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Fault Detection and R2R Control Solutions Applied to Large Flat Panel Display Manufacturing

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Purpose:

This paper focuses on the successful implementation and return on investment (ROI) of fault detection (FD) and run-to-run (R2R) control solutions deployed at a large flat panel display (FPD) manufacturer. The ROI analysis is based on results obtained from FD monitoring via univariate and multivariate analysis on a CVD tool and R2R process control applied to a lithography process.

Display Manufacturing APC Challenges:

Taking their cue from semiconductor manufacturers who started using APC solutions over a decade ago, FPD manufacturers have started using FD and R2R control to improve substrate quality control and increase equipment uptime. But unlike the semiconductor industry that has developed standard interfaces such as SECS/GEM for tool data collection, display manufacturers lack sensors available through standard interfaces. The lack of standards makes detecting critical parameters much more challenging: APC suppliers must work with display tool manufacturers to access tool data. Another challenge display manufacturers face is controlling their critical lithography process with manipulated input (overlay, dose amount) and getting a controlled output (critical dimension and overlay).

Data Collection:

For FD monitoring and R2R control, Applied E3™ (Figure 1) was deployed at a large display manufacturer to provide the functional capability for data collection, configuration of FD models with respect to the critical sensors with the control limit to trigger the alarm or fault from the system and to notify engineers, and configuration of R2R process model for CD and overlay control of lithography process.

The amount of sensor data available through SECS/GEM interfaces was limited, but additional data was collected from the file server connected to the controller in the tool directly by working closely with tool engineers. This file data was imported into the E3 database and used for FD and R2R control modeling.

Model Development:

The FD models were based on the critical processes that generated the most frequent alarms or faults potentially impacting the loss of substrates or reduction of equipment up-time due to unscheduled downtime. For R2R control, the control model was based on the model predictive control in E3 for the lithography process and feedback control was applied for fine tuning of manipulated inputs (dose and overlay) and controlled variable (CD and overlay).

APC Benefits:

To determine the customer's ROI, we considered the overall investment, including costs to install and maintain the E3 system with FD monitoring and R2R control capability. Improvements included: 1) reduction or savings of scraped substrates 2) reduction of manual operation and overhead cost 3) increase of Cpk and equipment up-time compared to the process without the R2R control for lithography process. Total return or savings was estimated at the 70% confidence level using a 3-point estimation. (Figure 2). α is the ratio of FD frequency resulting in saving divided by total number of faults detected. Model 1 shows the best case scenario and model 2 shows the most conservative model. Saving of R2R benefit was 100% counted in the estimate since the benefit of reduction of manual operation and increase of tool up-time was known as 100% for saving. In case of FD, due to a part of false alarms from all published FD events, we should apply the best and the conservative case.

The analysis showed the return of initial investment after one year from the system implementation (Best model case). Because the equipment and process controls are easy to update with E3, this FD and R2R control solution can also be applied to larger size FPD manufacturing in future.

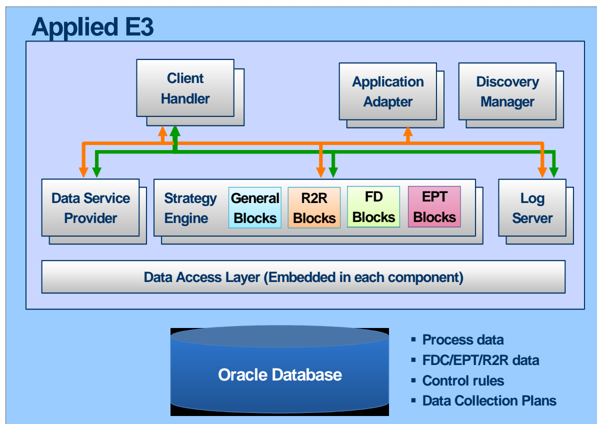

Figure1. Applied E3 solution for fault detection and R2R control.

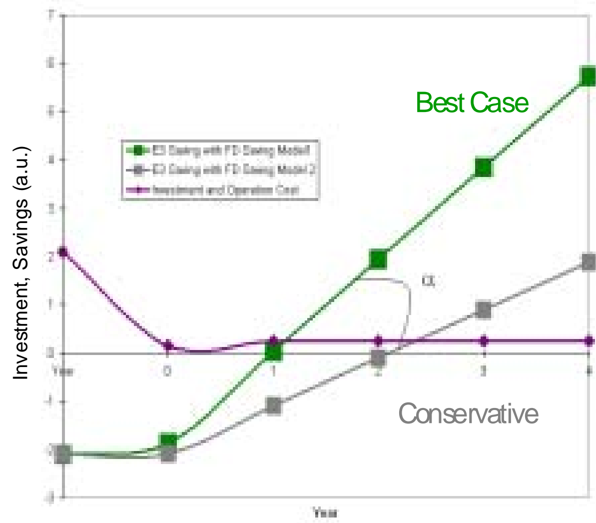

Figure2. ROI estimate for five depreciation years with the initial investment and savings from FD and R2R control.