Photoresist Bar Code Monitor

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Abstract

Automation, intelligently applied, reduces human error and the effects of human error on a working wafer fab. When a task cannot be taken over, but can be monitored by automation, the effects of human error can be eliminated.

This article describes the automated system implemented by NEC Electronics America semiconductor fab to monitor photoresist bottle changes on coaters. The system prevents installation of the wrong resist type, an error that could have costly results. Two generations of resist monitoring systems are discussed.

The first system was created in the 1990s, when the potential problem was identified and the consequences considered. That system has been in place, successfully, for nearly 12 years. More than a decade later, when a new set of coaters was being installed as part of an expansion, NEC Electronics America extended protection to the new coaters by working with the designer of the original system. That designer, now with Landry Engineering Development, a custom equipment manufacturer, designed a second-generation system that today provides improved protection with a simpler design.

Even in the hyper-automated manufacturing environment of a modern wafer fab, there remain many operations that defy automation. Replacing spent photoresist bottles is one of those tasks likely to be performed by operators well into the foreseeable future. In such a case (of a mission-critical task that can't be performed automatically), the best option is to monitor the task via an automated system.

This is the approach that NEC Electronics America has used in the past—with proven success. Over a decade ago, using the wrong bottle to replace an empty resist was a real possibility—with real potential for serious consequences. To prevent this possibility, equipment engineers at NEC Electronics America developed and implemented a networked, photoresist-monitoring system. Since that system was installed, there have been zero incidents of mis-set resists.

Recently, as part of an ongoing expansion and conversion to 8-inch equipment, several additional coaters were installed and put into production. It was clear that the additional coaters would have to be monitored too. The question facing NEC Electronics America was, "How can we dig into a 10-year-old, one-of-a-kind system with antiquated hardware, unsupported software, and orphaned programming without risking its continued operation?"

History

1n 1996, NEC Electronics America became increasingly concerned about potential losses of product due to mis-set photoresists at its wafer fab in Roseville, California. A mis-set photoresist event can occur if a technician mistakenly replaces an empty bottle with a bottle of a different resist type, and then the coater resumes processing of the wafers with a resist not suited to the next process step.

It is not hard to understand how this could happen. At any point, a wafer fab can have upwards of a dozen resists in use, on different coaters. Each coater would have three or four different resists on board, each selectable by different recipes for different processes. Commonly, the only indication the technician has (as to which photoresist to bring to the coater) is a brief glance at the empty bottle before heading off to retrieve its replacement. All resists from a particular supplier can have the same label style; the same colors, layout, and logo—the only difference being the resist name printed on the label. In the production environment, with multiple demands on a technician's attention, it is easy to see how a mistake could be made.

The impact of a mis-set resist could be anywhere from bad to very bad. In the best-case scenario, where a mistake is caught before wafers are etched, the affected wafers could be reworked and the coater taken offline while the resist circuit is purged, cleaned, and set up with the intended resist. In the worst-case scenario, the replacement resist would be too similar to the intended one, so similar that it would not be caught at inspection, and the wafers would be etched. In cases of anti-reflective coatings, detection of an error would be even more difficult. The loss calculation in these situations would include the loss of product, the loss of fab time already invested in that product, and the loss of the affected lots. Since the empty bottle is the main indicator of which replacement to retrieve, the potential exists to dispense more than one bottle of the wrong resist.

Once the NEC Electronics America team identified this potential problem in 1996, it determined that the situation was unacceptable. It was investigated and a number of process controls were considered. There was a strong feeling that such a simple problem should be simple to overcome. Check sheets, buddy system checks, oversized tags dangling over the bottle position, and daily meetings and reminders were all considered by production managers at that time, but no one option offered 100% protection.

Engineers at the NEC Electronics America wafer fab in Roseville determined that the only foolproof system would be a mandatory, interlocked system, in other words, a bottle of resist could not be changed without using the system, and the coater could not run unless the system was satisfied. The goal was complete elimination of the potential problem, so the system had be 100% self-enforcing.

Approval and budget was given for a server-based, networked, photoresist barcode verification system. A DeviceNet network line was run under the floor with branches running to I/O cards mounted in the coaters. Existing sensors in the coaters were monitored and additional sensors were installed. Wireless barcode scanners were networked to the host system. The system functionality was designed to be self-enforcing and foolproof, but still easy to use, so that no one was encouraged to find a way around it.

Success

That system went live in June 1997, and has been working nearly 12 years without a problem, or the threat of a problem. Exact savings are unknown, but, assuming a mistake would have been made during that time, the company has reaped savings of wafers lots not scrapped, production deadlines not missed, chemicals not wasted in purging, and morale not lost due to a simple mistake with huge repercussions. The potential drawback was that the additional steps required of the chem techs would be seen as a burden, and cause complaints. But, according to the techs, the relief from stress overshadowed any additional steps in the bottle change procedure. The system has, more or less, become invisible and continues to work.

