SMART MANUFACTURING SOFTWARE

WEAVING DIGITAL THREADS INTO A GLOBAL FABRIC OF ENTERPRISE KNOWLEDGE

Automated process control drives fast, easy improvements in process capability index (Cpk)

DISCOVER® SMART MANUFACTURING SOFTWARE SUITE

Discover Software provides visibility and control of all phases of the semiconductor manufacturing process (figure 1). Run-to-run (R2R) automated process control gathers critical data from each production run and automatically adjusts process parameters for the next run based on sophisticated models of process performance. Fault detection and classification (FDC), works with R2R to prevent model adjustments based on runs that include an equipment fault. Other components of the software suite include: Discover Dashboard, which presents critical information to the operator at-a-glance on a user-configurable dashboard -- the user can easily drill-down to underlying details with a few clicks of a mouse. Discover Yield software uses traditional statistical and multivariate analysis techniques to model process performance and automate yield learning. Discover Defect software and TrueADC® software work together to collect inspection and metrology data and automatically classify defects. Automatic classification allows the operator to focus on yield-limiting defects and ignore nuisance defects, while constant monitoring improves analysis and permits tighter process windows of process data. Finally, AutoShell® software provides a consistent and easy-to-use operator interface for the entire suite.

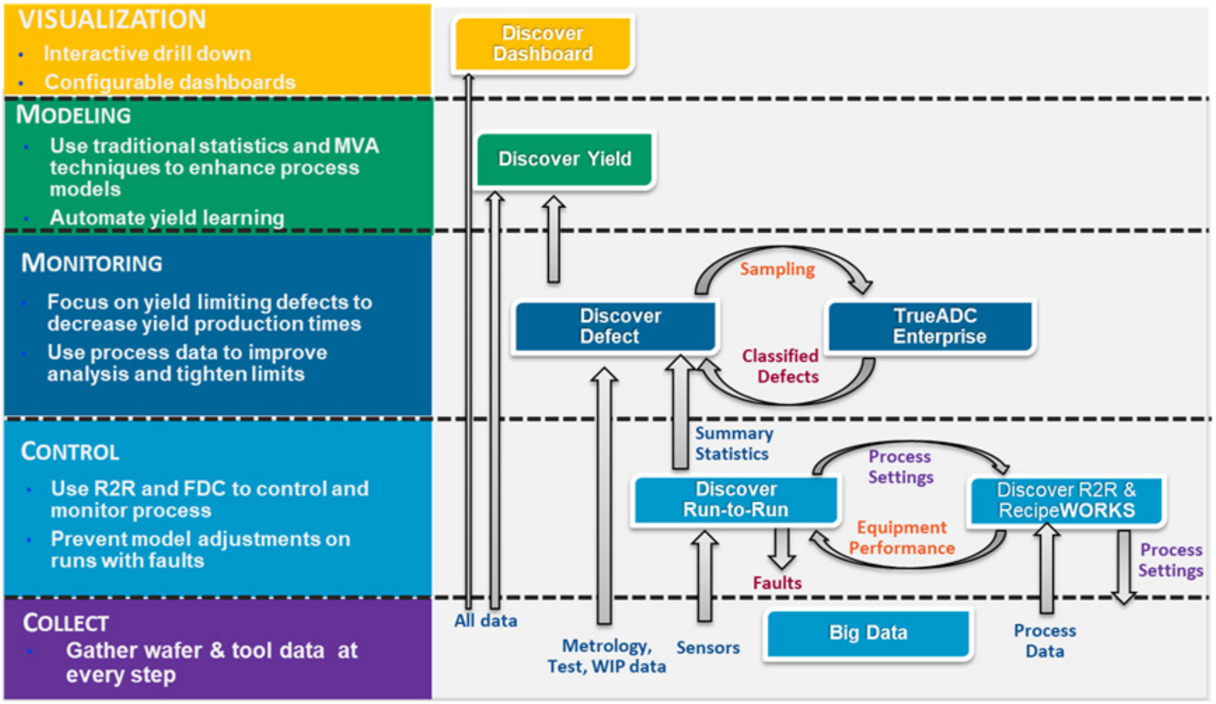

FIGURE 1 *Discover smart manufacturing software suite provides visibility and automated control of all phases of the semiconductor manufacturing process.*

