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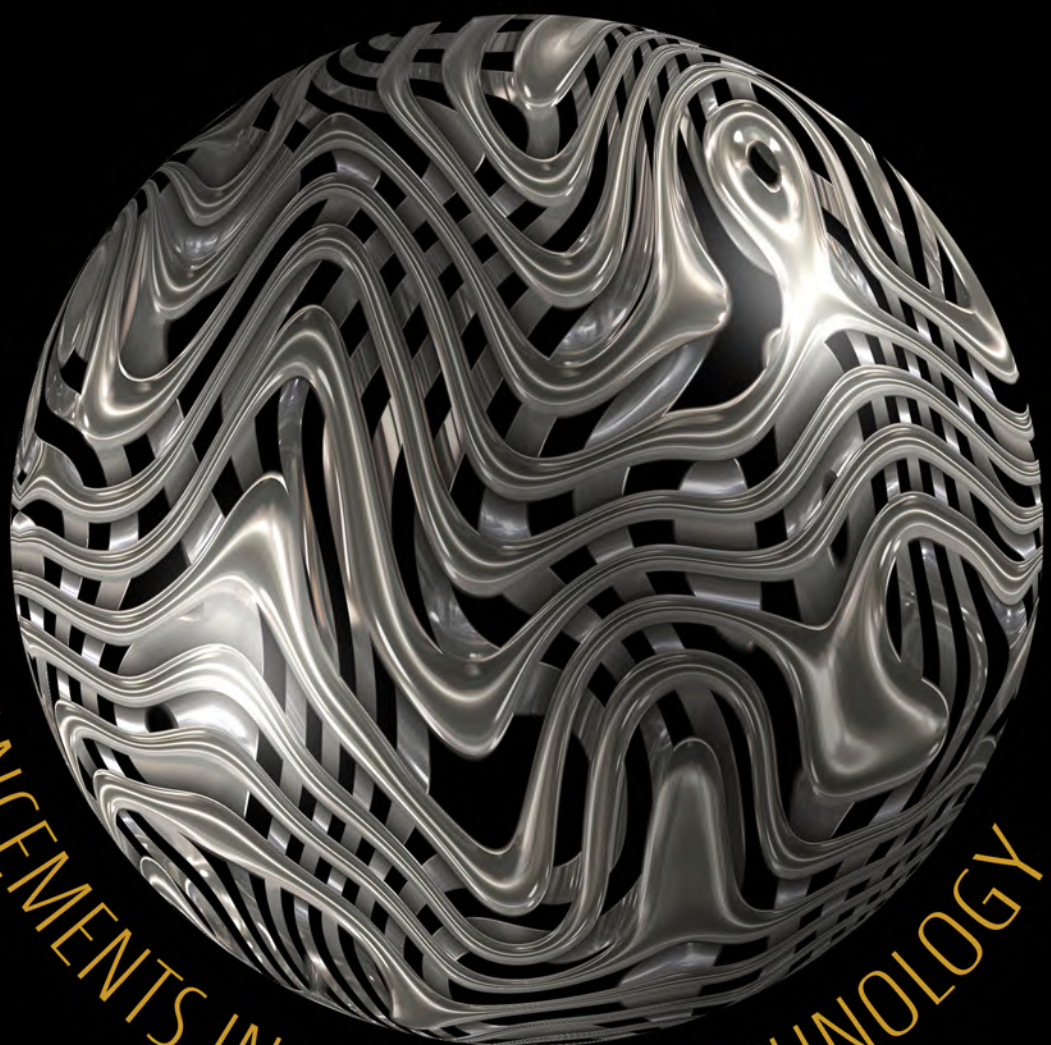

ADVANCEMENTS IN SOLDERING TECHNOLOGY

How Engineers Can Use SPI Tools for Verification

Feature Interview by Nolan Johnson
I-CONNECT007

Koh Young's Ray Welch and Brent Fischthal detail how engineers can work with SPI tools to verify how small they can go in component size with their solder paste application, and how the company's SPI equipment is helping not only to verify but also to help drive the development collaboration between solder paste and stencil printer manufacturers, and inspection tools and software.

Nolan Johnson: What trends and advancements do you see right now in solder and solder application in the manufacturing process?