How to Protect Additional Coaters

Recently, over a decade later, as part of its ongoing 8-inch expansion, NEC Electronics America installed and put into service additional coaters. It was obvious that these new coaters should be protected, but it was not clear whether to try to expand the original system or replicate it.

Second-Generation Protection

The NEC Electronics America team consulted with Landry Engineering Development, a custom equipment manufacturing company, and selected, a modular, server-less system. The modular system would be self-enforcing, interlocked, and easy to use. Eliminating the central database, the network backbone, and the networked wireless scanner system reduced the company's costs significantly.

Figure 1. The manufacturer's bar code and other information is collected and evaluated during a resist change.

Improved Success

Working closely with NEC Electronics America to ensure that all needs were addressed, Landry Engineering Development developed a system that monitors the same criteria as the original system. When a replacement resist is brought to the coater (figure 1), the coater remains interlocked until it is verified that:

- The new resist is the correct type
- The resist is placed in the correct position in the coater
- The thaw time for that resist type has elapsed, and
- The bottle being scanned is, in fact, new to that coater

In addition, the new system ensures that the new resist has not passed its expiration date, and also monitors all resists continuously to prevent the coater from running with an expired resist.

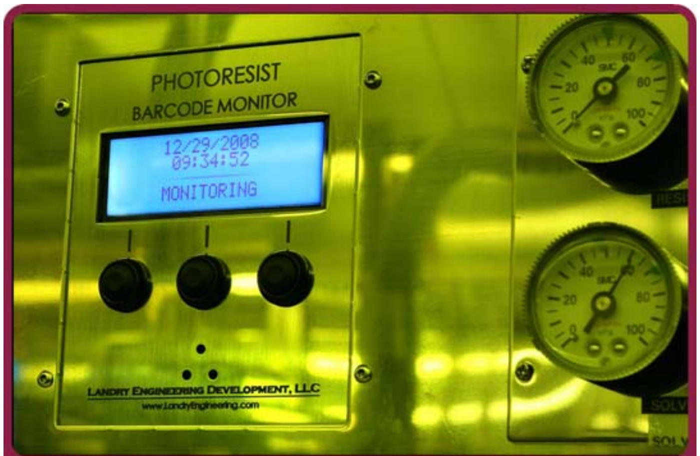

Figure 2. The system's user interface was designed to fit within existing panel cutouts.

The system uses a dedicated, Bluetooth scanner at each coater. The controllers were installed in the coater's chemical cabinets so it was not necessary to find space on the coaters or add to their footprint. The user interface was customized to fit into the standard cutouts in the coater's instrument panels (figure 2).

As with the original system, functionality was designed to minimize the impact to the bottle change procedure. The user interface is only used for utility and setup functions (figure 3) or if a new user needs to be prompted through the bottle change steps. A trained tech, however, will not use the interface except as audio confirmation of the barcode scans.

Figure 3. Utility and setup operations are performed at the user interface.

Conclusion

Any opportunity to remove the potential effects of human error is a benefit to a wafer fab. The ideal case is when a task can be automated to remove human error altogether. If the task cannot be automated, it is possible that mistakes will be made. Automated monitoring is the best way to catch those mistakes and prevent losses.

Photoresist bottle changes are a good opportunity to catch mistakes and eliminate their effects through automated monitoring. A successful system must be self-enforcing and easy to use. NEC Electronics America was in need of a second-generation system to monitor recently installed coaters and was able to have it developed by the architect of their proven, first-generation system. ■

About the Authors

Mark Crabtree is an equipment engineering manager responsible for the masking, implant, sputter, and wafer sorting areas at NEC Electronics America's wafer fab in Roseville, California. Mark joined NEC Electronics America in 1994 and worked as an equipment engineer in masking and wet etching before becoming a manager. He received a B.S. in mechanical engineering from the University of California at Davis; he has a professional engineer's (P.E.) license in mechanical engineering in the state of California and holds three patents in the semiconductor industry.

Dan Landry is a partner and co-owner of Landry Engineering Development, LLC. Dan received a B.S. degree in mechanical engineering and materials science from the University of California at Davis. His first patent was initiated as a student intern at IBM. He joined NEC Electronics America in 1990. As equipment engineering group leader over masking, he created the company's original photoresist barcode system. Dan left NEC Electronics America and became engineering manager at a small chemical supply system manufacturer. He was there for one year before leaving to start Landry Engineering Development, which has been providing custom equipment and modifications to the semiconductor, bio-medical, and pharmaceuticals industries since 2000.