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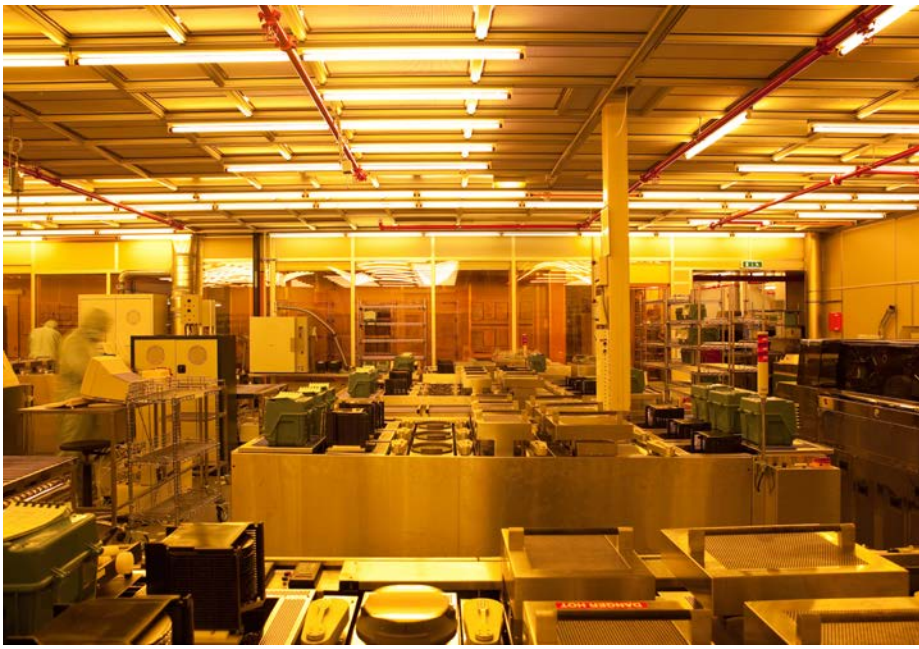
CASE STUDY

APC: R2R CONTROL

Semiconductor Maker Improves Lithography Overlay Performance Through Workflow Automation Based Run-to-Run Control

A U.S.-based semiconductor manufacturer, operating a 200,000 square-foot facility that includes 62,000 square feet of clean room space for wafer fabrication, was in pursuit of better control of its processes. To that end, this semiconductor manufacturer worked with Savigent Software, using Savigent Workflow™ (workflow automation software) to take run-to-run control to new levels of efficiency in improving its overlay control (i.e., registration) process.



The semiconductor maker's manufacturing facilities include a six-inch (150mm) and an eight-inch (200mm) wafer fab. With these fabs, this semiconductor manufacturer has the ability to process more than 4,000 wafers a week.

Going Further

Semiconductor fabs put a pattern on a wafer using a photolithography process. On subsequent layers, they put down another pattern. The layers need to overlay nicely to ensure high yield and device performance. That's the principal technical challenge addressed by overlay control. "About three years ago, when overlay control was initially becoming an issue here, we found a 'poor man's solution,'" says a photolithography process engineer at the company.

For a given lot of wafers, the company set up what it called a restricted aligner. Out of maybe 22 photolithography layers, maybe three were designated critical to have good overlay to each other; the rest were considered non critical. The manufacturer recorded wherever that first critical layer went down on a particular step or lithography tool number. Later, when the wafers came back for the second of the critical layers; engineers made sure that the automation system forced the wafer back to the same lithography tool that had been used previously (hence the term "run-to-run control"). "It wasn't active control;

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but by making sure that the wafer went back to the same lithography tool, we improved our overlay control a little bit," explains the engineer.

This process achieved what is called "single tool overlay performance." It was a move in the direction the manufacturer wanted to go, but not quite enough. So the company began working with Savigent to make this happen.

"In our lithography program, we were looking to make adjustments from lot-to-lot, and to gain feedback information based on output," the engineer adds. In this case, feedback is based on metrology performance metrics that company has for materials. Then, based on that metrology information, adjustments are made to the lithography tool recipe for the next lot to be processed. Integrating the feedback information from the metrology tool to the process tool was critical to making these run-to-run adjustments.