Ray Welch: You may be familiar with Chrys Shea's new SMTA miniaturization test vehicle (MTV). I've worked with her and Indium recently, using this new test vehicle; she's trying to give people a tool to be able to challenge themselves to print smaller and smaller. That test vehicle goes down to 008004 chip components. I don't know of any customers that we have that are printing that small yet, in terms of chip components, but we have people who are printing near wafer-level prints for RF devices and cellphones. I was working with Indium because they were trying to verify their new pastes and how well they perform for the smaller parts. We've been working with our industry partners to help them understand how to use our SPI to be able to get accurate measurements for the smaller and smaller parts.

Johnson: This sounds like a bit of back and forth, building operator skillsets while also verifying that the machines can do that kind of feature size.

Welch: Yes, Chrys and I went to MPM in Hopkinton, Massachusetts. Indium was there, and they wanted to verify several of their new pastes for printing the smallest part at this time. The challenge for us was to make sure that we could measure such small parts, and we can. We performed a DOE, and everything worked out quite well, both in terms of solder paste performance and the Koh Young SPI system. Since then, I helped Indium remotely

to use the Koh Young SPI system they have at their shop to verify their pastes. Again, I don't have any end-users that I know of using the 008004 parts yet, but we're giving them a system via the aSPIre3 and 10-micron lens resolution to be able to inspect those smaller parts.

Ray Welch

Johnson: The equipment and material suppliers have proven that they can deliver the functionality needed for the current smallest parts of the market, even if people may not be using them yet.

Welch: Yes, but the caveat to that is that whenever we do something in the lab with a bunch of engineers involved, you can oftentimes get very good results. You don't always get those results when you put it into manufacturing.

Since joining Koh Young in April 2016, I've visited about 50 customers delivering our two- to three-day SPI and print process characterization training program. People can't print those small parts until they improve the discipline of their process. For a number of customers, it seems the operators have hijacked the SPI process. The engineers aren't there or don't like to go out to the line except when there are serious issues. Many times, the process engineers aren't watching over the process like they should or don't know the process as well as they should, so there will be a reality check when they move to smaller and smaller parts.

Johnson: Is it fair to say that the control of the inspection processes on the manufacturing floor with the manufacturing operators who are under one set of incentives for part of their job that may be at odds with being accurate and getting good yields, and not having field failures later?

Welch: That's correct. A lot of engineers don't want to be called to the line if they don't have to be, so they leave it to the operators or process technicians. If they don't visit often enough, then the operators are going to hijack the process and do whatever they think is right. I've stood there many times watching an operator pass boards that should have been failed. I call those "wall of shame" examples, where they've opened up the inspection tolerances, or the operators are doing whatever they want to do, and then products are escaping SPI. They have a great tool in SPI, but they're not using the tool as best they can. That will definitely be a challenge when they get to the smaller parts.

Johnson: Let's paint a possible scenario then. Right now, maybe it's working, they're getting by, and they're doing okay purely by accident. As they move to smaller and smaller parts, that's going to break at some point. What should they be looking for, and how do you fix it?

Welch: SPI reveals the sins of the process. I'm trying to teach people how to use the tool as best they can, as well as tools and techniques for analyzing the data. It's also important not to be driven by just defects but by the parametric data that shows them how well the process is performing in terms of process capability. Then, it's about improving the process and not just trying to turn off SPI defects.

Johnson: This must be a challenge. You're providing products that could help customers see fewer field failures and better yield, but by default, it's exposing the dirty laundry in the process. That can be potentially embarrassing or even job threatening. How do you change that from a threat to a benefit?

Brent Fischthal: When Ray delivers these engagements to our customers, he helps them

understand how to use SPI. SPI has been around for a while, but not everyone uses it the right way. Sometimes, bad habits form. This specific class resets those bad habits. We're educating them on how to implement the best practices. Ray does find that wrong processes have been implemented, or that operators are using it incorrectly or sub-optimally. Everybody who has experienced Ray's class has come away appreciative of the insight they've gained. More importantly, most change the way they've been doing things right away.

Brent Fischthal

Johnson: If you don't have support from the C-level executives, then you may encounter managers who have a very different set of objectives.

Fischthal: Most people want to build the best products they can and not have to worry about rework or field failures because an operator was incorrectly using the SPI.

Welch: Yes, but as Nolan was saying, some people have a different objective or performance goals to meet, so even though the engineers might want to make improvements, sometimes they're held back because the line production doesn't give them the time. The engineers need to be given the time and line availability to identify issues and opportunities for improvement and then implement the necessary actions. Right now, the biggest thing I see is management often wants to get down to one operator per line and no engineers on the line. That's not going to work very well when your process isn't robust—a hands-off process—and none of them are there right now.

