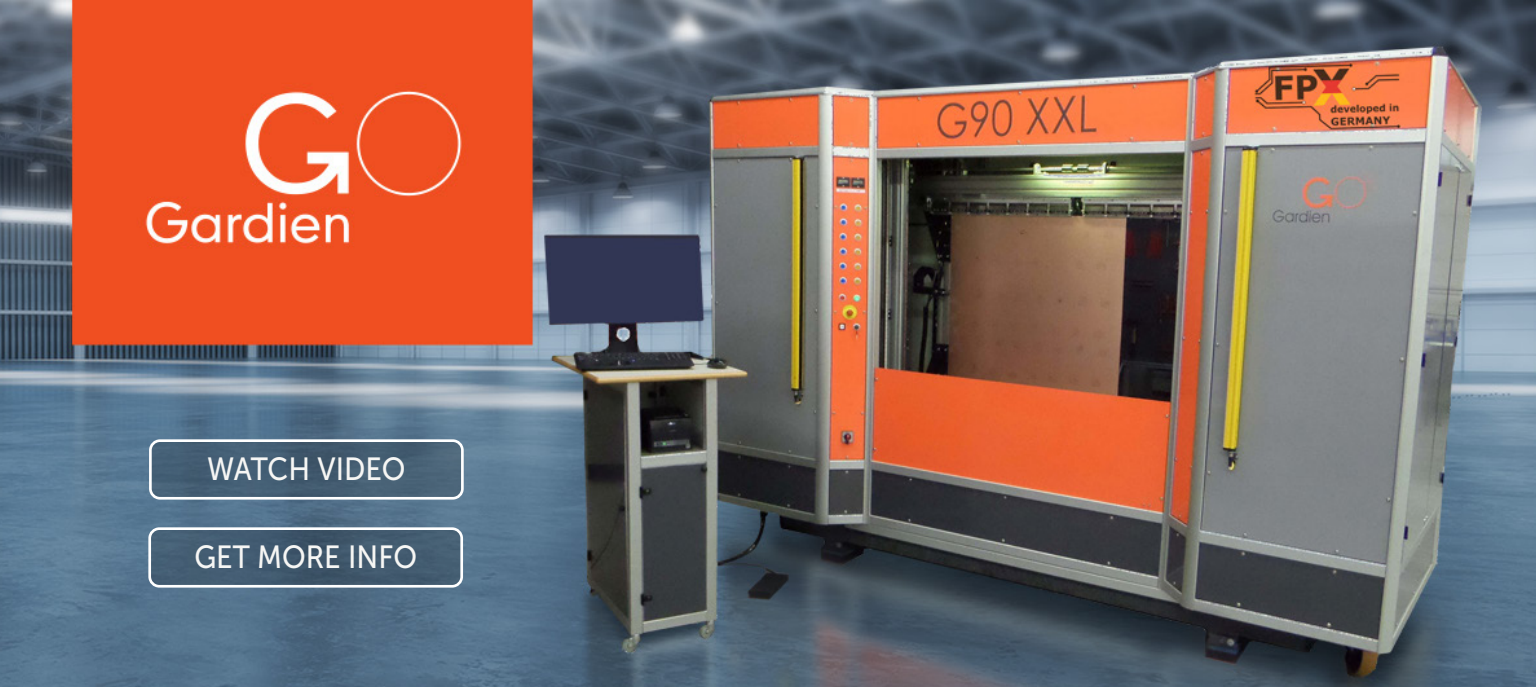

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gone away. The techniques of how you do it have been modified over time and adapted to specific instances, industries, and equipment. It's the core of what everyone does. Quality is fundamental. You must have some form of a quality system, as well as operators involved in running and managing the process, or you're going to fail. It's not a top-down approach; it's a bottom-up approach. The people doing the work have to believe in it and stick to the processes that they're trained to do and give feedback when they don't work and, most importantly, they then need to be rewarded after the improvement shows a positive result.

Johnson: That's an interesting perspective because some of the other TQM experts that I've talked to, such as Happy Holden, stated that to make TQM effective, it has to be pushed from the top down. The CEO has to buy into it entirely. Perhaps it's a top-down and bottom-up approach simultaneously. The vision and priority need to come from above, but the commitment to doing the tasks needs to be a bottom-up approach.

Korf: Yes, because that's where it gets implemented. The people who run the equipment, carry the boards around, and do the front-end engineering are the bottom line. If you go in and say, "We have to constantly improve," but you never do what they suggest or ask them what their opinion is, they're not going to buy into it. It becomes just another chart they show off every Friday afternoon. I agree with the top-down push, but I don't like the term push as much as support. The top-down approach gives you the process and how they want to manage it, but they also need to support what they hear even if it's bad news and contradictory to what they believe. Support people, test it, and see if it has an impact. And if it does, implement it. Then, you get the buy-in. It's both ways. If there's a bottom-up approach and no one cares, then it's dead. It's like, "We have an employee suggestion plan where there are 1,000 suggestions put in every month," but then you only do three of them, so people quit sending suggestions.

Johnson: With what the industry faces today—the challenges exposed by COVID-19, recent tariff changes, and exposure of choke points in the supply chain throughout the whole manufacturing process, especially with PCBs—what advice do you have for PCB manufacturers with regard to their total quality management approach?

Korf: COVID-19 adds another layer right now because we don't fully understand how it works yet. There's not a cure, in case you do get it, or a vaccination to inhibit you from getting it. Everyone worries about employee protection, and money is spent wisely on protecting employees so that they don't get hurt, injured, or killed. This adds another layer of cleanliness that you have to maintain. Fortunately, a lot of the processes are already in cleanroom environments, so some of them will be much easier to implement additional processes than others.

From a business perspective, I don't think the current environment changes much. You always have to find ways to reduce your costs and not produce waste. In particular, you don't want to produce bad products that go out to your customer, whether it's a cosmetic defect, a functional defect, or a defect that could affect long-term reliability. That's still there and doesn't change at all.

This is an industry where the cost always has to go down every year because the price goes down every year. That's the way it has been and will be forever. "How can I save money?" is always on the lips of everyone. Part of this is retaining employees. One way to save money is not having to replace people. Retain them instead, and avoid going through the learning curve again with a new employee. Every year, you have to tighten your business up, use your assets well—which are people, equipment, and dollars—to make sure you stay in business along with keeping up on the technology curve as required for your business.

Johnson: That gives us a great perspective. Do you have any final thoughts?

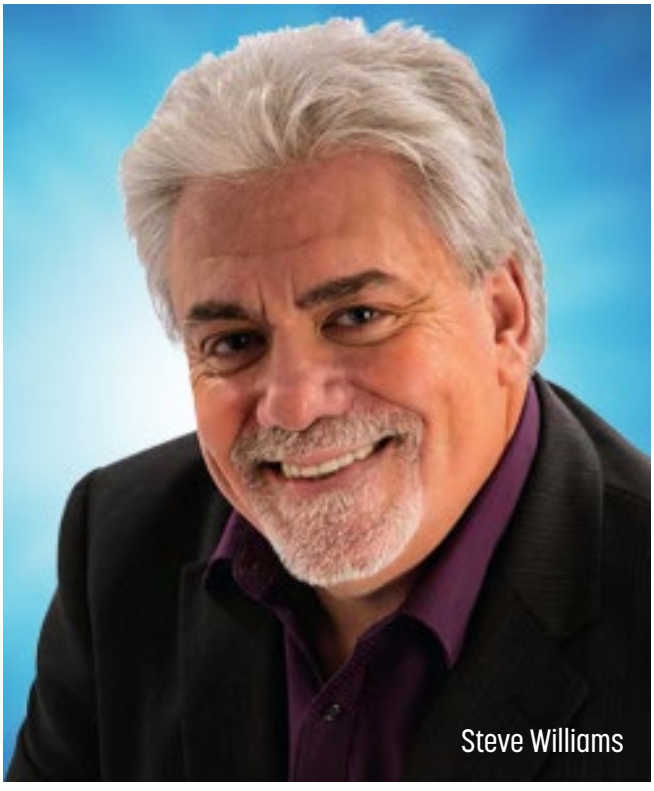
Korf: When you first contacted me about talking about TQM, I thought, "Wow. That's a huge topic. TQM covers a lot of stuff." Fundamentally, TQM is more of a mindset. You have to have the mindset that you must produce good stuff. It's a full team approach, and it starts with the customers. If they gave you bad information, you have to find out before it gets to the production floor, down to what a defect is in your customer's mind. You may not agree with it, but that doesn't matter; it's what they want. TQM is an underlying philosophy.

My key point is not to get stuck on the process of collecting the data and documenting it. Look at the measurable impact. If you haven't made a measurable impact, then you haven't done a good job. Always focus on whatever you're doing in the quality system to make things better, have a real impact, and evaluate everything you're doing. If it doesn't make sense, stop it or change it; don't keep going down a path if it doesn't make sense just because someone said that it was what you had to do. That's where you have to rely on the entire team to be honest with each other. If they are, you get excellent results. I've been through this many times.

Johnson: Dana, thank you.

Korf: Thanks, Nolan. PCB007

Emotional Manufacturing Intelligence


Steve Williams

Feature Interview by the I-Connect007 Editorial Team

According to Wikipedia, "Emotional intelligence has been defined, by Peter Salovey and John Mayer, as 'the ability to monitor one's own and other people's emotions, to discriminate between different emotions and label them appropriately, and to use emotional information to guide thinking and behavior.'"

In this conversation with Steve Williams, we look at change and why it can be so difficult. And, of course, with the recent COVID-19 outbreak, massive changes were forced on us; we had no vote. That is the type of change that makes us rethink every aspect of our lives and businesses.

Editor's note: This interview was conducted before the shutdown of the U.S. and the world. However, the core message being conveyed is more appropriate than ever.

Barry Matties: Thanks for joining us, Steve. You have probably heard of or maybe even read the book, *Emotional Intelligence: Why It Can Matter More Than IQ* by Daniel Goleman, which looks at the way our emotions drive our decisions. Today, we're looking at emotional manufacturing intelligence. Perhaps it sounds like a stretch, but there's a real emotional intelligence at play when decisions need to be made in our manufacturing facilities.

Whether you are looking at hiring employees, automating your factory, purchasing new equipment, changing suppliers, or planning your next strategy, decisions are not driven by IQ or data alone. The emotional impact is very real and often keeps us locked into the status quo until it's too late.

Steve Williams: Today, hiring managers are more focused on EQ than IQ; instead, they're looking for attributes when they're hiring new people. I'm not sure if that's exactly what you're talking about here, but for many hiring managers, it's about matching people and the company culture. Over 60% of people said they wouldn't hire someone with a high IQ but a low EQ. It's now becoming part of manufacturing when it has never been broached before.

People don't like to change. They resist change and anything that is different than the

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way it has always been done. It's like any initiative. When you look at things like MEQ, you talk about what the benefit is going to be. It's going to increase lost time from accidents, decrease grievances, improve productivity, and increase profitability, but 20–40% of the employees aren't going to make that transition; instead, they will leave.

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Matties: Is the problem that they don't have the specific knowledge to make this? Without the necessary knowledge, it's more difficult to take the next step and find somebody to help you, or is that even a problem?

Williams: It is a problem, and what can they do? They have to change their thinking. As you said before, it takes a different mindset to look at how to take the waste out of a process versus add more inspection or live with our terrible yield rates. The mindset for running your business has to be different; you have to go all-in or not at all. I keep coming back to the fact that people don't like change; that's the biggest impediment to any of this stuff, whether it's improving quality, changing the culture, or getting people to not resist and get on board. You have to think about it differently, and some companies are never going to get there.

The mindset for running your business has to be different; you have to go all-in or not at all.

Matties: Part of the makeup of the industry now is owners and leaders that have been doing this for 30–40 years, and now, they're thinking about the smart factory, retooling, and all of that. Do they have the energy to drive, or are they looking for their exit strategy?

Williams: There's probably the same percentage of business owners who can't get there. They can't change the way they think about their business. Again, that's why they went from thousands of shops to sub-200 right now. People weren't able to make that switch and say, "We have to do something different because what we're doing is not working."

Happy Holden: How do we revitalize what people think is old, such as the concepts of Lean, Six Sigma, and TQM? Those basics don't change. We have a tendency to think that it's just the latest fad. If somebody is using Industry 4.0 and the smart factory to bring back Lean manufacturing, they might say, "Before we start spending all the money, we have to do some basic homework. If the homework is going back to doing it by hand with Lean, then we'll put the money in." They have to simplify it before they automate, or they're going to automate poor performance.

Williams: Right. You're going to automate waste. When we talk about Industry 4.0, maybe it's a matter of rebranding it to Quality 4.0. As you said, it's not so much Lean or best practices anymore, but how we realign that with the Industry 4.0 concept. We do it through analytics and data. We do it through connectivity and collaboration, and maybe the key is putting a new name on it, even though it's the same old thing.

Holden: I wonder. People follow fads, and they must have a catchy name, even though anybody who looks into this would say, "Wait a minute. I've seen this all before." After studying the Malcolm Baldrige Award winners, Hewlett-Packard told us that a concept would stick with production workers and people after they do it four times. You have to use the LUTI model (learn, use, train, instruct) and have every person go through the same material four

times; only after that, will change be adopted from a top-down.

The president of HP taught the LUTI method to all the vice presidents, and all the vice presidents used it with all the directors, and all the directors did it from the top down. Everybody had to go through it four times, and then it finally stuck, but doing it once for engineers or operators never went anywhere. It goes all the way down to the individual worker.

Today, nobody talks much about Malcolm Baldrige, Deming, Juran, or Crosby, which shouldn't have happened; they should be immortalized or institutionalized. In my list of 24 essential skills for engineers, Lean, Six Sigma, TQM, and problem-solving are the most important things an engineer can learn and have in their toolsets.

Williams: Yes. The second most frequent thing I run across in companies is they don't know how to problem-solve. They don't know how to do the root-cause analysis, and they can't permanently get rid of a problem because they don't have or want to learn that skill set.

Holden: I visit Michigan Tech on occasion, and every time I go, we have refresher courses on statistics, design of experiments, Six Sigma, TQM, and problem-solving for their engineers and technicians to keep re-exposing these concepts because they take a while to sink in.

Williams: I completely agree.

Holden: Barry is always telling us it's not enough to be good; we have to be great. And if we ever think we are there, then we've missed the whole point of the exercise. We can always be better.

Matties: Right. I've referred back to this numerous times lately, but recently, I interviewed Frank Lorentz from Ventec in Europe, who came to the company without any industry experience. He was from the newspaper industry, but his expertise was logistics. He came in and turned the thinking around completely. At one point, they thought that they needed to rent another facility to have enough room for their equipment. He came in, and the first thing he did was benchmark it. Then, he looked at flow and rearranged the equipment into the right flow.

Not only did they not need another facility, but they had added floor space for expansion of the current facility. They drove cost down and quality up, and he was looking at things like not shipping the prepreg on Thursday because it would sit on the truck over the weekend without being able to control the temperature; instead, ship prepreg on a Monday or Tuesday. He brought that kind of change in thinking.

Thus, are we not hiring the right people? Are we trying to hire industry talent rather than logistics expertise?

Williams: We are. And it's also about hiring the right people with the right mindset. That's a good way to start changing the way people think.

Matties: Not only did he start benchmarking, but he came in and created a culture of quality, which meant empowerment, communication, and listening, which will translate into success. This is the distribution sector for Ventec. As Frank said in the interview, in the newspaper business, if you are a day late with your product, then it's only good for wrapping fish. He brought that kind of EQ to laminate distribution.