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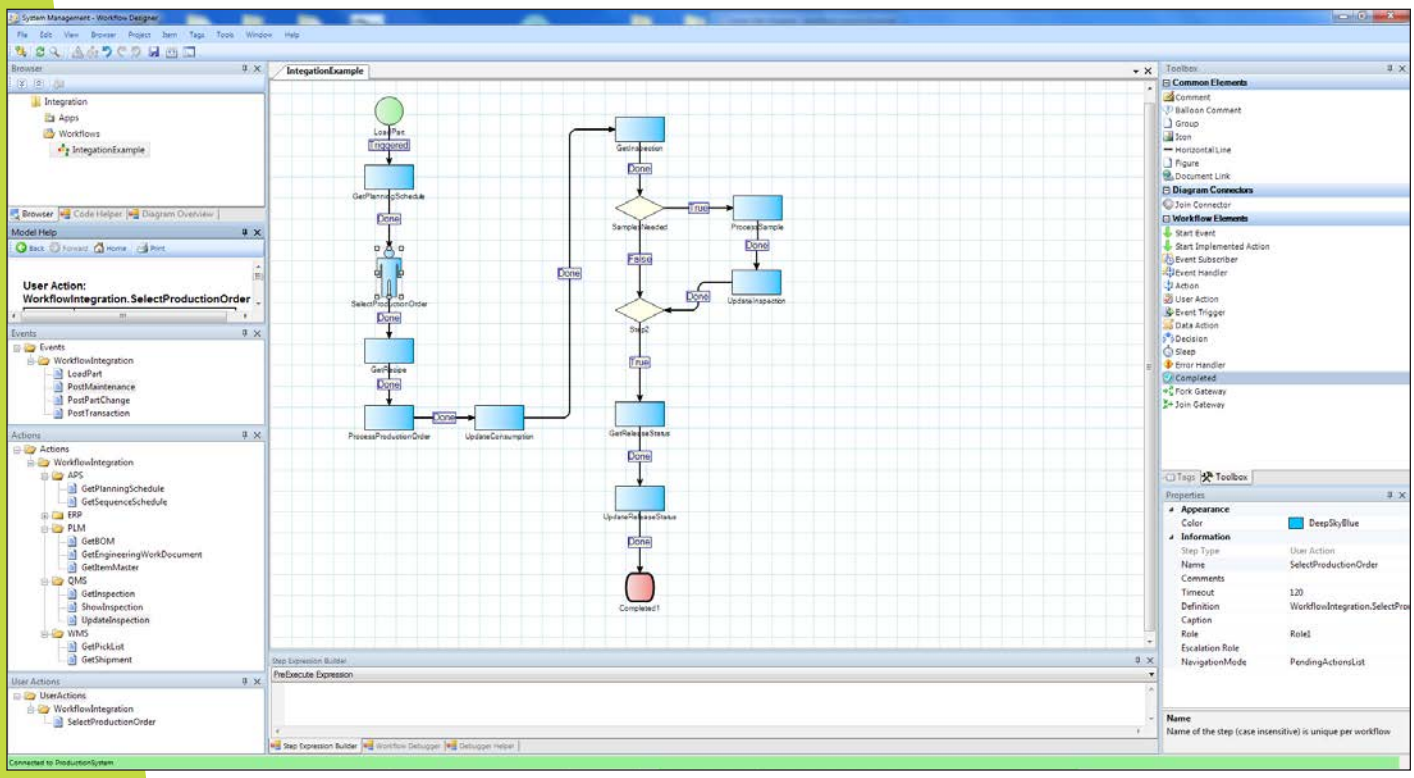

Getting More Precise

A SECS/GEM station controller cues up the stepper job so that an operator can run a lot of wafers through a lithography tool. The run-to-run controller is integrated to the manufacturer's MES system, the lithography tool (through the station controller) and metrology equipment, providing the means for real-time communication of critical data such as lot numbers, routes, metrology data and more. "Now when a lot is coming to a particular lithography tool that's about to do an align layer, information is shared by all the tools involved," states the engineer. "Once that information is handed off, a decision is made."