Johnson: When you talk to a customer about putting Koh Young equipment into their line, they're already motivated to some level and have invited you. They've had some sort of a compelling event that caused them to decide that they need to make this change. Are you at liberty to share some of those compelling events?

Fischthal: We've seen some people that want to look at their paste because they realize if they are able to fix the process in the beginning, it's much better than adding process steps at the end to check after reflow. We've had people that will build products with insufficient solder, bridging, or other common printer errors that happen in an uncontrolled process. These manifest as quality issues on the other end of the line. Then, they will bring in an SPI. In general, there's a shift to believing that if they can fix it at the front, it saves them at the end. Which is true.

Johnson: Your training materials contain discussion about changing the thinking: ongoing process monitoring more than inspection at the end.

Welch: Most people are using SPI as just a go/no go system, and even for the brightest engineers, there might be only a few who dig in a little deeper, but not necessarily day in, day out. I've tried to teach them how to use the tool better, as well as use it for developing more robust processes—not just fixing day-to-day issues. When I go to some of the big operations, the operations people control the line. Sometimes, it's hard to get time on the line to make even simple improvements. I say, "Let's make the change now," and they say, "I can't change it now." If you can't change it then, it may not ever get done. It's a cultural thing from the top down.

Johnson: Based on all the developments with the digital factory, is there an opportunity to

use the SPI information to keep things like solder paste jetting or solder paste application in compliance within tolerances?

Welch: To a limit. Our Koh Young Process Optimizer (KPO) now has various printers that have opened up the key print parameters so that we can take control of the printer. First, we do it to perform a real DOE to try to optimize the print parameters. Then, we monitor the process via SPI and fine-tune the print parameters in real-time to stay in compliance. There are still other factors, but at least it's trying to keep the process in control. There's another module in the KPO tool that looks for patterns and variations in volume across the board. We are trying to maintain or achieve some real-time control of the printing process through the three parameters of print speed and pressure and separation speed. But you still have to practice good, sound printing process practices on the part of the operator.

We are trying to maintain or achieve some real-time control of the printing process through the three parameters of print speed and pressure and separation speed.

Johnson: Part of your presentation talks about making sure that you're programming your tests appropriately and testing for the right thing. That strongly implies that good testing involves a more thorough thought process while programming the tests. How much skill level is involved in that work? What kind of training is required to be a good programmer with the Koh Young SPI equipment?

Welch: The level can be a good process tech up to an engineer. It can't be an operator, per se, unless they're a super operator, but a process tech and above. Every customer I've visited has an issue with programs. Often, the people who were initially trained by Koh Young have moved on. There has to be discipline in the program itself. I usually start by looking at the programs and making sure that the SPI system is set up correctly, so you know you're getting good, valid results. Then, we can talk more about characterizing the process, which plays back into the printer itself.

Johnson: Isn't what you described an HR problem?

Welch: Sometimes, large organizations have the CAD or test engineering people create the SPI programs, but that person may have no connection with the print process itself. The person who creates the program may never see it on the line, or the people on the line don't understand programming themselves, so there's a disconnect. Oftentimes, when I go there, I'll see something on the screen, and I'll say, "Do you see that?" and the engineers or process technicians don't even know what I'm talking about. It reveals the sins of the process, which may be the sins of them creating a program or something with the way they're doing SPI.

Johnson: It is the operator or technician attrition on the floor that I was flagging as an HR department issue. The trained staff are gone, and somebody who's untrained is now in charge. There's where I point back at HR to make sure that that company has the appropriate training programs in place for the people taking over the job.

Welch: I agree. I've seen places in manufacturing where they're short a person or two, and they walk someone in front of a machine and say, "Run this machine," without good training. Otherwise, the person offering the training candidate might not realize the skill or discipline required to run something like an SPI system, and certainly our AOI systems, which are far more complicated than SPI. Sometimes, they give us the wrong person to train.

Johnson: There seems to be a circle of development here. You're working very closely with the solder paste application companies and the solder paste manufacturers to make sure that you're all communicating appropriately here. We started by talking about how you've proven down to the smallest currently manufacturable component sizes, and that was working in concert with multiple vendors in this space. How active or how aggressive are you all in working together?