Williams: Absolutely. Why is this endemic to the PCB industry? I work with injection-molded plastic companies and metal fabrication companies. If a customer orders 100 pieces, they build 100 pieces; they don't build 110, 115, or 120. If they scrap out one piece, it's a major ordeal. We don't have that mentality in the board business.

Matties: Because even overage is profit sharing.

Williams: It is, and that's built into the price. The customer pays for it one way or the other.

Matties: Build it right, enjoy the profit, and invest it in smart ways rather than buying shelf space in your warehouse to store boards that people may or may not buy in the future.

Williams: Yes, that's a conversation I've had a number of times. They'll say, "Why do I need ISO? I have great delivery and very few customer returns. I may be building 20% over, but I always fulfill virtually 100% of my orders." But what I tell them is, "Eventually, you're going to run out of customers willing to pay for that inefficiency because if you're building 20% over, you factor that into your quote and the customer's paying for it." As soon as a customer wises up, they're going to be gone.

Matties: As long as there's a place for them to go, and that's my point. Is there a market difference between one shop to another?

Williams: Correct, and there's a market difference between a lot of shops here and in other countries. One customer I have builds 30–40% over on a lot of part numbers to ensure they can make yield and ship a complete order because a complete order is more important to them than parts going into inventory or scrap. It's all about the mindset.

Holden: This is a pretty dynamic industry that constantly requires reinvestment in equipment and technology, or you can't continue to ship a product that people are designing. Any waste saps away from that money available for reinvestment growth, training, or whatever it takes to stay in there. You wouldn't be in the business for a long time, or you'd eventually be making single-sided boards.

Williams: I agree.

Matties: Steve, thank you for sharing your expertise here. We certainly appreciate you.

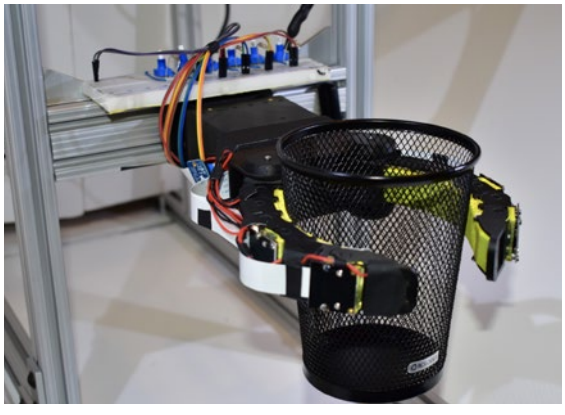
Williams: Thank you. PCB007

Giving Soft Robots Feeling

One of the hottest topics in robotics is soft robots, which utilize squishy and flexible materials rather than traditional rigid materials. But soft robots have been limited due to their lack of good sensing. A good robotic gripper needs to feel what it is touching (tactile sensing) and sense the positions of its fingers (proprioception). Such sensing has been missing from most soft robots.

Researchers from MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) came up with new tools to let robots better perceive what they're interacting with: the ability to see and classify items and a softer, delicate touch.

One paper builds off last year's research from MIT and Harvard University, where a team developed a soft and strong robotic gripper in the form of a cone-shaped origami structure. It collapses in on objects, much like a Venus' flytrap, to pick up items that are as much as 100 times its weight. The new sensors let the gripper not only pick up objects as delicate as potato chips but also classifies them, letting the robot better understand what it's picking up while also exhibiting that light touch.



In another paper, researchers created a soft robotic finger called "GelFlex" that uses embedded cameras and deep learning to enable high-resolution tactile sensing and "proprioception" (awareness of positions and movements of the body).

The gripper, which looks much like a two-finger cup gripper you might see at a soda station, uses a tendon-driven mechanism to actuate the fingers. When tested on metal objects of various shapes, the system had over 96% recognition accuracy.

(Source: MIT News)

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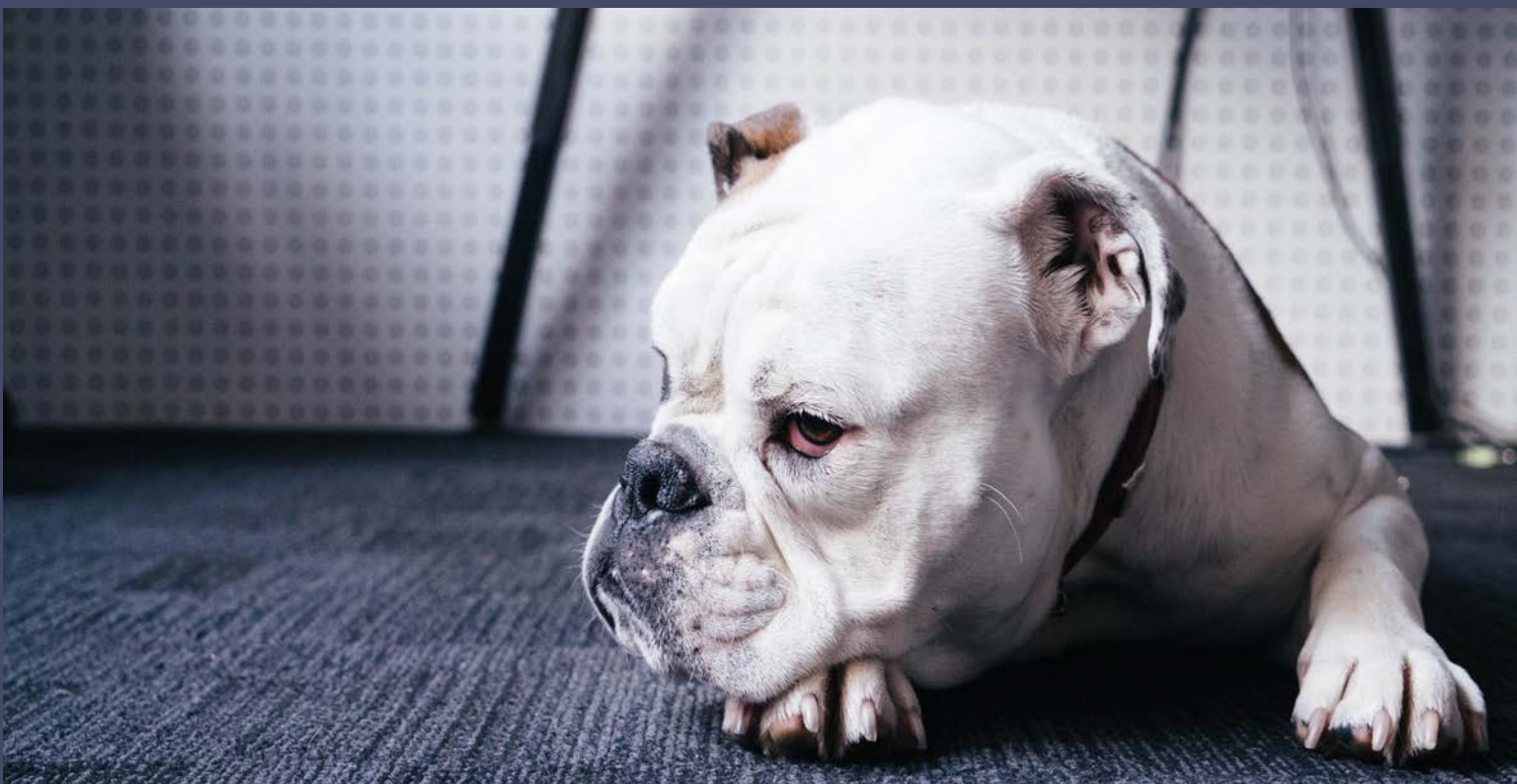

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Dr. W. Edwards Deming

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W. Edwards Deming's Lost Chapters Recovered

Feature by Happy Holden
I-CONNECT007

Hewlett-Packard (HP) had a reputation for excellence long before I joined the company in 1970. The owners and creators of the company had a passion for excellence in their DNA. But when HP's Japanese Division Manager Yoji Akao won the Deming Prize in 1978, HP realized that as good as it was, it could be better (Figure 1).

Early benchmarking of our product designs with the Boothroyd Dewhurst Method (DFMA) provided data showing that we weren't as good as we thought we were, and improvement was needed. The book the Japanese Division of HP wrote about the process of winning the Deming Prize created a whole new sense of urgency for top management. Foremost in their process was the advice of Dr. W. Edwards Deming.

Even in the 1980s, Dr. Deming was world-famous. He was known as the person responsible for the "Japanese quality revolution" of the 1950s. Dr. Deming was so successful at training the Japanese that he was in constant demand to help American corporations learn to compete against their Japanese competitors. However, his first requirement for working with a company was that the program had to be driven and championed by the company head.

I was cleaning up my bookcase recently and came across a tired, dog-eared set of papers that was Dr. Deming's initial draft of his book *On The Management of Statistical Techniques for Quality and Productivity,* which I received when he came to HP to lecture about quality and productivity on March 11, 1981. Dr. Deming's presentation took place in the company's largest auditorium in Cupertino, California. The front row was populated with the company's president at the time, John Young, as well as the VPs and directors. I received an invitation, but alas, I was in the rear row of the auditorium.

Figure 1: The Deming Medal.

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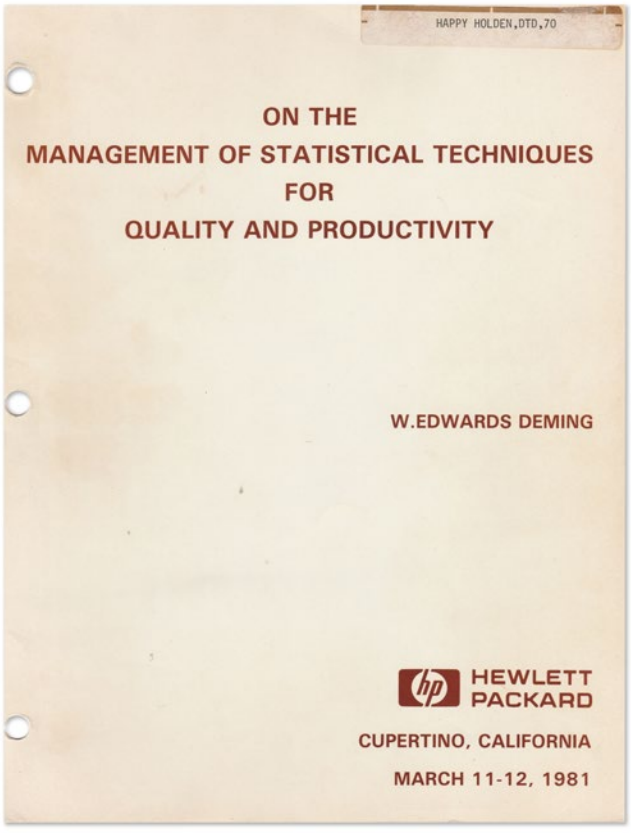

Figure 2: The front cover of the 1981 manuscript Dr. Deming provided HP.

Dr. Deming's lecture was inspirational but very much directed to all the managers in the auditorium and focused on leadership. His 14 points for management took shape during his lectures and were covered in various locations in the early draft he supplied to HP (Figure 2). When his book was finally published in 1982 by the Massachusetts Institute of Technology Center for Advanced Engineering Study under the name *Quality, Productivity, and Competitive Position*, the 14 points had their own chapter (Figure 3) [1].

14 Points for Management

Dr. Deming's 14 points describe responsibilities for top management. He asserted that shareholders were best served by profitability—not by quarterly manipulation but by quality—and quality was everyone's job, but it had to be led by management. His 14 points include the following [2]:

1. Create constancy of purpose toward improvement of product and services with a plan to become competitive and to stay in business. Decide to whom top management is responsible.
2. Adopt the new philosophy. We are in a new economic age. We can no longer live with commonly accepted levels of delays, mistakes, defective materials, and defective workmanship.
3. Cease dependence on mass inspection. Require, instead, statistical evidence that quality is built in to eliminate the need for inspection on a mass basis. Purchasing managers have a new job and must learn it.
4. End the practice of awarding business on the basis of the price tag. Instead, it depends on meaningful measures of quality, along with the price. Eliminate suppliers that cannot qualify with statistical evidence of quality.
5. Find problems. It is management's job to work continually on the system (design, incoming materials, composition of material, maintenance, improvement of machines, training, supervision, health and safety, and retraining).
6. Institute modern methods of training on the job.
7. Institute modern methods of supervision of production workers. The responsibility of foremen must be changed from sheer numbers to quality. Improvement of quality will automatically improve productivity. Management must prepare to take immediate action on reports from foremen concerning barriers, such as inherited defects, machines not maintained, poor tools, and fuzzy operational definitions.
8. Drive out fear so that everyone may work effectively for the company.
9. Break down barriers between departments. People in research, design, sales, and production must work as a team to foresee problems of production that may be encountered with various materials and specifications.
10. Eliminate numerical goals, posters, and slogans for the workforce, asking for new levels of productivity without providing methods.

11. Eliminate work standards that prescribe numerical quotas.
12. Remove barriers that stand between the hourly worker and his right to pride of workmanship.
13. Institute a vigorous program of education and retraining.
14. Create a structure in top management that will push every day on the above 13 points.

Lessons Learned Throughout My Career

In the years following, I've put together my comments and observations on Dr. Deming's 14 points based on lessons I learned throughout my career [3].

1. Long-term perspective and constancy of purpose are necessary ingredients for continuous improvement of the extended process or products. Concern for improvement and innovation of products, processes, or services for today and tomorrow gives management foresight to allocate resources to become competitive, increase productivity, stay in business, satisfy return for stockholders, and provide jobs.

2. Top management must be committed to nurturing an "I win, you win" mentality rather than an "I win, you lose" mentality. The organizational vision needs to include all members of the extended process: customers, suppliers, employees, investors, and the community. This vision must consider and balance the needs of all members of the extended process.

3. Mass inspection is essentially checking goods with no consideration for how to make them better, improve the process, or achieve higher quality. Quality is not improved by after-the-fact inspection; the defective items have already been produced. One way we practiced this point was to start to statistically analyze the rejects of our electrical test data, rather than just using it to sort the good from the bad. We found that random defects that kept reoccurring were not random but based on specific PCB design practices rather than manufacturing processes.

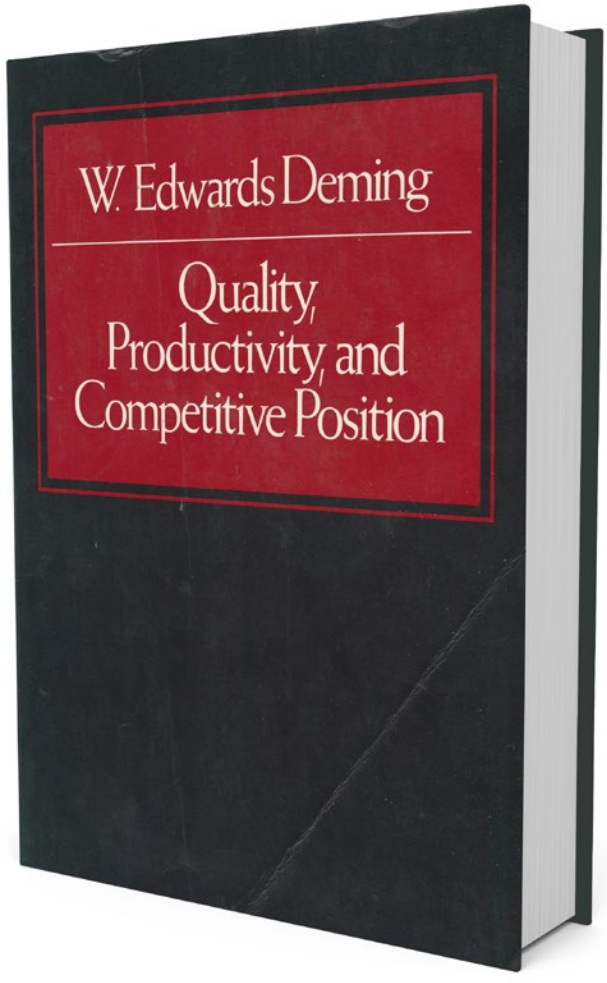

Figure 3: The final published book in 1982.