When a lot is recognized as one that needs automated process correction (APC), information is exchanged between the SECS/GEM host controller and the Savigent server; that information can be applied in the manufacturing process step. "For example, we might know that we want to expand

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the pattern a little bit," he explains. "In this case, we could introduce a variable called 'MAG'; or, we might want a little translation and shift the pattern a little to the left or a bit downward. Those are called 'X translation' and 'Y translation.'"

Based on previous material and overlay measurements from earlier process steps, a calculation is performed, and a prediction is made that if a little bit of translation and a little bit of MAG is added on the current lot of wafers, the overlay control will be improved. That calculated correction is used on that particular lot. Later, a metrology tool will measure the overlay. At that point, the company can see if any overlay errors still exist. This new data is fed into the Savigent server and run-to-run controller.

The manufacturer is now able to take what were baseline numbers with no corrections applied and look at key output metrics from the overlay tool: registration maximum, registration minimum, and mean values for both the X and Y dimensions. "With Savigent's technology, we're able to drive those metrics to lower and lower numbers," says the engineer. "Zero would be our ultimate goal for the mean. Max and min won't ever go to zero, but we're always trying to make them smaller. That shows we've achieved a better overlay than without the run-to-run controller."

Since implementing the new system, the company has reduced a typical max/min value in the range of 100 nanometers into the range of 60 nanometers, an improvement of 40 percent.

Adding Flexibility

Another key element in the new approach has been the use of SharePoint in managing activities around the controller and configuring the system. "From my point of view, this has been very beneficial," states the engineer.

Typically, when the company rolls a new software capability into the fab, engineers want some kind of interaction with it. So they go to IT and ask them to modify an interface or create a new one to enable desired features. Because Savigent has created an easy point of access to the system through SharePoint, the IT department doesn't have to get involved anymore. SharePoint gives the engineers tremendous flexibility in allowing them to make changes and tweak their processes directly. This is faster, more efficient, and provides much better documentation.

"The problem with changing the values in a process recipe is that people lose track of what they are," he continues. "Many individuals were manipulating those values. The Savigent system documents who changed what, when it was changed and what values were changed."

According to the company's photolithography process engineer, traditional lithography vendors don't offer a solution with such broad utility and flexibility across the fab. "We also use SharePoint for viewing what's happened in the past and for setting up baseline tables," he adds. "There are times when I know a lot is coming soon, and I want to see a prediction of what corrections will be applied to a particular lot. Savigent has set up a simulation feature in SharePoint, so I can enter in a few details about what the route is going to be and what the layer is going to be as well as the tool number for the stepper it's going to be run on. The simulator then uses the information in the run-to-run controller database just like it would on a stepper when it arrived. The simulator gives me an output and shows me what I can expect for the applied correction values. Now I have the ability to make a change if I want to fine tune something for a particular lot."

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A Better Approach

When the company sat down and evaluated packages that could be used for the run-to-run control project, cost and flexibility were two key factors they considered. Savigent excelled on both counts. "Savigent provided, in some ways, a source code that we could change," says the engineer. "The others had out-of-the-box functionality but were very restrictive in how we could work with them. They locked us down and limited engineering's ability to do things that the Savigent solution has empowered them to do."

The engineer says a good point of comparison is other software the company has purchased and implemented quickly for its out-of-the-box functionality. "To make needed changes, we have to go through the software vendor's company to get the modifications," he explains. "With Savigent's system, the adjustments needed by engineering are not gated by a change in the software itself; they can go to SharePoint and change the values that they need to. In that respect, the Savigent solution is a huge plus for everyone."

Another advantage is the ability for the software piece to sit on a virtual server; there is no actual point of use PC hardware needed to do the communication from the tool to the Savigent software. "In the Savigent system, everything is virtualized, which is a great advantage for us," the engineer states. "It eliminates hardware costs and reduces the likelihood of failures."

Pattern of Responsiveness

The company's photolithography process engineer concludes by tipping his cap to Savigent for the way they work: "I give kudos to Savigent in general for their responsiveness and willingness to work with us. They have been really helpful in terms of customer service. With a phone call or an email, they'll look at an issue in less than 24 hours, and then they'll either remotely access the server running the code or come to our site to help us troubleshoot the issue. We've made some code changes very quickly to address unexpected problems. They've been very helpful in this process."