AUTOMATIC PROCESS CONTROL

Automatic process control (APC) incorporates measurement and inspection feedback from the previous run and feeds forward data from preceding process steps to calculate and implement optimal recipe settings for the next run. APC relieves the operator from the need to manually analyze data and adjust recipe parameters, ultimately reducing process variability and improving process capability and yield.

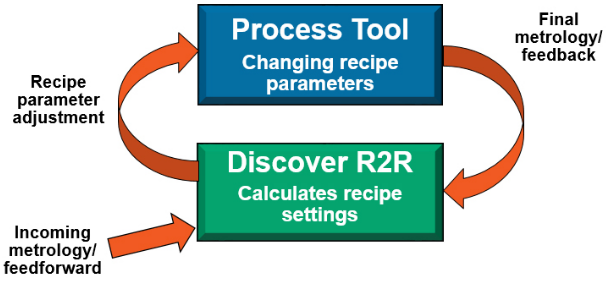

FIGURE 2 *APC uses feedback from previous run and feedforward data from preceding process steps to automatically calculate and update recipe parameters.*

CASE STUDIES: LITHOGRAPHY, ETCH, DEPOSITION, CMP

In the interest of providing the broadest possible overview in the examples below we cite relative increases (%) in the process capability index (Cpk) as a generalized measure of improvement. Cpk measures the inherent variability in a process and its ability to yield acceptable results. More detail on any of the results cited here is available from your Rudolph representative.

LITHOGRAPHY CD AND OVERLAY

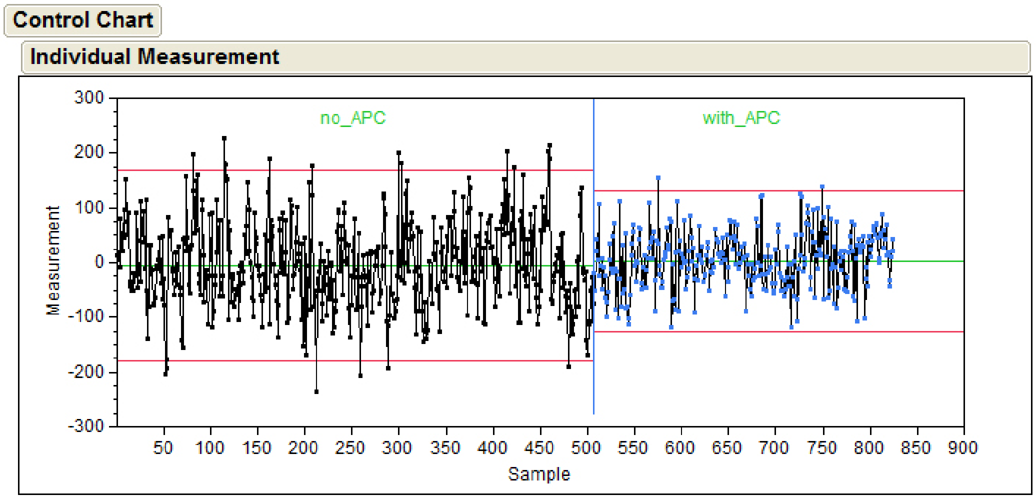

FIGURE 3 *Control chart showing the improvement resulting from R2R automatic process control in a lithography application.*

CUSTOMER #	Δ CPK	OTHER BENEFITS
1	↑45%	Sigma ↓ 55% rework ↓ 70%
2	↑20%	Rework ↓ 87%
3	↑40%	Probe yield ↑4-6%, rework ↓ 75%, monitoring lamp intensity w/ FDC for predictive maintenance → $20M capital avoidance–R2R + FDC
4	↑32%	After 3 weeks
5	↑53% (CD) ↑57% (OL)	Adaptive metrology saved 53.8 hrs/day of cycle time for all operations