4. We started to create a working system for the cost of quality with purchasing. By brainstorming and looking at all aspects of production—not just the price of an object—a consensus was obtained that created a new linear model for the figure of merit for a purchase rather than just its price.

5. Management is responsible for the entire system and all its various processes. Process and product improvement and innovation are accomplished by planning projects that require statistical and behavioral methods. We found that training the process engineers in DOE and other topics in engineering statistics—and making it fun—was the best way to give them new tools to improve process yields and eliminate waste (rejects). We used the successful training program developed by DuPont and Dorian Shannon.

6. Proper training—which gives workers an understanding of their jobs, specific procedures to do their jobs correctly, and a method of evaluation when training is complete—will result in quality improvement. Everyone knows his or her job and is in statistical control, pursuing never-ending improvement. Further, everyone in an organization should be trained in basic statistical methods, and organizations should foster everyone's ability to understand variation.

My engineers and workers interpreted this to request "confidence tests" for each major process in printed circuit manufacturing—not the tests that the chemical lab does but simple tests for them to understand that the process was behaving correctly; otherwise, how could they be responsible for the quality of the PCBs? This was an interesting request, so engineering developed simple, short tests that each worker could perform in less than two minutes that provided that confidence.

7. Institute leadership at every level. The aim of leadership should be to help people and machines to do a better job, not to assign blame. Attributes of a leader at any level are to be a coach, counselor, and facilitator—not judge and jury.

8. Fear is a malady that may not be apparent to top management, but it affects quality. Many managers and supervisors use their power to create fear because they believe the way to motivate employees is through coercive power, but it is not. During the COVID-19 pandemic, workers may be reluctant to voice a concern about how their job is performed while still ensuring that they will be safe for themselves and their families. Management has control over these work elements and is responsible for changing the organizational climate.

9. Barriers impede the smooth flow of the extended process and its information, and everyone suffers—especially the customer. The most notable effect is that it can cause multiple interpretations of a given message. In his book [4], Alfie Kohn said, "Operationally defining the ultimate customer's needs and expectations so that everyone understands how he contributes to the success of the organization is a solid step to breaking down barriers between departments." I always felt that HP's practice of having quarterly "beer and hamburgers busts," where top management would tell us about business and then do the cooking and service while everyone else talked shop, solved more problems between departments than formal systems.

10. This is a tough one for management because many expect that leadership includes being a cheerleader with slogans, which will motivate the individual to achieve and clarify what is expected of that person. Unfortunately, it usually has the opposite effect. Targets and slogans that are set arbitrarily without an understanding of the process, as well as new methods to achieve such goals, are meaningless and do not help anyone do a better job. Management owns the system.

Examples of slogans, posters, and targets that do not help anyone do a better job are:

- Do it right the first time
- Safety is job number one
- Increase return on net assets 3% next year
- Decrease costs 10 percent next year

These targets do not represent action statements for employees, but rather management's wishes for the desired result. Management is simply lazy or incompetent if it thinks its only responsibility is to create slogans rather than improving the system.

11. Similar to point #10, this is a tough point for management to swallow. Old-style management believes they own the quota, production rates, and shipments, but these targets do not represent action statements for employees. Rather, they represent management's wishes for the desired result and ignore quality, so they are at odds with the new philosophy Dr. Deming is talking about. Output—quantity and quality—is based on the process's capability as determined by statistical methods.

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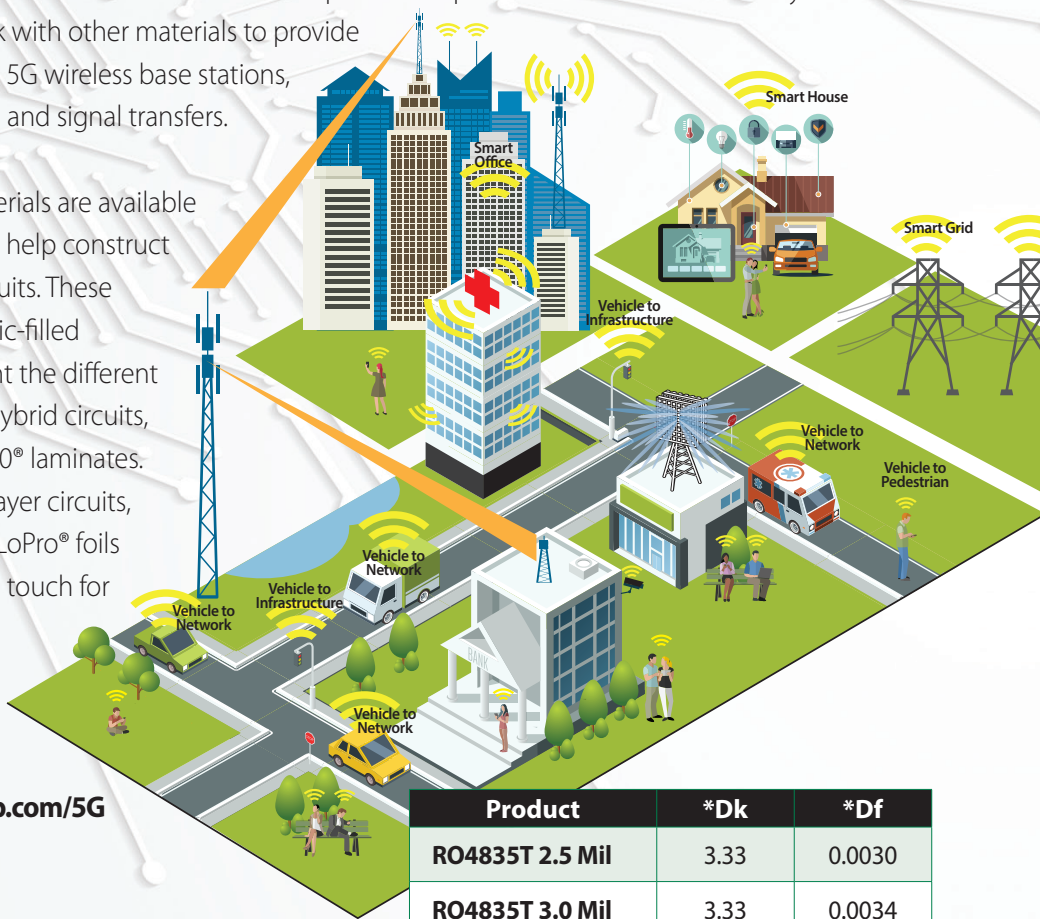

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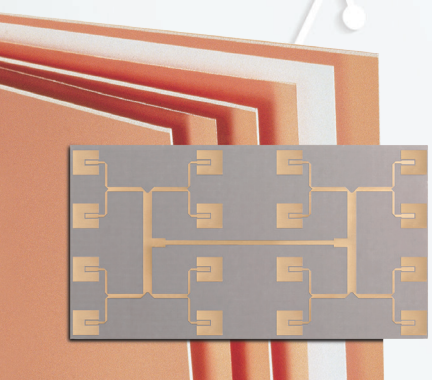

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Management owns the budgets, machines/processes, and systems. To change the output, change the system (point #7).

12. Many organizations in the United States do not use workers to their fullest potential, robbing them of their pride of workmanship and treating them as commodities. This loss of pride is an obstacle to achieving a competitive advantage. There is a lot of wisdom that accumulates by workers doing a job repeatedly. One of the insights that General Electric found while investigating the high quality and productivity of Japanese corporations in the early 1980s was that they had nearly three times the number of engineers on the factory floor working with employees to eliminate waste and losses than GE employed. The Japanese were not working harder than Americans; they were working smarter, and the engineers were there to implement what the workers had discovered and to make their work go smoother—to change the system!

13. In Dr. Deming's theory of management, education is the first step for an organization that wants to improve quality. Everyone in the organization should receive this education, beginning with top management. Statistical education at all levels is also necessary to prepare employees to implement these methods.

I was impressed that John Young started the "Stand in Quality" training program personally. Self-development is an attitude and characteristic that is essential in electronics, as we have the fastest-changing technology in the world. One of my jobs was to make sure each of my engineers had a self-improvement plan for themselves. Together, we helped every production supervisor create a plan for each worker. Installing a love of learning for production workers was one of the toughest activities I ever undertook.

14. Top management in an organization must make a commitment to transform the organization. Setting the change process in motion involves the recognition that problems exist and a desire to create a new organizational environment—one in which the never-ending improvement of quality is the primary goal. Dr. Deming's message to managers is to stop focusing on the judgment of results from a process and to start focusing on the improvement of the process that created the results.

This Time, TQM Stuck

HP had tried to introduce statistical quality/process control twice before, but both times, it did not really stick. Dr. Deming was right; this time, the program was pushed from the top management. In fact, John Young appointed a corporate facilitator to work with Dr. Deming and put together HP's plan of implementation. One of the first tactics was the plan for TQM training called "stand in quality."

It involved taking advice from past Malcolm-Baldridge winners. They all emphasized Dr. Deming's 14 points but also introduced us to the LUTI (learn, use, teach, implement) training strategy—a training process from the top, moving down. Starting with the corporation president, he would instruct his staff (the learn step) and then give each member an individual project (use). After completion, each of his staff would train (teach) their respective staff and assign a project (implement) to each person. The four-step process is repeated all the way down until everyone has been trained.

I learned the "stand in quality" concept from my boss, and after my project, I taught it to my engineering staff, who taught it to supervisors and technicians, and so forth. This time, it stuck! It was not merely being exposed four times, but having it come from the top down that made it real. And the enthusiasm created by this process never dissipated.

Quality circles were created that gave production workers an active role in improving board quality. A willing young engineer was selected to champion the DOE course we licensed from DuPont. This course and workbook went out to all engineering groups in the company. When my engineering group had the opportunity to take the 5.5-day course, the response was immediate. Yields went up, problems were solved—and didn't come back—and my engineers wondered why this important tool was left out of their education.

Conclusion

There is a lot of overlap between HP's pursuit of excellence in the 1980s and the situation in which companies find themselves during the COVID-19 pandemic. Process and procedures will have to change. Now is the ideal time to start to (re)implement Dr. Deming's 14 points. Documenting your process, looking for obvious areas for improvements, guaranteeing the safety of all employees, eliminating all forms of "waste," deciding what functions can be permanently left "at home," and (re)focusing on retraining/skills were all part of Dr. Deming's teaching. I consider TQM and DOE the two most important skills for any engineer in printed circuit design and manufacturing.

If you want further reading on TQM and DFM, from someone that comes from PCB/A, check out Dr. Sammy Shina's books. Sammy Shina, Ph.D., was an HP engineer in PCB and PCBA who went back to school for a Ph.D. and is now a professor at the University of Massachusetts-Lowell. **PCB007**

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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. To read past columns or to contact Holden, click here.

Making Nuclear Energy Cost-Effective

Nuclear energy is a low-carbon energy source that is vital to decreasing carbon emissions. A critical factor in its continued viability as a future energy source is finding novel and innovative ways to improve operations and maintenance (O&M) costs in the next generation of advanced reactors. The U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) established the Generating Electricity Managed by Intelligent Nuclear Assets (GEMINA) program to do exactly this. Through $27 million in funding, GEMINA is accelerating research, discovery, and development of new digital technologies that would produce effective and sustainable reductions in O&M costs.

Three MIT research teams have received APRA-E GEMINA awards to generate critical data and strategies to reduce O&M costs for the next generation of nuclear power plants to make them more economical, flexible, and efficient. The MIT-led teams will collaborate with leading industry partners with practical O&M experience and automation to support the development of digital twins. Digital twins are virtual replicas of physical systems that are programmed to have the same properties, specifications, and behavioral characteristics as actual systems. The goal is to apply AI, advanced control systems, predictive maintenance, and model-based fault detection within the digital twins to inform the design of O&M frameworks for advanced nuclear power plants. (Source: MIT News)

MilAero007 Highlights

Photo Slideshow From Historic U.S. Launch Into Space ▸

Hugs and cheers followed NASA astronauts Bob Behnken and Doug Hurley as they made their way from the Dragon capsule into the International Space Station just before 3:30 p.m. EDT Sunday, marking the first successful leg of America's return to a full-fledged space program. We've put together a slideshow of some of our favorite images provided by NASA, from the preparations to liftoff to the final docking and entry into the International Space Station.

SpaceX Manned Mission Promises More Success for Milaero and Electronics Manufacturing ▸

On May 30, 2020, SpaceX became the first nongovernmental organization to send human cargo into orbit and to a successful docking rendezvous with the International Space Station. On June 1, Nolan Johnson spoke with military/aerospace consultant and I-Connect007 columnist Mike Hill about the significance of this mission.

Defense Speak Interpreted: What's an RCV, and What Do Electronics Have to Do With It? ▸

In "Defense Speak," RCV does not stand for ranked-choice voting, a remote control vehicle, a riot control vehicle, or a refuse collection vehicle, although the second one is close; it stands for a remote combat vehicle. Denny Fritz explores this concept and its defense applications.

Quest for Reliability: New Solder, Same Old Testing ▸

Solder is inarguably one of the required building blocks for electronic assemblies and, apart from a few exotics, every assembly in the world has it. When it comes to meeting the lead-free requirement, opinions and historical reliability data are not taken into consideration. Eric Camden explores testing and reliability related to solder.

What It Takes to Be a Milaero Supplier, Part 4 ▸

The decision to pursue military and aerospace (milaero) certification impacts every facet of the organization, and not every shop is prepared to make this transformation. This is the final article in a four-part series, breaking down what it takes. In Part 4, Anaya Vardya explores what it takes to be a milaero supplier in the area of manufacturing.

BAE Systems Awards Amphenol Ardent Concepts 2020 Gold-Tier Supplier Award ▸

Amphenol Ardent Concepts is proud to announce receiving a Gold Tier Supplier status with BAE Systems. This coveted honor, part of BAE Systems' Partner 2 Win program, recognizes suppliers who have achieved operational excellence and eliminated defects in its supply chain by raising the bar of performance expectations to meet the demand of current and future customers.

From the Hill: MIL-PRF-31032 Offers a Rewarding Twist ▸

If you are fabricating PWBs to military specifications, the master drawing will state: "Fabricate to MIL-PRF-55110, MIL-PRF-50884, or MIL-PRF-31032." This sounds very complicated on the surface, but there is a rewarding "twist" if the fabricator is certified to MIL-PRF-31032. Mike Hill explains.

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The Importance of Quality Management

The PCB Norsemen
Feature Column by Didrik Bech, ELMATICA

Why Your Company Should Focus on Quality Management

Most companies have a quality management system (QMS), but the important factor is not if you have one; it's about how that system is implemented in your company's values, strategies, and goals. How can you use your QMS as a competitive advantage to support your core business and not be just a document collecting dust?

Over the last 18 months, we have worked diligently in the board and officer group on our strategies and QMS. This work has been done to facilitate adjustment in market trends, updating it for potential future challenges and opportunities, risk analysis, and ensuring that we are internally aligned. Most importantly, we have included the manager group in this development to further enhance and improve our strategic implementation and execution strength.