Welch: Pretty well. I've done a fair amount of work with Chrys Shea now, and I've been to MPM many times, mostly as part of our KPO development and testing. I think we all work very well together. Some of the printer and solder paste companies have our systems so that they can do SPI in their labs.

Johnson: From your perspective, are most of the participants playing well together?

Fischthal: We've had some pretty good success with collaboration across the printer suppliers. From the SPI standpoint, we have a couple of different ways we can improve the closed-loop communication from basic correction to AI-powered process optimization. When we look at what our KPO is doing, we're working with the major providers, so we're all working together with them to come up with some powerful solutions. Everybody is striving to improve the process.

Johnson: Components are going to go smaller, and there are going to be challenges. Where is the spot that needs the most work right now?

Welch: I'd say miniaturization. The biggest challenge is inspecting those near-wafer level solder bumps on the little RF devices that go in cellphones and such. They're printing down to stencil apertures of about 3.7 mils with one-mil stencils. They're still being printed with traditional printers; our partners are working with our joint customers to try to get the best possible print process and the best possible solder paste and stencil technology.

Johnson: Thank you, gentlemen.

Welch: Anytime, sunshine.

Fischthal: You're welcome. Thank you very much. SMT007

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True 3D™ SPI Innovations Powered by AI

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Factory of the Future Needs AI

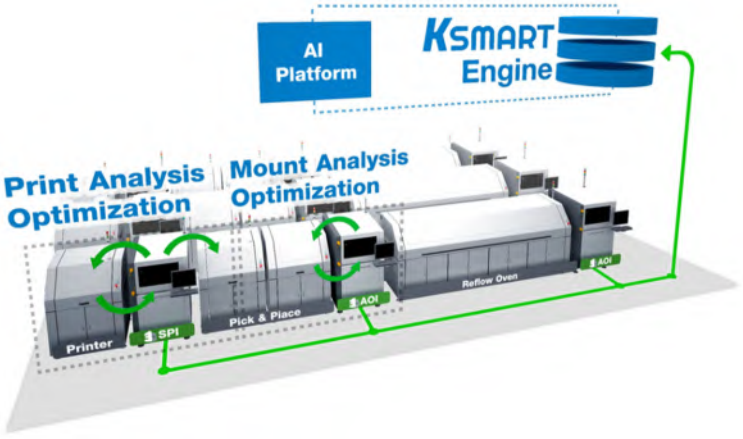
The machine-to-machine (M2M) communications, guided in part by Industry 4.0, are quickly changing the manufacturing process by aggregating process data such as first pass yield and throughput. What's more, Artificial Intelligence (AI) has enormous potential across a variety of industries, including the manufacturing sector too. By using the right mixture of AI technologies, manufacturers can boost their efficiency, improve flexibility, speed up processes, and even achieve self-optimizing processes. Equipment providers like Koh Young are enabling the Smart Factory of the Future by adopting AI to generate "knowledge" from "experience."

3D Data Accuracy Value

Data is the most crucial element of the success of the AI solutions. Deep learning effectiveness is linked to the quality and quantity of the input data to address many different requirements from numerous fields. The use of AI to provide smarter inspection systems has been desired by every inspection provider. However, it has been difficult to realize due to the limitations of 2D imaging, which was the de facto standard for the past 25 years. Every aspect of 2D inspection relies on 2D features like contrast; thus, it is extremely challenging to correlate with to the quantitative measurement of 3D objects.

Increasingly Accurate Measurement

So how do we use AI? It begins with solving inspection challenges of SMT assemblies. The solder and components on finished boards have many specular surfaces, which will reflect some light back to camera, while creating strong inter-reflection with other lighting reflections. Since some of the reflected light does not reach the camera, they generate false signals which may cause measurement value errors. This specular reflection issue is becoming more troublesome, in relation with increasing board density and decreased component spacing. Using AI can prevent measurement errors by incorporating learning in the product. The hybrid fusion of an analytic approach utilizing a mathematical measurement model and AI used for learning abnormal symptoms from the combination of good and bad measurement data, allows the system to detect and eliminate abnormal measurements, which reduces false calls and escapes. Through the hybrid fusion approach, the measurement accuracy only gets better against many different challenges.