TABLE 1 *Lithography - Cpk gains from APC.*

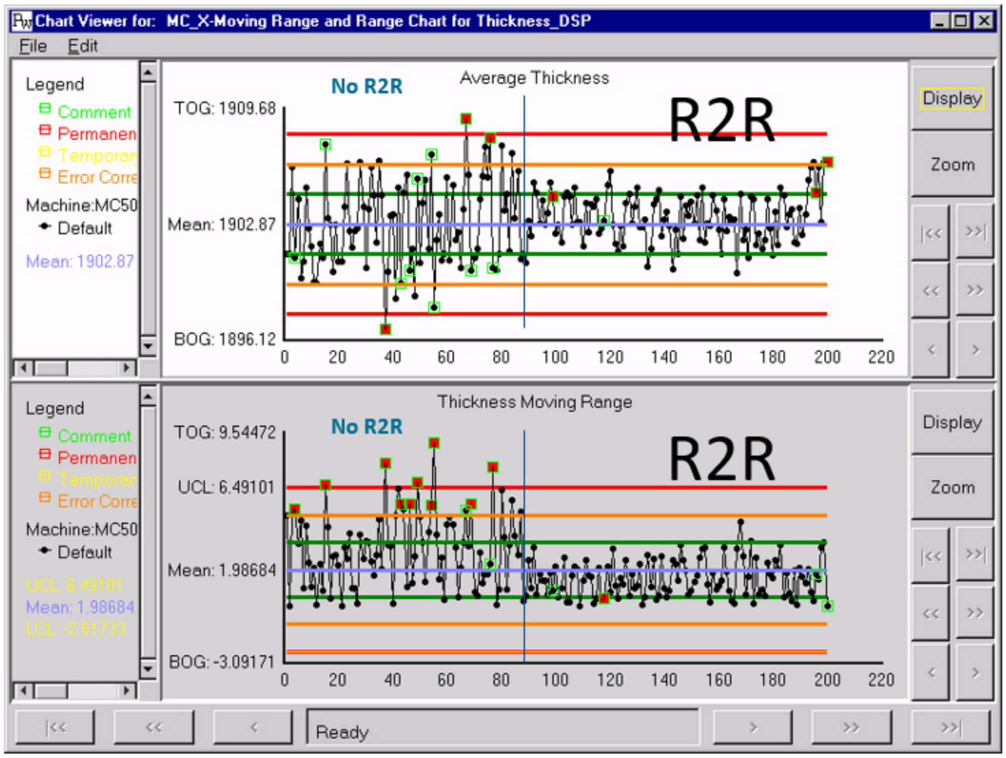

FIGURE 4 *Control chart showing the improvement resulting from R2R automatic process control in an etch application.*

CUSTOMER #	Δ CPK	OTHER BENEFITS
1	↑50%	Sigma ↓40%, rework ↓10%, pilots ↓, recipes ↓from >200 to <50, pinpoint yield excursions with automatic data feed to YMS. Also used FDC to monitor component wear (reduced grid purchases 30%), verify R2R setting used, monitor equipment data / interdict.
2	↑68%	Cycle time /lot ↓8 hrs, pilots ↓, 200K parameters controlled with a single strategy. Gate etch - controller tracks variation based on stepper (photo) and device (etch) – 200K parameters (steppers x etchers x reticles)