Having the full team aboard has resulted in a more agile, responsive, and coherent organizational structure, which has proven invaluable during the COVID-19 outbreak. We are able to detect, respond, and implement global measurements with speed and efficiency relative to prior times.

The Must-Haves in Quality Management

To ensure that a QMS functions optimally, it needs to represent the core aspects of the company, known by heart by every employee, and linked to every department's procedure and methodology. It's like building a house or producing a faulty printed circuit; if the design is wrong, then the end-product will not be as planned.

Implementing a QMS is all about ensuring that it is designed to support the organization and its procedures and not something irritating, representing bureaucracy and extra work. It should be well-written and documented, but often it is hidden away in a dusty drawer and only read when there are major challenges. Quite often, that's too late.

What factors should you consider when implementing a QMS? First, start with the basics: Why, how, and when?

Why Is It Smart and Necessary to Implement a QMS?

Unquestionably, a QMS will improve the effectiveness of your organization. It is needless to say that with clear goals, mandates, and responsibilities, life becomes easier for everyone. With clearly defined goals and measurements, one will be able to determine the efficiency of one's strategies. The consequences of improving your performance and introducing innovative processes are as endless as the pursuit of outstanding quality performance.

Firstly, by understanding and keeping track of your actions and your external environment, you will be able to implement changes before an emerging market condition, environmental circumstance, or government regulation is in full effect. This ability will improve your competitive position and strengthen your shareholders' values.

Secondly, by eliminating defects and waste, you will benefit from higher profitability as a result of reduced costs by having a better cost management system. This will result in increased job security for the employees and allow them to focus on other value-generating aspects for your customers. The end result of this chain reaction will be an increase in customer loyalty, retention, and improved market value.

How Should You Build Your QMS?

As we all know, there are as many paths as there are masters, but only one destination. For example, our quality methodologies are based on Six Sigma, Lean, Kaizen, and good old common sense, but these must be adapted to customer and company requirements to be optimal.

A good starting point is quality performance toward customers and what creates value for them. Set your goals based on this. Once the goals are defined, determine where you can support our customers and create value in your systems, procedures, and decision processes. Accordingly, once you determine and define where you can create value in your systems, procedures, and decision processes, create an internal log system and methodology to document and measure this value-creating process.

When Is Your Attention Required?

As important as defining strategies, goals, and measurements is, the method and routine for continuously analyzing the situation are just as critical. Hence, a sturdy organizational routine in your management structure to ensure that one is monitoring the situation frequently and consistently.

Establish a regular analysis meeting with one responsible person from each department, let them make decisions, and implement corrective actions and measurements to improve the company's excellence. This will be one vital step during a long journey in your company path towards continuous working with your QMS.

Five Reason Why a QMS Is a Smart Investment

If you are still in doubt about implementing a QMS, here are the top five reasons why you should. Having a QMS improves:

1. Organizational Effectiveness

It's all about goals. We need a goal to stretch toward, no matter if you work in sales, customer service, technical, or procurement. No goals = no gains. With no parameters to measure im-

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provements, or a lack of them, how can you expect the teams to keep the spirit up? Set clear goals and measure and review the organization's ability to reach them. When an organization can present clear and reachable goals, increased improvement and effectiveness can happen.

2. Customer Satisfaction

Satisfied customers mean returning customers, which is what we all work hard to achieve. A well-integrated QMS should focus on customer satisfaction and be designed to document customer feedback on performance and further use this information to improve customer satisfaction. Then, the "circle of improvements" in your company will avoid any disruptions.

3. Compliance

Compliance is a high priority. Developing and following multiple standards and regulations for an industry allows no room for slack when documenting, auditing, and reporting internally to governments and customers. There is no room for mistakes. By integrating these processes into your QMS and tailoring your IT systems to handle this data, you can obtain full control of your customers' data, access control, audits, and certificates.

4. Company Culture

Humans have different purposes and goals, but working in a company where there is no goal or strategy can potentially drain your energy and make the job and role unfulfilling. By establishing clear goals and priorities in the QMS, communicating it internally, and aligning the departments, your colleagues will know where the company is heading and feel more secure and confident in how to support the goals.

5. Documentation

The need for documentation, review control, escalation levels, and process control is as important in small as large organizations. Including this in the QMS will ease the review situation and secure that correct information is shared at the right level. Implementing routines and documenting all processes in the QMS provides predictability and ensures that all activities and documents are aligned and fulfilled. This makes life easier for all colleagues with clear mandates and objectives and complete control for the manager and officer group.

Quality is never an accident. It is always the result of intelligent effort.

All On Board, or Else the Ship Goes Down

I stumbled across this quote the other day by John Ruskin: "Quality is never an accident. It is always the result of intelligent effort." I absolutely agree. Quality is not something you will naturally obtain overnight; it's an ongoing expense that needs to be constantly developed and nurtured.

The world, as we know it today, offers endless opportunities and challenges in all industries and on all levels. However, by implementing a QMS, it's easier to stay on track, avoid costly deviations on the road, and make sure the entire team is on the same path. Success does not come because of one group of leaders with good ideas. Success can only be achieved when all are on board, contributing at every level of the organization toward common goals. Seek to be aligned with your customers' processes, support their value-creating process, and strengthen their competitive advantage, ensuring quality process control. **PCB007**

Didrik Bech is the CEO of Elmatica. To read past columns or contact The PCB Norsemen, click here.

Introducing the IPC Certified Standards Expert—the know-it-all your business needs.

When it comes to ensuring consistent quality and reliability, IPC standards are the backbone of the electronics manufacturing industry. With Certified Standards Experts (CSEs) on your team, you'll have in-house subject matter experts on specific IPC standards who can navigate the ins-and-outs of those standards quickly and efficiently. They draw upon the same knowledge as Certified IPC Trainers (CITs) but are not required to train. Your CSEs will be the know-it-all go-tos for questions, issues, updates and best practices on standards specific to your organization.

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Electronics Industry News and Market Highlights

Intel Capital Invests $132 Million in 11 Disruptive Technology Startups ▶

Intel Capital, Intel Corporation's global investment organization, recently announced new investments totaling $132 million in 11 technology startups. These companies bring to market breakthrough innovations in artificial intelligence, autonomous computing, and chip design.

Robotics Reaps Rewards at ICRA: NVIDIA's Dieter Fox Named RAS Pioneer ▶

Thousands of researchers from around the globe gathered—virtually—recently for the IEEE International Conference on Robotics and Automation. As a flagship conference on all things robotics, ICRA has become a renowned forum since its inception in 1984.

New Printed Electronics Material From CHASM Advanced Materials Fuels Next-Generation Transparent Wireless Antennas ▶

CHASM Advanced Materials announced a new generation of its AgeNT™ transparent conductive film platform specifically formulated for applications requiring very low sheet resistance and high visible light transparency, such as transparent RF antennas, transparent RF/EMI shielding films, transparent heaters, and transparent electrodes, and wiring for LED lighting.

iDriverplus Selects Ouster Lidar for Autonomous Robotics Platform ▶

Ouster Inc., a leading provider of high-resolution lidar sensors for autonomous vehicles, robotics, security, and mapping, recently announced a partnership with Chinese robotics leader iDriverplus for autonomous cleaning and sanitation robots used to safely sanitize and disinfect potentially contaminated sidewalks and public areas.

DOT Autonomous Farming Platform Has Arrived in Ontario ▶

Haggerty Creek is the first DOT unit operator in Ontario and arrived in Bothwell on May 13, 2020. It has already taken to the fields of Chatham-Kent to be used in commercial fertilizer applications.

WISeKey 'Foresight' IoT Early Warning System Technologies Can Be Used to Facilitate the Detection of Future Virus Outbreaks ▶

WISeKey International Holding Ltd, a leading global cybersecurity and IoT company, announced it is partnering with global technology organizations to provide an IoT early warning system that can be used to facilitate early detection of viruses and future outbreaks.

Manage Disruption Through Collaboration at Virtual SEMICON West 2020 ▶

SEMICON West will occur in a virtual format for the first time in 50 years, featuring all the world-class talent and leading technologies that have come to symbolize the flagship microelectronics annual conference.

NTS Longmont Expands Capabilities to Become One of Colorado's Most Advanced 'One-Stop Shops' for Packaging, Energy, Space, and Aviation Industry Testing and Certification ▶

NTS announced that its laboratory in Longmont, Colorado, is once again expanding its services. The NTS lab secured ISTA Laboratory Certification earlier this year and now tests to Amazon, FedEx, and Sam's Club requirements. ISTA Certification ensures packages undergo rigorous testing to protect against shock, vibration, and atmospheric hazards.

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Minimizing Signal Transmission Loss in High-Frequency Circuits

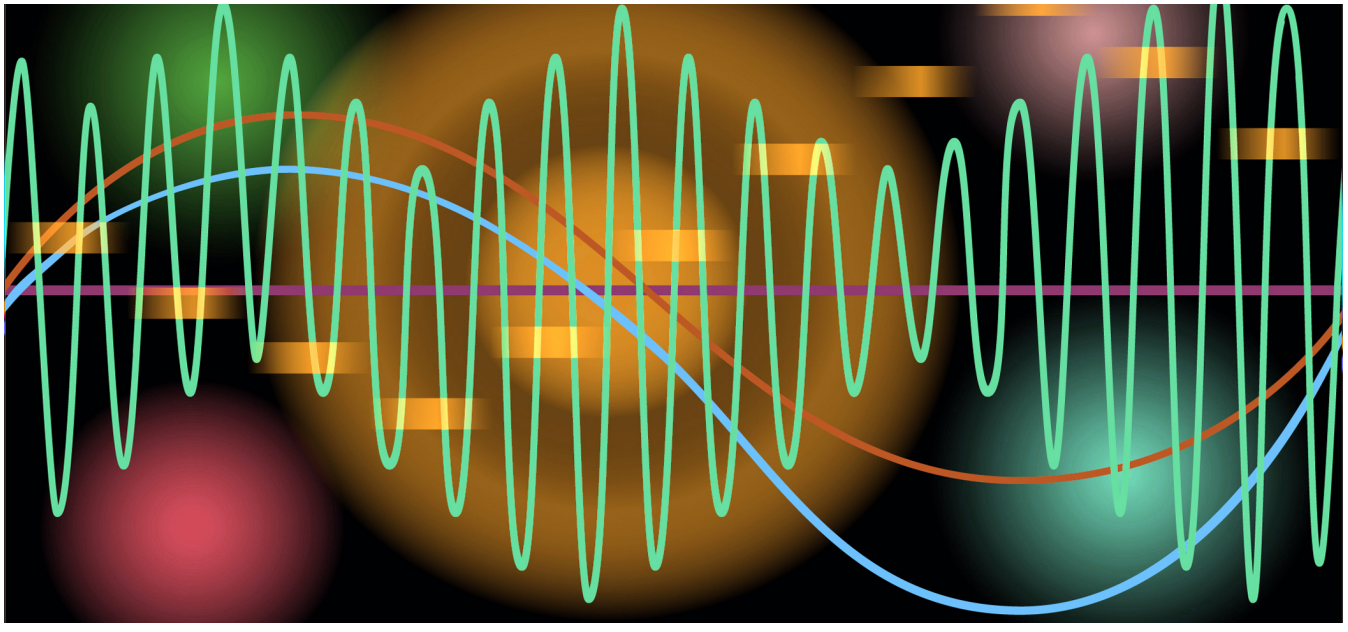
The Plating Forum
by George Milad, UYEMURA

Introduction

The amount of information transferred on wireless networks has increased dramatically with the growth of mobile phones, internet access, and handheld devices. The transmission of a high-speed RF signal is increasingly required in PCBs to handle massive data in electronic systems. The transmission speed of signals propagating inside the system has been increasing. RF signal loss, also known as insertion loss, becomes remarkable on a PCB in the higher GHz frequency ranges. Insertion loss is the loss of signal power resulting from the insertion of a device in a transmission line or optical fiber and is expressed in decibels (dB). Insertion loss could lead to rising edge degradation of signals or higher rate bit error and so on.

All PCB materials have both conduction and dielectric RF signal losses. The conduction losses are resistive and are caused by the conductive copper layer used in the board. The dielectric losses, on the other hand, are associated with the substrate (insulating material) used in a PCB. In this column, I will highlight resistive conduction losses by the copper layer used in the board.

The study of transmission loss involves plotting the electrical behavior (scattering matrix), measured in dB, of linear electrical networks when undergoing various steady-state stimuli by electrical signals versus increasing signal frequency (GHz). Transmission loss, also known as insertion loss, is the extra loss produced by the introduction of the device under test (DUT) between the two reference planes of the measurement. The extra loss may be due to intrinsic loss in the DUT and/or mismatch. In case of extra loss, the insertion loss is defined to be positive. The negative of insertion loss expressed in dB is defined as insertion gain.



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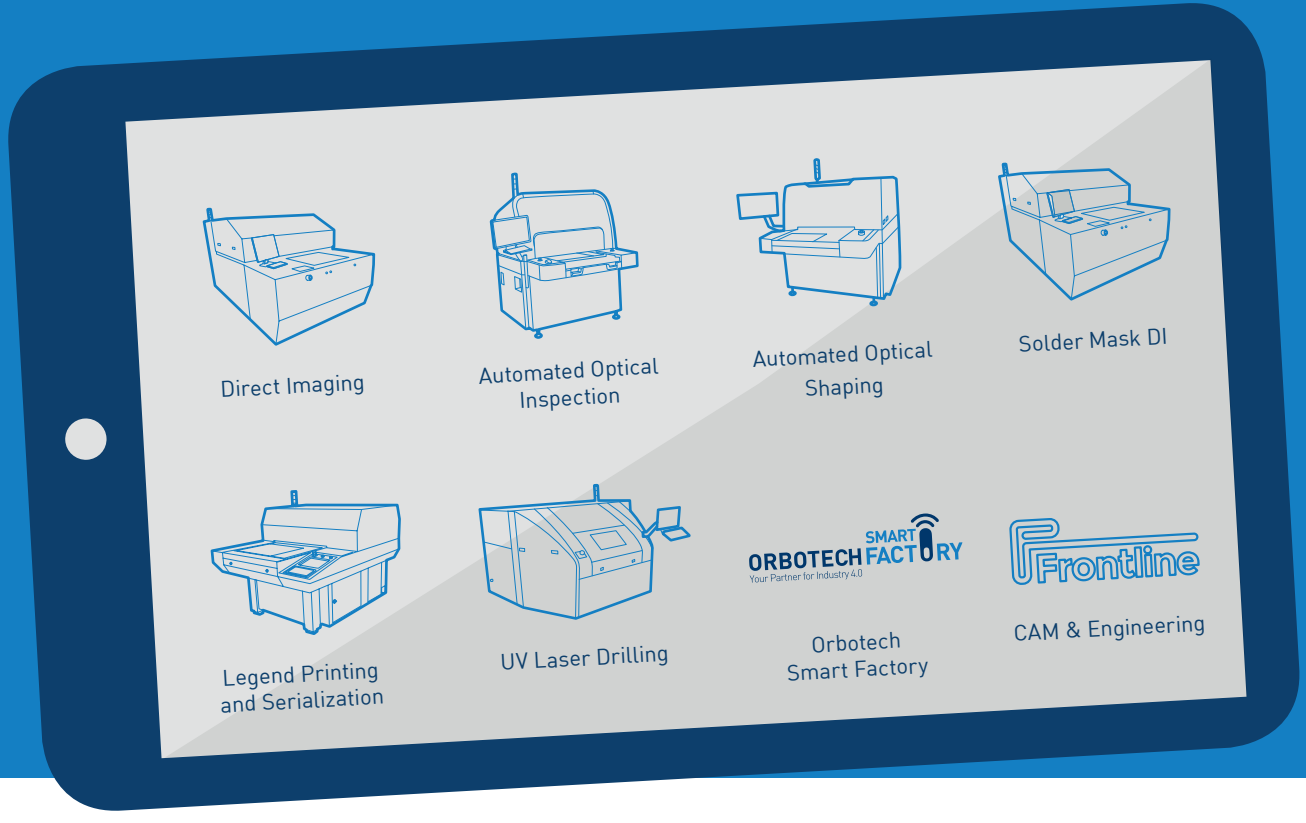

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Skin Effect

Unlike DC or AC current that flows through the whole conductor trace, RF current does not penetrate deeply into electrical conductors but tends to flow along their surfaces; this is known as the skin effect. Signal loss in the conductive copper layer is directly related to the phenomenon of "skin effect." Skin depth is the depth of the conductor the RF current uses. Basically, less of the conductor is used as the frequency increases Figure 1.