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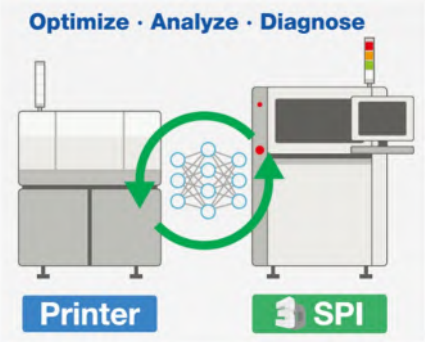
Improve yield and process optimization

With improving inspection quality is paramount to the manufacturing industry. It requires more computational power, which then yields even better inspection solutions. AI implies improvements can be fulfilled quicker with machines that continuously learn to solve the latest problems. Harnessing the power of its own AI solution, Koh Young has developed Koh Young Process Optimizer (KPO) solution.

Innovative SPI Solutions

KPO is the Koh Young smart factory solution driven by AI to control and optimize the printing and mounting operations. KPO heavily relies on accurate 3D measurements data and error detection from SPI and AOI machines, which sets the stage for smart factory solutions.



The KPO printing solution includes three interlinking modules that exercise complex algorithms to develop closed-loop print process recommendations to help diagnose, analyze, and optimize. By combining real-time printing and SPI measurement data, the enhanced AI engine actively adjusts the printing process. While each module provides inherent standalone process benefits, the combined power of the three modules ensures the highest process reliability and production flexibility while reducing dedicated resources and expertise.

While solder defects are associated with the printing process, these defects pose serious concerns to the industry, especially with the component miniaturization trend. Manufacturers cannot scrap boards or the components due to procurement challenges and costs. However, if the manufacturer does not repair the issue, the board is susceptible to failure. Implementing new innovations like integrated solder dispensing tools to repair defective solder depositions improve quality.

In addition to the AI-based solutions, “in situ” solder dispensing solutions that automatically identify and repair defects within the Solder Paste Inspection (SPI) system can further improve production quality. The 3D SPI system can accurately measure for defects, thanks in part, to its precisely engineered mechanical structure and a “stop and shoot” image capture Moiré technique. The process eliminates vibration and image stitching. Once the solder is measured, the optional Auto Repair tool can automatically add more solder and measure again without ever leaving the work area. This eliminates operator interaction improves production yield.

Superior Flexibility

The design is highly flexible and considers many production variables. For example, imagine a hundred different board layouts with different components – each component type requires a unique solder paste amount. The system can be an effective solution, especially for small BGAs and microchips. It can dispense solder to repair insufficient errors to a wide range of component sizes, including 0402M microchips with a pad-to-pad distance of over 100-microns. Additionally, dynamic z-axis tracking automatically adjusts the distance between the head and the board surface to maintain the ideal focal range and prevent false calls due to PCB warp. Such flexibility allows users to readily improve yields and efficiency in their SMT assembly lines.

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BGA Pad	Capacitor Pad
	

Figure: Comparison when using Auto Repair system. BGA Pad – (Left) Insufficient: Before was 2.57% Volume with 16.25% Area (Right) After Auto Repair was 62.79% volume with 86.54% area. Capacitor Pad – (Left) Insufficient: Before was 58.92% volume with 73.66% area (Right) After Auto Repair was 89.21% Volume with 95.9% Area

Future of Smart Factory

What is next for the SPI Auto Repair system in a future smart factory? In the ideal future, connected systems should remove inefficiency from the start, so there may not be anything to repair. Will manufacturers still need an Auto Repair system? The answer may be "yes," as this is not going to happen soon. Indeed, the Smart Factory will not replace rework applications, instead it will enhance the functionality. Auto Repair powered by AI may be able to recognize complex patterns of solder pads, synthesize information, draw conclusions, and provide recommendations to optimize the solder paste printing process.

Looking forward, Industry 4.0 is rapidly gaining traction among manufacturers. The factory is not a static place, it is a dynamic zone where machines work together to execute complex tasks. In fact, the Koh Young's Auto Repair system already addresses Industry 4.0 in many aspects. By integrating 3D inspection and repair, it establishes a closed-loop process and eliminates unnecessary board cleaning or scrap. Additionally, it integrates a real-time process dashboard, so operators can quickly verify rework performance and make the right decisions by comparing with previous results.

Artificial Intelligence and its associated benefits will help advance the manufacturing industry confront challenges like the lack of skilled manpower and cost reduction. Koh Young is focusing on using an AI-based solution as the primary vehicle to enable the future of manufacturing for SPI, AOI, and beyond.

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