TABLE 2 *Etch - Cpk gains from APC.*

DEPOSITION

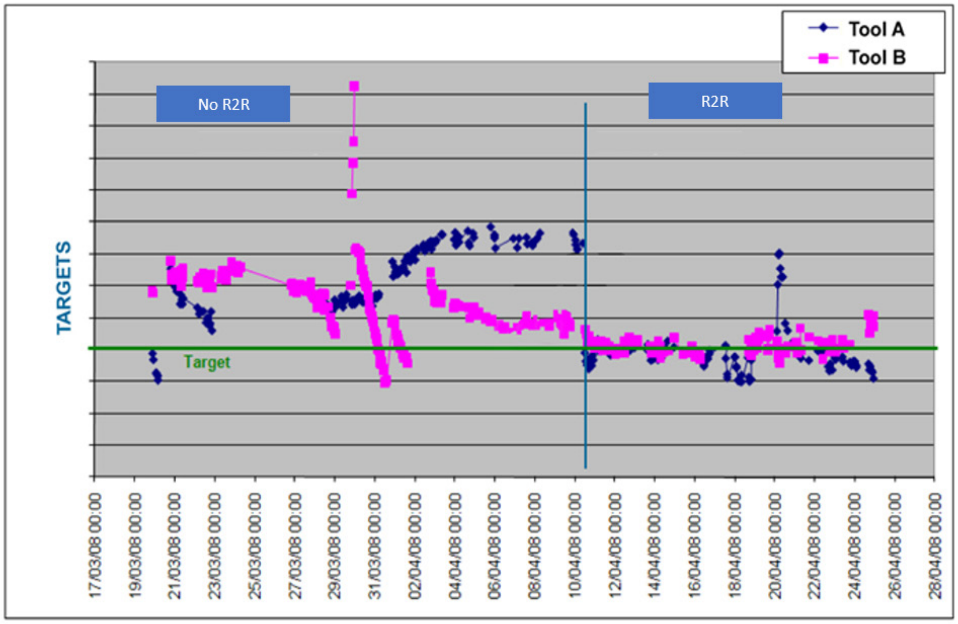

FIGURE 5 *Control chart showing the improvement resulting from R2R automatic process control in a deposition application. The two tools (different colors on the chart), were both out of control before APC and both were in control after APC. The APC tracked the changing deposition rate to calculate the deposition time, and adjusted gas flows and RF power to control uniformity.*

CUSTOMER #	Δ CPK	OTHER BENEFITS
1	↑51% (thickness) ↑26% (stress)	Final thickness closer to target, fewer lots out of specification, easier changes between products, quicker update to controller by process engineers, faster feedback to compensate for tool drift.

TABLE 3 *Deposition - Cpk gains from APC.*

CMP

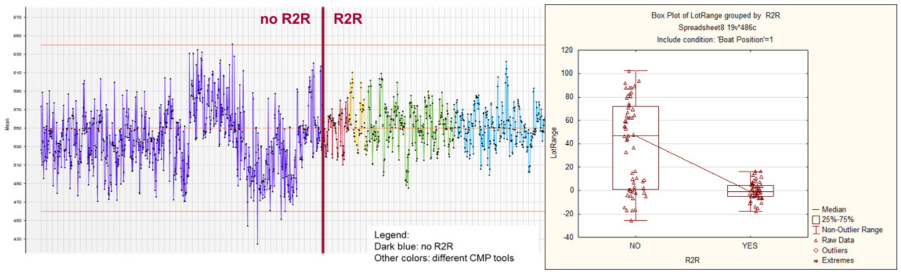

FIGURE 6 *Control chart showing the improvement resulting from R2R automatic process control in a CMP application. APC tracked removal rate and used incoming thickness to calculate polishing time. Back pressure was adjusted to control uniformity. FDC ensured calculated setting was used by controller. FDC was used to monitor slurry – one interdiction saved nine lots. Also, monitored tool idle time and only ran pilot if idle >2hrs, improving throughput 25% and avoiding $36M capital expenditure.*

CUSTOMER #	Δ CPK	OTHER BENEFITS
1	↑150%	Rework ↓86%, scrap ↓40%, pilots ↓40%
2	↑137%	5 weeks from green-field (no R2R) to full production, wafer to wafer thickness variation down 70%.

TABLE 4 *CMP - Cpk gains from APC.*