Two phenomena that have a direct impact on insertion loss due to the "skin effect" are the degree of copper roughness (Figure 1) and the nature of the surface finish used. Surface finishes that contain electroless nickel on the surface, like electroless nickel immersion gold (ENIG) and electroless nickel electroless palladium immersion gold (ENEPIG), show greater insertion loss due to the resistive properties of the electroless nickel as compared to copper. Newer finishes like electroless palladium immersion gold (EPIG) and immersion gold electroless palladium immersion gold (IGEPIG) are the preferred finishes for minimum insertion loss in high-frequency applications.

Copper Surface Roughness

Copper surface roughening is purposely done to enhance adhesion of the conductor to the dielectric in multilayer structures. Roughening is accomplished by chemical or mechanical means, creating anchoring sites for the resin. This has worked well for non-RF current applications, and it would also work well for RF signals propagating at lower frequencies. However, as the frequency increases closer to 10 GHz or above, the skin depth is reduced. When the skin depth is equal to or less than the copper surface roughness (Figure 1), then the roughness will result in increased resistivity of the trace and will impact the conductor loss and the phase angle response of the circuit.

As signal frequency increases, electrical signals increasingly run closer to the copper conductor surface. This leads to increased resistance and transmission loss.

Circuits using copper with a rougher surface will have more conductor loss than circuits using copper with a smoother surface. More specifically, the copper surface at the substrate-copper interface is the concern for surface roughness in relation to conductor loss. Recent developments in enhancing adhesion in multilayer boards go beyond the standard roughening created by black and brown oxide.

Today, most inner layers rely on chemical etching to micro-roughen the traces for maximum bonding. However, micro-roughening is not the answer to minimizing conductor signal loss. Chemical bonding is becoming the choice for adhesion for traces carrying high-frequency RF signals; it is also very effective on smooth copper surfaces.

One chemical bonding system offered today is a combination of immersion tin, followed by a treatment with a silane coupling agent. The treatment is usually carried out in horizontal conveyorized equipment and results in excellent adhesion between conductor and di-

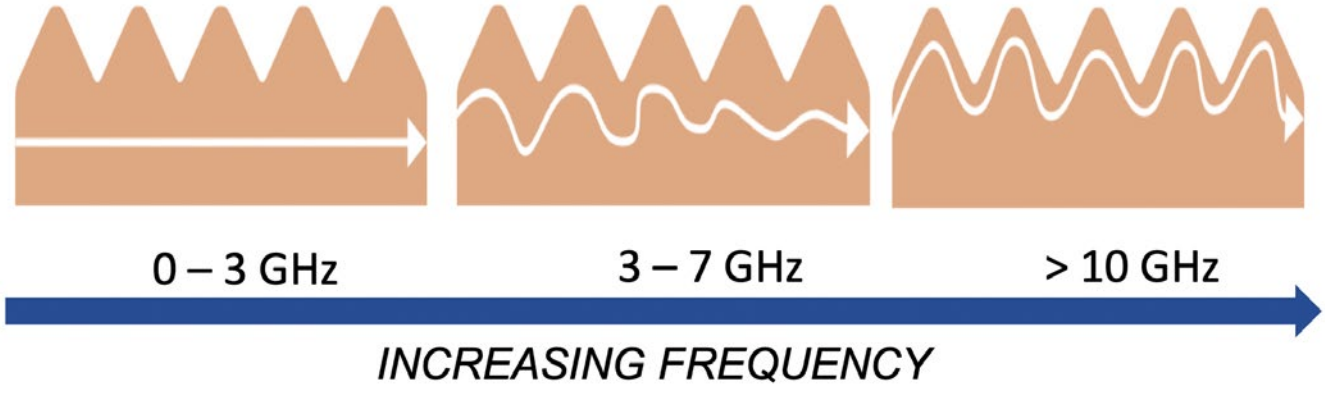


Figure 1: Copper conductor skin effect.

electric. According to one source [1], "Studies have shown that copper foil types of varying degrees of roughness have a direct effect upon the insertion loss of a stripline structure. New treatments targeted at conductor insertion loss and surface roughness minimization are being offered by chemical suppliers."

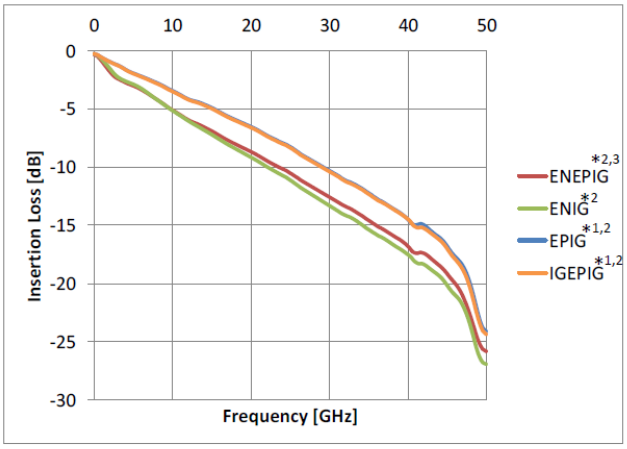
Insertion Loss and Surface Finish

Handheld devices are a key driver for miniaturization by circuit designers. Fine lines and spaces are being normalized for many of these applications. In addition, the need for wire bonding focuses attention on nickel gold (ENIG) and nickel palladium gold (ENEPIG). These finishes are beginning to meet limitations when it comes to high (10 and 10+) GHz RF signal transmission. The electroless nickel layer is an integral part of the surface of the conductor. There is a transmission loss associated with the skin effect of the electroless nickel as compared to copper.

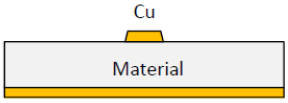
Newer surface finishes for high-frequency RF transmission are now available. These finishes eliminate or reduce the use of EN. The most common one today is electroless palladium immersion gold (EPIG). I covered EPIG in a previous column. Here, the focus is on insertion loss.

Figure 2 includes a plot of the scattering parameter (S-parameter) as the vertical axis versus the signal Frequency on the horizontal axis. With S-parameters, scattering refers to the way in which the traveling currents and voltages in a transmission line are affected when they meet a discontinuity caused by the insertion of a network into the transmission line. A baseline is first established, and a new plot is then measured with the introduction of the DUT. The difference is the transmission loss or insertion loss and is measured in dB.

Figure 2 compares the insertion loss of surface finishes with nickel (two variations of ENEPIG and one for ENIG), reduced nickel (thin nickel ENEPIG), and no nickel (EPIG and IGEPIG). Thin nickel ENEPIG has as little as 4.0 µins (0.1µm) of electroless nickel. IGEPIG is a variation of EPIG. EPIG uses an immersion palladium catalyst on the copper surface to initiate electroless palladium deposition; IGEPIG uses an immersion gold layer as the catalyst for the deposition of electroless palladium.



■ Test board
Specification:
Material: Megtron6
Trace: single-end 50Ω /
Length = 250mm w = 0.52mm



■ Measurement
VNA ZVA67 (ROHDE & SCHWARZ)
■ Test board provided and measured by OKI printed circuits Co., Ltd.

*1; EP: pure Pd type for ENEPIG,
Thin Ni ENEPIG, EPIG and IGEPIG
*2; IG: mixed reaction type
*3; EP: Pd-P type

Insertion loss [dB]	Normal ENEPIG*2,3	Normal ENEPIG*1,2	ENIG*2	Thin Ni ENEPIG*1,2	EPIG*1,2	IGEPIG*1,2
10 GHz	-5.1	N.D.	-5.1	N.D.	-3.4	-3.5
20 GHz	-8.6	N.D.	-9.1	N.D.	-6.5	-6.6
30 GHz	-12.5	N.D.	-13.3	N.D.	-10.3	-10.4

Figure 2: Comparison of the insertion loss of surface finishes with nickel, reduced nickel, and no nickel.

The different finishes were deposited on a single end 50Ω transmission trace (250 mm in length and 0.52 mm in width). Insertion loss measuring equipment was VNA 2VA67 (Rhode and Schwartz). As shown in the graph and summarized in the table (Figure 2), the insertion loss of low nickel and nickel-free gold surface finishes show a significant improvement in insertion loss value as compared to thick (120–240 µin or 3–6 µm) nickel gold finishes.

As the industry continues down the path of massive data transfer and miniaturization, the frequency of RF signal transmission will continue to increase. As 10 and greater GHz RF frequencies are designed into PCBs, special allowance must be made to minimize transmission loss due to copper roughness and type of surface finish used. **PCB007**

Reference

1. S. Hinaga, A. Rakov, M.Y. Koledintseva, & J.L. James, "Insertion Loss Reduction Through Non-Roughening Inner Layer Surface Treatments," Proceedings of IPC APEX EXPO, March 2014.

George Milad is the national accounts manager for technology at Uyemura. To read past columns or contact Milad, click here.

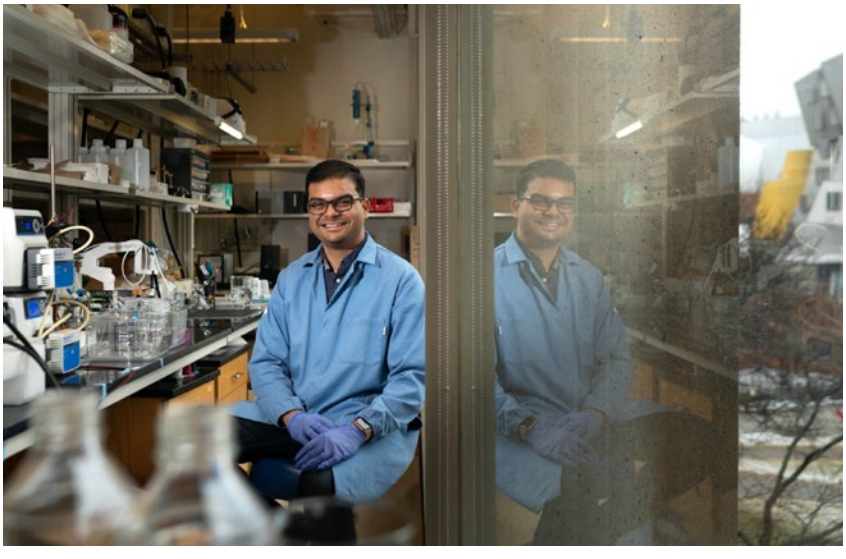
Lighting the Way to Better Battery Technology

Growing up in Kolkata, India, Supratim Das saw that a ready supply of electric power was a luxury his family didn't have. "I wanted to do something about it," Das says. He's been investigating what causes the batteries that power the world's mobile phones and electric cars to deteriorate over time.

Lithium-ion batteries power most rechargeable devices today. Lithium has properties that make lithium-ion batteries portable and powerful. In principle, rechargeable batteries shouldn't expire. In practice, however, they can only be recharged a finite number of times before they lose their ability to hold a charge. An ordinary battery eventually stops working when the terminals of the battery are permanently altered by the ions passing from one terminal of the battery to the other.

In a lithium-ion battery, one electrode is made of graphite, and the other of lithium compounds with transition metals, such as iron, cobalt, or nickel. At the lithium electrode, lithium atoms give up electrons, swim through the battery fluid (electrolyte), and wait at the other electrode. The electrons flow out the battery, through the circuit, and into the second electrode, where they rejoin the lithium ions. When charged, the ions and electrons retrace their steps, and the battery can be used again.

Charging cycles leaves ions at the graphite electrode, and the battery loses capacity over time. When a battery is "fast-charged," lithium ions start layering (plating) over the carbon electrode instead of transporting (intercalating) into the material. Prolonged lithium plating can cause uncontrolled growth of dendrites, causing short-circuiting and even fires.



Das and team have been able to understand the microscopic changes that degrade a battery's electrodes and develop physics-based models to predict them. These models can aid battery manufacturers to reduce battery health diagnostics costs and make batteries safer for consumers. (Source: MIT News)

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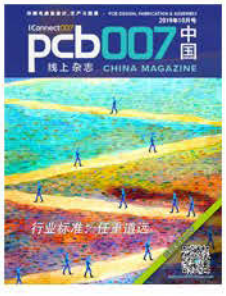

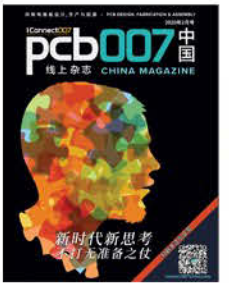

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Supplier Highlights

ESA Approval for Ventec VT-901 Material in ACB Belgium Rigid and Flex-Rigid Production ▶

Ventec International Group Co. Ltd. is pleased to announce that its VT-901 polyimide material is now fully qualified by ESA in ACB Belgium's manufacturing process for rigid and rigid-flex polyimide PCBs and HDI PCBs.

Raytheon Technologies Supporting the Supply Chain ▶

To support its small business suppliers, Raytheon Technologies formed a Small Business Supplier Stimulus Team focused on coordinating support to its supply base. This team brings together cross-functional members from each of the company's businesses, creating a hub of knowledge, expertise, and experience.

Atotech to Present at the ECTC Virtual Conference 2020 ▶

Atotech, a leading global provider of electroplating and surface-finishing chemicals and equipment for PCB, semiconductor advanced packaging, and dual-damascene applications, will participate in this year's IEEE 70th Electronic Components and Technology Conference (ECTC). The virtual conference will be held in June.

MacDermid Alpha Releases Complete Semi-Additive Process for IC Substrates and Panel-Level Packaging: Systek SAP ▶

MacDermid Alpha Electronics Solutions, a global leader in specialty materials for electronics, announces the release of Systek SAP. The MacDermid Alpha Systek SAP is a family of high-performance build-up processes for IC substrate RDL that provide multiple process flows for different materials as well as revolutionary technology innovations in the desmear, conditioning, activation, and metallization steps.

Rogers Corporation Keeps Materials Moving ▶

The I-Connect007 editorial team spoke with Roger Tushingham of Rogers Corporation about the company's current priorities with everything that's been changing recently, including his perspective on the distributing and manufacturing trends he sees as a global supplier.

Language of Electronics: HENSOLDT and Nano Dimension Achieve Breakthrough in Electronics 3D Printing ▶

Sensor solutions provider HENSOLDT, together with additively manufactured electronics/printed electronics provider Nano Dimension, has achieved a major breakthrough on its way to utilizing 3D printing in the development process of high-performance electronics components.

Key Considerations for Your Next Direct Imaging System ▶

In this column, Orbotech West DI expert Rick Jackson provides a guide detailing which issues should be considered when choosing a new DI system. As your PCB manufacturing company considers a new DI system, here are some key considerations to keep in mind.

Elsyca Offers Free White Paper on How Plating Simulation Raises Yield and Profitability ▶

What if the PCB pre-production engineer could upfront identify problem areas for the pattern plating and apply auto-intelligent copper balancing, as part of the CAM process to provide a right-first-time panel layout for production?

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Guerilla Tactics to Pass Any QMS Audit, Part 3

The Right Approach

by Steve Williams, THE RIGHT APPROACH CONSULTING

Introduction

Continuing Part 1 and Part 2 on "Guerilla Tactics to Pass Any QMS Audit," I share Tactic 9. Hopefully, you are finding a number of solid strategies you can apply immediately to improve your audit success.

Guerrilla Tactic 9: Documentation Tips To Avoid Audit 'Dings'

> ***Williams' Law 9***
> *Teach it, preach it, and audit to it. Prepare so that no question should be able to be asked that an operator does not know the answer to.*

> ***Williams' Law 9.1***
> *If you can't prove it, it didn't happen!*

> ***Williams' Law 9.2***
> *The ONE time a supervisor asked someone else to sign for them, the auditor will find it.*

Avoid audit dings.

Tip 1: KISS

"Keep it simple, Steve." The goal is to develop a system that:

- Is effective
- Is easy to understand
- Is flexible
- Minimizes opportunity for error
- Is simple

Tip 2: Standardization

Develop a standardized procedure template. Standardized sections might include the following:

- Responsibilities Section 2.0
- Quality Requirements Section 3.0
- Operations Section 5.0
- PM Section 7.0
- Forms Appendix A

This standardization should facilitate:

- Ease-of-use
- Training
- Recall
- Memorization of structure, not procedure
- Time-to-retrieval

Tip 3: Verbiage

Consider verbiage as follows:

- Functional vagueness
  - Precise enough for functionality
  - Vague enough for practicality
- Shall/must
  - Critical
  - Non-compliance would jeopardize operation

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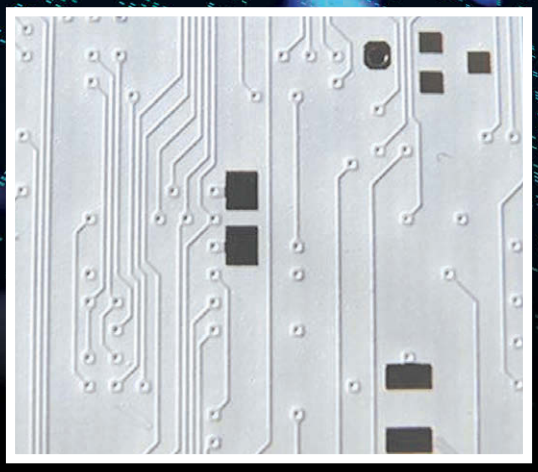

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- Should/may
  - Non-critical
  - Non-compliance would not jeopardize operation
  - Leaves room for external circumstances
- Examples
  - "Bath pH shall be verified and logged onto form 203-004 every two hours."
  - "Workplace should be kept clean on a continual basis."

Further, always use the term "designee." For example:

- Don't: "The molding supervisor shall review and sign-off on the daily SPC results."
- Do: "The molding supervisor, or his/her designee, shall review and sign-off on the daily SPC results."

Tip 4: Intelligent Conventions

If you are certified to an international QMS standard, such as ISO 9001 or AS9100, now that the powers that be have "harmonized" the standards, it is a great idea to number your system to align with the standard. For example, procedures, work instructions, forms, and attachments are numbered using the following number scheme with the prefix representing the type of document:

- QM: Quality manual
- QP: QMS procedure
- XX: Manufacturing work instruction (XX = department abbreviation)
- F = Form
- A = Attachment

Some examples include:

- The internal audit procedure that relates to section 9.2 is numbered as QP-920
- F-920-1 is the first form for the internal audit procedure QP-920
- Work instructions can start with WI, a three-digit department code, and a sequential number (e.g., WI-DRL-1 = first work instruction for the drill department)
- Same format for forms (WI-DRL-1-1 = first form for WI-DRL)

This makes it easy to identify all forms associated with each procedure or work instruction. Also, try to avoid an automatic sequential numbering scheme (QP 102345C) and large procedure numbers.

Tip 5: Reference Documents

Add a "reference documents" section to every procedure:

- Easy form maintenance
- Facilitates training
- Do not include form revision
- Reduces time-to-retrieval
- Assists in revision purge
- Helps maintain system integrity

Tip 6: Purge Control

Develop a control mechanism for revision purges. Don't take a "hands-off" approach and assume individual departments will effectively purge.

Tip 7: Keep Six Months of Quality Records at the Work Source

Have posted procedures at the work source (paper or electronic). For instance, a 3" binder will easily hold 180 pages (six months). This allows quick and easy access and retrieval, calibrates with six-month surveillance audits, and provides finite history to verify.

Tip 8: 'Outlaw' White-Out

Do not allow White-Out in the facility. You can write exceptions into document control procedures for correspondence if absolutely necessary. Have a "controlled substance" mentality; it's a simple matter of discipline. Teach "line, sign, date" (LSD) and audit to it internally

Tip 9: Eliminate Blanks

Issue edict: No forms shall have blanks. If a form has a section no longer used, remove it and revise the form. For instance:

- Infrequent non-use, line through, or "N/A": Write clause into the document control procedure

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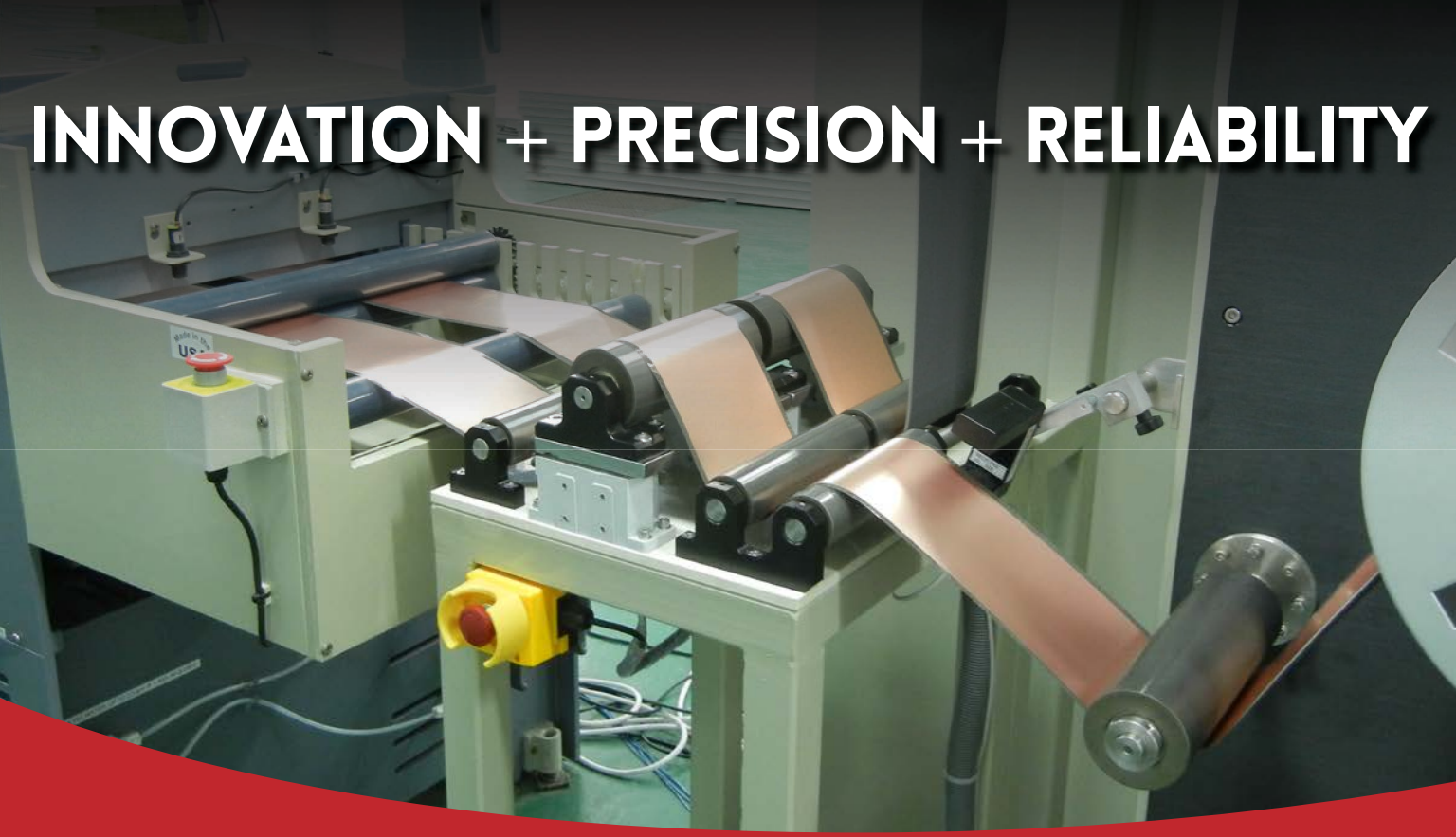

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- Blanks throw up red flags that something required wasn't completed and make it difficult to defend missing information

Tip 10: Include All Forms

All forms should be included in the document control system (manufacturing, office, etc.). Preventive maintenance forms/logs are often overlooked and should be posted at the equipment and highly visible. Forms are quality records, and you would be hard-pressed to find an example that doesn't contribute to the quality of the product in some form or another.

Tip 11: Resolve All Temporary Process Changes

Use three-month or six-month durations to sync with ISO surveillance audits. Try to resolve all TPCs prior to surveillance audits. If they can't, or for customer audits, review the entire list of TPCs to make sure they are not expired. Also, verify that all resolved TPCs have been closed out appropriately (i.e., approved with appropriate procedure revision and unapproved with documented reason).

Tip 12: Procedure Revision

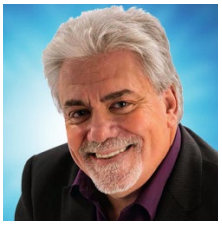
Procedure revisions show an auditor that continuous improvement is happening. A red flag to most auditors are procedures that were written five years ago and have not been revised since. For example:

- Preference: Annual procedure revision for a sample of procedures
- Acceptable: Touch all procedures at least once every three years

Don't forget forms that may need revision accordingly, and don't go overboard on revisions. Use a temporary process change process to combine multiple small changes.

Conclusion

It is my desire that as we work through the various strategies, techniques, and tactics presented throughout this series, you will appreciate these are tried-and-true, practical applications and lessons learned over the course of my career. I hope you will find some value in them. **PCB007**



Steve Williams is the president of The Right Approach Consulting. To read past columns or contact Williams, click here.

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IPC APEX EXPO is in San Diego in January 2021, and we plan to proceed as scheduled.

A Process Engineer's Guide to Advanced Troubleshooting, Part 1

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

The Case of Failed Boards at Assembly

Defects may "manifest" or be detected in or after a specific operation within the PCB manufacturing process, but the underlying root cause may have occurred earlier (perhaps much earlier) in the process. As has been written in many of my columns published thus far, I chose to present the anomaly or defect where it is most likely to be detected and subsequently present the most likely root causes wherever they might have been introduced. It should be noted that these examples are presented as likely starting places for the investigation of anomalies or defects presented or the kinds of causes that might be investigated.

The process engineer's task (aka "the troubleshooter") is complicated by the fact that there are many possible ways to combine or sequence the individual process steps available to achieve the desired end structure. As an example, a "simple" single-lamination multilayer printed wiring board may involve 30–50 process steps, while a complex, multiple lamination ("sequential lamination") printed wiring board, with pre- and post-machining and other mechanical operations and selective plating processes, could involve several hundred process steps.

In an ideal world, each step could be verified to be correct immediately during or after the process, but in practice, the effect of many processes cannot be readily evaluated until the completion of many subsequent steps makes latent errors visible. Much effort is expended and has been expended in attempts to improve this with limited success. Thus, it remains a troublesome issue.

Process Control

Before presenting the main subject of this month's feature, a word with respect to process control is in order. What gets measured

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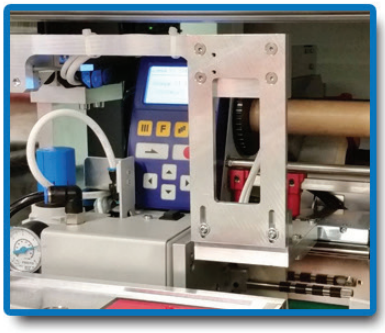

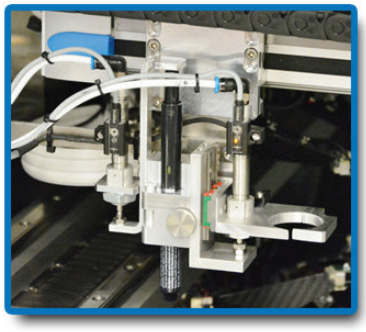

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gets managed. Simply put, one needs to understand that processes by themselves (excuse the non-technical term) have hiccups. Even when employing in-tank sensors and controllers to monitor chemistry, it is strongly suggested that wet titrations be employed to verify that chemical parameters are in check. While wet analysis involving titrations may be time-consuming, a skilled operator will get accurate results. More on specific aspects of process control in a future column.

In this issue of "Trouble in Your Tank," the focus will be on several anomalies that may have their origins in process steps not normally recognized as the root cause of the issue.

Assembly-Related Defects

It happens. You receive the dreaded phone call from one of your assembly customers. Some of the boards (very expensive ones!) that your company built failed during assembly. There were some vias with poor solder flow-up and a few vias with blowholes in the solder fillet. Obviously, the assembly company is placing the blame squarely on you (Figures 1 and 2).

In Figure 2, there are concerns with solderability as well. For reference, the final (solderable finish) on these boards is organic solderability preservative (OSP). Note the lack of solder fill or flow-up. OSP was also the finish of choice on the other part numbers that did not fail.

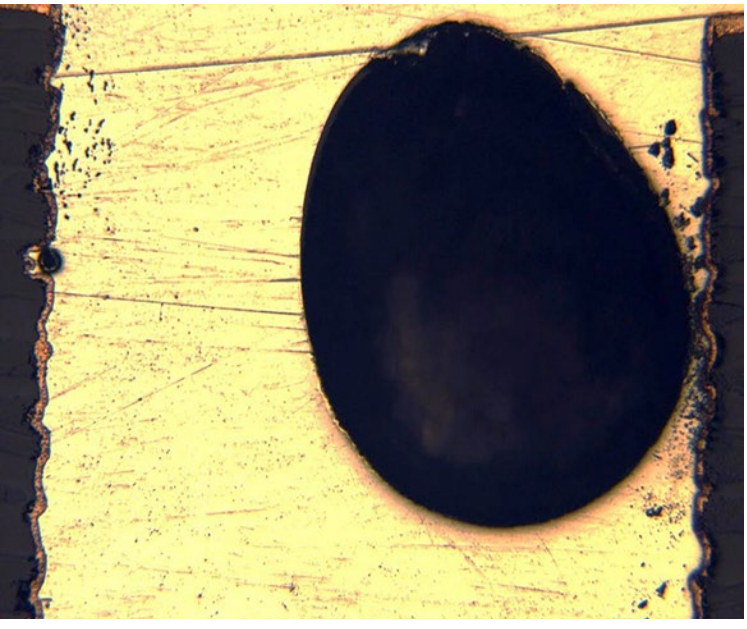

Figure 1: Blowhole or outgassing—major void in solder fillet. (Source: RBP Chemical Technology)

Figure 2: Poor solder flow-up and possible blowhole. (Source: Carano, Advanced Troubleshooting Course)

In Figure 2, the through-hole component lead wetted well. It would be difficult to assign cause to poor component lead wettability. Figure 3 shows another view of the issue.

Some additional background here for the troubleshooter: As part of this story, this group of boards flagged by the assembly company was processed through metallization and electroplating on the same day. And all the boards in question were of the same part number. Two other part numbers manufactured for the same assembly company processed without issue. Adding further mystery to the problem was the fact the boards passed electrical test before shipping to the assembler.

Working Backward to Get to the Root Cause

At first glance, you will see that in Figure 1, the electrolytic copper looks very thin yet continuous. However, the blowhole or outgas is quite evident, leaving a void in the solder fillet. Upon re-examination of the coupons associated with this job, some sections did show the copper plating thickness at 0.5 mils

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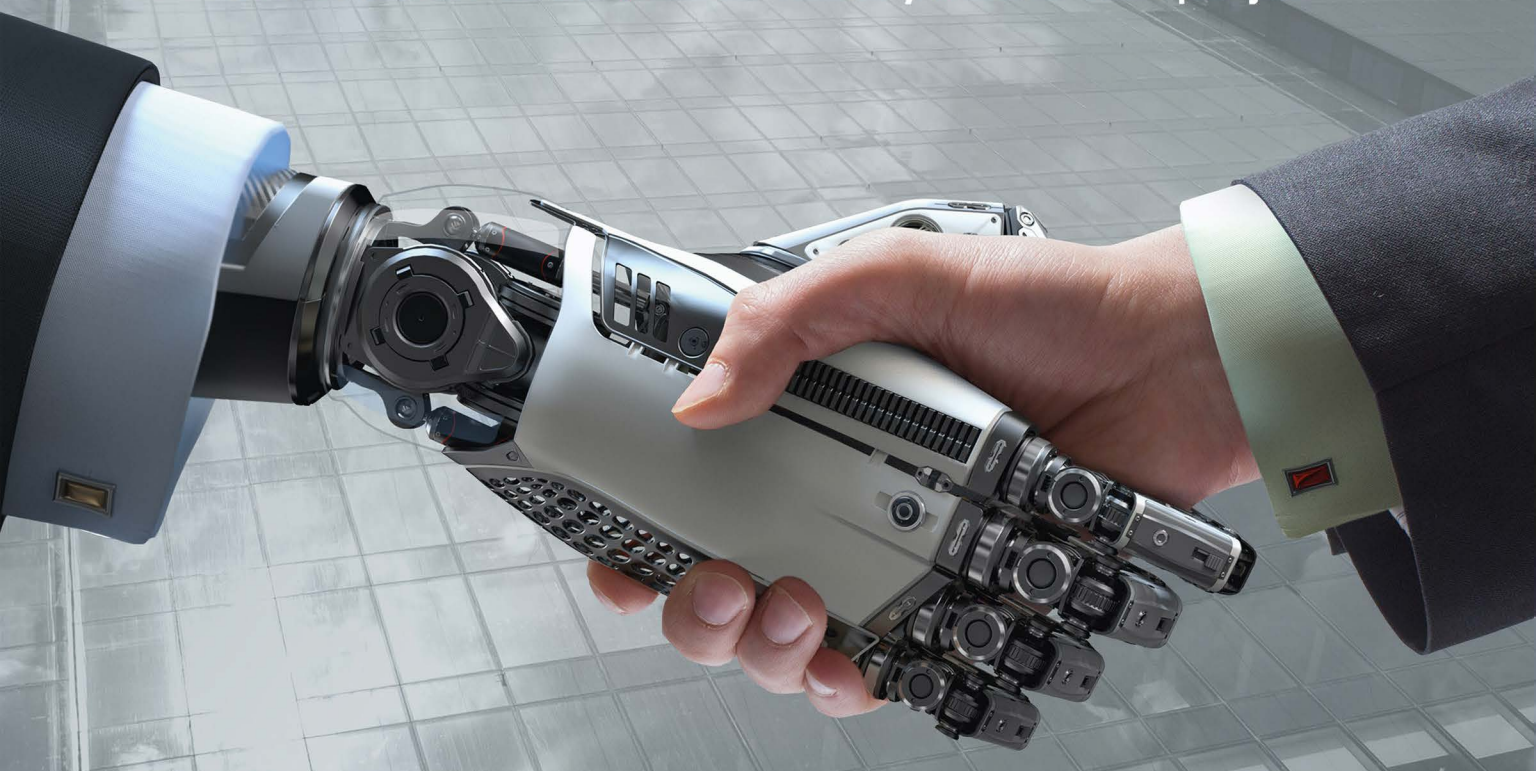

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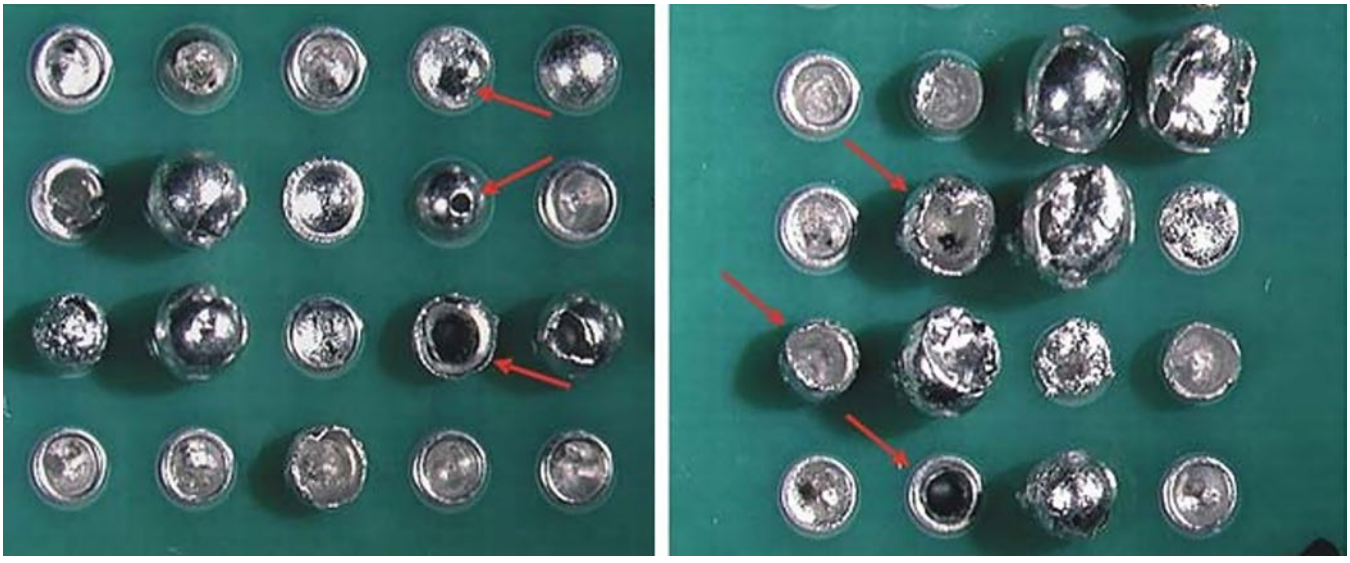

Figure 3: Blowholes or outgassing. (Source: Carano, Advanced Troubleshooting Course)

(12 microns), which was obviously thinner than the specification. Could this have been a contributing factor? The answer is yes, clearly. In simple terms, the thinner copper did not provide sufficient strength to prevent the possible rupture of the copper during assembly. It is also possible that there was a micro-void that went undetected. Regardless, it resulted in a combination of rough holes due to poor drilling (excessive in-feed rates, slow up-feeds, incomplete cure of the laminate material).

What went wrong in the electrolytic copper plating operation, at least for this part number? Electroplating follows the rule of Faraday's Law of Electrolysis [1]. Simply put, when electroplating any metal from a solution of its electrolyte (in this case, copper ions +2 valence in a water/acid solution), it takes so much current flowing per unit of time to reach the required plating thickness. This assumes excellent plating distribution and high efficiency. In the real world, there will be deviations that do not allow for the perfect distribution and uniform plating thickness across the circuit board.

Process engineers must use the tools available to optimize the plating distribution as much as possible. However, in this case, the tools were not used properly. As Figure 2 shows, plating is also related to the thin amount of copper at the knee of the hole. When thin plating over the knee (often referred to as dishing) is encountered, the most likely causes are excessive solution agitation, organic contamination in the copper plating electrolyte, or additional agent imbalance. Agitation is easily adjusted. Organic build-up must be rectified through solution purification.

A final word on this defect analysis: There were clear issues that caused the plated copper to be below specification. On the day in question, there were several electrical issues, including lower direct current to be applied to the plating cell lead in part to lower plating thickness in the hole (Faraday's law). In addition, the fabricator should look into improved drilling, more uniform solution agitation (less turbulence), and adjustment of the organic additives in the plating electrolyte. **PCB007**

Reference

1. Wikipedia, "Faraday's laws of electrolysis."

Michael Carano is VP of technology and business development for RBP Chemical Technology. To read past columns or contact Carano, click here.

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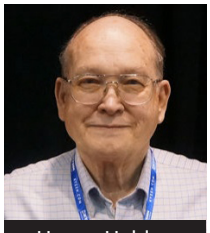
Editor Picks from PCB007

1 3D Additive Electronics Manufacturing: Are We Nearing an Inflection Point? ▶

Recently, Dan Feinberg was invited to attend an informative webinar by nScrypt titled "The Strength of 3D-Printed Electronics," which covered the status and advances in the use of 3D printing for electronic device design and manufacture. Here's what Dan learned.

2 Happy Holden's Essential Skills: Online Instruction and Distance Learning ▶



Happy Holden

Online courses have become increasingly available and popular. For this to be effective, specific requirements must be met for courses taken or produced over the internet in order to provide the user with a positive experience.

3 Michelle Te Joins I-Connect007 Editorial Team ▶

Michelle Te

I-Connect007 would like to welcome Michelle Te to the editorial team. We are excited to welcome her, and we know that she will be a great addition to our editorial team. Michelle has over 20 years of experience as a writer, editor, and manager for newspapers and magazines, both print and online.

4 Monika Stoisser-Göhring Resigns From the AT&S AG Board for Health Reasons ▶

Stoisser-Göhring

For health reasons, CFO Monika Stoisser-Göhring, in agreement with the supervisory board and the company, has decided to resign from the AT&S Management Board at the end of the 2019/2020 financial year.

5 It's Only Common Sense: This Is the Right Place at the Right Time ▸


Dan Beaulieu

As the world opens up, so will many opportunities. Dan Beaulieu describes some of these changes he sees, as well as how salespeople will have to be in front of the right people at the right time as the demand for innovative products explodes.

6 Sunstone Circuits Pledges Proceeds from Orders Will Be Donated to Feeding America ▸

Sunstone Circuits—PCB solutions provider for prototypes, medium volume, and production quantities—recently announced that it would donate proceeds from PCB sales to help families in need across the United States.

8 North American PCB Industry Sales Up 4.3% in April ▸

IPC announced the April 2020 findings from its North American Printed Circuit Board Statistical Program. The book-to-bill ratio stands at 1.19.

7 Price Circuits LLC, a Division of Circuitronics, Installs LED Laser Direct Imaging System From Miva Technologies ▸

Price Circuits LLC of Elgin, Illinois—a leader in electronics manufacturing of PCBs specializing in leading-edge technologies—announced the most recent capital investment to support fine line imaging and advanced HDI products with a MIVA 2025L Di Trio Laser Direct Imaging System. Final equipment installation and training were implemented in February 2020.

9 Digi-Key Electronics Launches PCB Builder to Streamline Ordering Experience ▸

Digi-Key Electronics, a global electronic components distributor, announced that it now offers a printed circuit board builder tool to streamline customers' ordering experience of PCBs and to more broadly support their rapid prototyping needs.

10 Arlon EMD Continues Business During COVID-19 Pandemic ▸

Arlon EMD is a manufacturer of critical components for the United States Defense. Many of our customer orders are included in the Defense Priorities & Allocations Systems (DPAS) and are designated with DX and DO ratings.

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Senior Process Engineer

Job Description

Responsible for developing and optimizing Lenthor's manufacturing processes from start up to implementation, reducing cost, improving sustainability and continuous improvement.

Position Duties

- Senior process engineer's role is to monitor process performance through tracking and enhance through continuous improvement initiatives. Process engineer implements continuous improvement programs to drive up yields.
- Participate in the evaluation of processes, new equipment, facility improvements and procedures.
- Improve process capability, yields, costs and production volume while maintaining safety and improving quality standards.
- Work with customers in developing cost-effective production processes.
- Engage suppliers in quality improvements and process control issues as required.
- Generate process control plan for manufacturing processes, and identify opportunities for capability or process improvement.
- Participate in FMEA activities as required.
- Create detailed plans for IQ, OQ, PQ and maintain validated status as required.
- Participate in existing change control mechanisms such as ECOs and PCRs.
- Perform defect reduction analysis and activities.

Qualifications

- BS degree in engineering
- 5-10 years of proven work experience
- Excellent technical skills

Salary negotiable and dependent on experience. Full range of benefits.

Lenthor Engineering, Inc. is the leader in Flex and Rigid-Flex PWB design, fabrication and assembly with over 30 years of experience meeting and exceeding our customers' expectations.

Contact Oscar Akbar at: hr@lenthor.com

apply now

Career Opportunities

ALPHA CIRCUIT CORP.

Image Department Operator

Alpha Circuit Corporation is a manufacturer of printed circuit boards located in Elmhurst, IL. We are currently seeking an operator in our Image department.

- All safety gear will be provided
- No experience required but a plus
- Full paid training provided
- Benefits: Health Insurance, 401(k), paid time off

Responsibilities:

- Expose dry film and liquid photo imageable ink
- Develop exposed photo imageable ink
- Develop exposed dry film
- Laminate dry film resist on inner layer and outer layer printed circuit panels
- Learn, understand, apply, and accept responsibility for in-process quality standards
- Be able to lift up to 15 lbs. shoulder high

If you are interested in this position, please contact Nita Buccino.
Email: nvb@alphacircuit.com,
cell: +1-847-489-2341.

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BÜRKLE NORTH AMERICA, INC.

Service Engineer
Schmoll Laser Drilling and Direct Imaging

Burkle North America seeks a full-time service engineer in the Northeastern U.S. This position will provide expert-level service on multiple laser drilling and direct imaging product lines. Install, commission, and maintain Schmoll products at multiple customer sites across the Northeast. The candidate will perform modifications and retrofits as needed. Maintain complete and detailed knowledge of Schmoll products and applications and handle a wide variety of problems, issues, and inquiries to provide the highest level of customer satisfaction. Assist customers with the potential optimization of their machine functions and work with clients on application improvements.

Qualifications

Required: Bachelor's degree from a technical college/university in an associated field. Three years directly related experience, or equivalent combination of education and experience. Must possess a valid driver's license and have a clean driving record.

Preferred: Experience in control systems and electronic troubleshooting, as well as in general electrical and mechanical service tasks. Experience and knowledge in the PCB manufacturing process, with a focus on laser drilling and/or direct imaging.

Send resume to hr@burkleamerica.com.

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Career Opportunities

WHELEN®
TRUSTED TO PERFORM™

Process Engineering Director

Whelen Engineering Co., Inc. seeks full-time process engineering director in Concord, NH, to develop, plan and execute GreenSource Fabrication, LLC Div.'s process technology business strategy; manage process engineering activities, staff and compliance; improve process design, cost, quality and resource utilization; interact w/ customers and incorporate feedback; develop financial capital and labor projections; travel internationally for conferences, supplier and customer visits (15-25% worktime); write white papers, IP applications and give talks re. Division's products/processes.

Min. req.: U.S. Bachelor's or foreign equivalency in environmental science or engineering; min. 10 yrs. work exp. in: PCB fabrication process engineering; comprehensive and current experience in PCB fabrication/substrate markets w/ SAP tech; developing chemical and mechanical processes, chemistries and equipment for PCB manufacturing demonstrated by international experience implementing complex processes; ability to direct and troubleshoot PCB manufacturing problems; min. 5 years exp. leading, managing and training process engineering teams, developing and executing process technology business strategies and plans in worldwide PCB markets, including Japan, Taiwan, China, Europe; min. 3 years exp. giving talks, writing and presenting white papers; ability to travel internationally (15-25% worktime).

Send CVs to: Corinne Tuthill,
ctuthill@greensourcefab.com
or GreenSource Fabrication, LLC,
99 Ceda Road, Charlestown, NH 03603.

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FREEDOM CAD SERVICES

Sr. PCB Designer–Allegro

Freedom CAD is a premier PCB design service bureau with a talented team of 30+ dedicated designers providing complex layouts for our enviable list of high-tech customers. Tired of the commute? This is a work-from-home, full-time position with an opportunity for overtime at time and a half.

Key Qualifications

- EXPERT knowledge of Allegro 16.6/17.2
- Passionate about your PCB design career
- Skilled at HDI technology
- Extensive experience with high-speed digital, RF and flex and rigid-flex designs
- Experienced with signal integrity design constraints encompassing differential pairs, impedance control, high speed, EMI, and ESD
- Experience using SKILL script automation such as dalTools
- Excellent team player that can lead projects and mentor others
- Self-motivated, with ability to work from home with minimal supervision
- Strong communication, interpersonal, analytical, and problem solving skills
- Other design tool knowledge is considered a plus (Altium, PADS, Xpedition)

Primary Responsibilities

- Design project leader
- Lead highly complex layouts while ensuring quality, efficiency and manufacturability
- Handle multiple tasks and provide work leadership to other designers through the distribution, coordination, and management of the assigned work load
- Ability to create from engineering inputs: board mechanical profiles, board fabrication stack-ups, detailed board fabrication drawings and packages, assembly drawings, assembly notes, etc.

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Career Opportunities

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

Qualifications and skills

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

Benefits

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

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APCT
Passion | Commitment | Trust

APCT, Printed Circuit Board Solutions: Opportunities Await

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

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

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

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

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Career Opportunities

TAIYO AMERICA

Development Chemist
Carson City, NV

Develop new products and modify existing products as identified by the sales staff and company management. Conduct laboratory evaluations and tests of the industry's products and processes. Prepare detailed written reports regarding chemical characteristics. The development chemist will also have supervisory responsibility for R&D technicians.

Essential Duties:

- Prepare design of experiments (DOE) to aid in the development of new products related to the solar energy industry, printed electronics, inkjet technologies, specialty coatings and additives, and nanotechnologies and applications
- Compile feasibility studies for bringing new products and emerging technologies through manufacturing to the marketplace
- Provide product and manufacturing support
- Provide product quality control and support
- Must comply with all OSHA and company workplace safety requirements at all times
- Participate in multifunctional teams

Required Education/Experience:

- Minimum 4-year college degree in engineering or chemistry
- Preferred: 5-10 years of work experience in designing 3D and inkjet materials, radiation cured chemical technologies, and polymer science
- Knowledge of advanced materials and emerging technologies, including nanotechnologies

Working Conditions:

- Chemical laboratory environment
- Occasional weekend or overtime work
- Travel may be required

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INDIUM CORPORATION®

Multiple Positions Available

The Indium Corporation believes that materials science changes the world. As leaders in the electronics assembly industry we are seeking thought leaders that are well-qualified to join our dynamic global team.

Indium Corporation offers a diverse range of career opportunities, including:

- Maintenance and skilled trades
- Engineering
- Marketing and sales
- Finance and accounting
- Machine operators and production
- Research and development
- Operations

For full job description and other immediate openings in a number of departments:

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Career Opportunities

Manncorp™

SMT Field Technician
Huntingdon Valley, PA

Manncorp, a leader in the electronics assembly industry, is looking for an additional SMT Field Technician to join our existing East Coast team and install and support our wide array of SMT equipment.

Duties and Responsibilities:
- Manage on-site equipment installation and customer training
- Provide post-installation service and support, including troubleshooting and diagnosing technical problems by phone, email, or on-site visit
- Assist with demonstrations of equipment to potential customers
- Build and maintain positive relationships with customers
- Participate in the ongoing development and improvement of both our machines and the customer experience we offer

Requirements and Qualifications:
- Prior experience with SMT equipment, or equivalent technical degree
- Proven strong mechanical and electrical troubleshooting skills
- Proficiency in reading and verifying electrical, pneumatic, and mechanical schematics/drawings
- Travel and overnight stays
- Ability to arrange and schedule service trips

We Offer:
- Health and dental insurance
- Retirement fund matching
- Continuing training as the industry develops

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U.S. CIRCUIT

Sales Representatives (Specific Territories)

Escondido-based printed circuit fabricator U.S. Circuit is looking to hire sales representatives in the following territories:

- Florida
- Denver
- Washington
- Los Angeles

Experience:
- Candidates must have previous PCB sales experience.

Compensation:
- 7% commission

Contact Mike Fariba for more information.

mfariba@uscircuit.com

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Career Opportunities

ZENTECH

Zentech Manufacturing: Hiring Multiple Positions

Are you looking to excel in your career and grow professionally in a thriving business? Zentech, established in Baltimore, Maryland, in 1998, has proven to be one of the premier electronics contract manufacturers in the U.S.

Zentech is rapidly growing and seeking to add Manufacturing Engineers, Program Managers, and Sr. Test Technicians. Offering an excellent benefit package including health/dental insurance and an employer-matched 401k program, Zentech holds the ultimate set of certifications relating to the manufacture of mission-critical printed circuit card assemblies, including: ISO:9001, AS9100, DD2345, and ISO 13485.

Zentech is an IPC Trusted Source QML and ITAR registered. U.S. citizens only need apply.

Please email resume below.

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BLACKFOX
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IPC Master Instructor

This position is responsible for IPC and skill-based instruction and certification at the training center as well as training events as assigned by company's sales/operations VP. This position may be part-time, full-time, and/or an independent contractor, depending upon the demand and the individual's situation. Must have the ability to work with little or no supervision and make appropriate and professional decisions. Candidate must have the ability to collaborate with the client managers to continually enhance the training program. Position is responsible for validating the program value and its overall success. Candidate will be trained/certified and recognized by IPC as a Master Instructor. Position requires the input and management of the training records. Will require some travel to client's facilities and other training centers.

For more information, click below.

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D.B. Management Group L.L.C. is currently working with many professionals who are seeking new positions. If any of these qualified professionals sounds like someone you would like to learn more about, contact **Dan Beaulieu** at **207-649-0879** or **danbbeaulieu@aol.com.** If you are a qualified professional looking for a new opportunity, contact Dan as well. Fees are 10% of candidates' first year's annual compensation. There is no fee for candidates.

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President, Company Leader, Business Builder
This professional has done it all. Built new businesses and turned around hurting businesses and made them successful. A proven record of success. This candidate is a game-changer for any company. He is seeking a full-time leadership position in a PCB or PCBA company.

General Manager PCB and PCBA
Senior manager with experience in operations and sales. He has overseen a number of successful operations in Canada. Very strong candidate and has experience in all aspects of PCB operations. He is looking for a new full-time position in Canada.

Regional Sales Manager/Business Development
Strong relationship management skills. Sales experience focused on defense-aerospace, medical, high-tech PCB sales. Specializes in technical sales. Also has experience in quality, engineering, and manufacturing of PCBs. He is looking for a fulltime position in the Southeastern U.S.

Field Application Engineer (FAE)
Has worked as a respected FAE in the U.S. for global companies. Specializes in working alongside sales teams. Large experience base within the interconnect industry. He is looking for a full-time position.

Business Development Manager
Understands all aspects of interconnect technical sales from PCB design and fabrication to assembly and all technologies from HDI microvias to flex and rigid-flex. Has also sold high-tech laminates and equipment. Proven record of sales success. He is looking for a full-time position.

CEO/President
Specializes in running multi-million dollar companies offering engineering, design, and manufacturing services. Proven leader. Supply chain manager. Expert at developing and implementing company strategy. Looking to lead a company into the future. He is looking for a full-time position.

PCB General Manager
Forty years of experience serving in all capacities, from GM to engineering manager to quality manager. Worked with both domestic and global companies. Available for turn-around or special engineering projects. He is looking for long-term project work.

Process Engineering Specialist
Strong history of new product introduction (NPI) manufacturing engineering experience: PCB/PCBA. Held numerous senior engineering management positions. Leads the industry in DFM/DFA and DFX (test) disciplines. He is looking for either a full-time position or project work.

VP Sales Global Printed Circuits
Worked with a very large, global company for a number of years. Built and managed international sales teams. Created sales strategies and communicated them to the team. One of the best sales leaders in our industry. He is looking for a full-time position.

Plant Manager
This professional has years of experience running PCBA companies. Led his companies with creative and innovative leaderships skills. Is a collaborative, hands-on leader. He is looking for a full-time position.

National Sales Manager
Seasoned professional has spent the past 20 years building and growing American sales teams for both global and domestic companies. Specializes in building and managing rep networks. He is looking for a full-time position.

Global Engineering Manager/Quality Manager
Has experience working with large, global PCB companies managing both engineering and quality staff. Very experienced in chemical controls. She is interested in working on a project-by-project basis.

CAM Operators and Front-end Engineers
These candidates want to work remotely from their home offices and are willing to do full-time or part-time projects.

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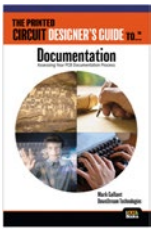
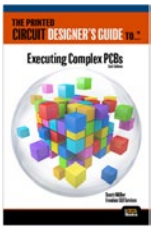
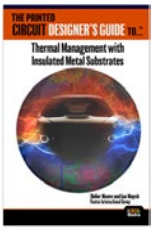


Documentation, by Mark Gallant, Downstream Technologies
When the PCB layout is finished, the designer is still not quite done. The designer's intent must still be communicated to the fabricator through accurate PCB documentation.



Executing Complex PCBs, by Scott Miller, Freedom CAD Services
Designing a complex circuit board today can be a daunting task. Never before have PCB designers on the cutting edge faced more formidable challenges, both electrical and mechanical.

Producing the Perfect Data Package, by Mark Thompson, Prototron Circuits
For PCB designers, producing a comprehensive data package is crucial. If even one important file is missing or output incorrectly, it can cause major delays and potentially ruin the experience for every stakeholder.



Thermal Management with Insulated Metal Substrates, by Didier Mauve and Ian Mayoh, Ventec International Group
Considering thermal issues in the earliest stages of the design process is critical. This book highlights the need to dissipate heat from electronic devices.

Fundamentals of RF/Microwave PCBs, by John Bushie and Anaya Vardya, American Standard Circuits
Today's designers are challenged more than ever with the task of finding the optimal balance between cost and performance when designing radio frequency/microwave PCBs.

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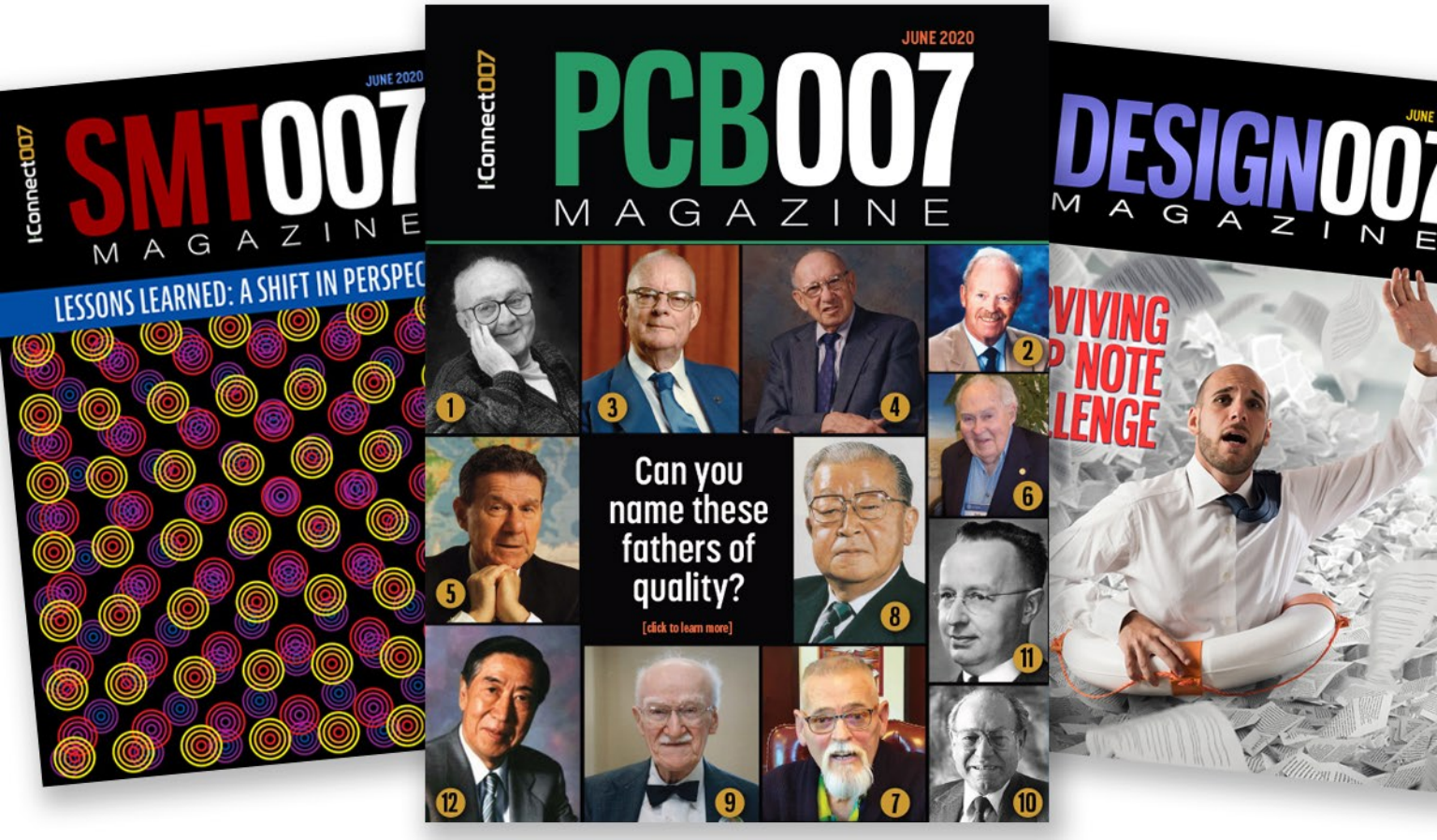

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