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The way to improve the effectiveness of a comprehensive FD system - Katsuhisa Sakai

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Abstract:
Comprehensive Fault Detection (FD) system extended to each part level of the tool was realized under the cooperation of an equipment supplier (ES), a system vendor and a device manufacturer (DM). This system can monitor the tool health of the same type of multiple CMP tools continuously with the same FD models and the control limits [(3)(4)]. Generally, the more ghost alarms tend to be reported and the less effective alarms are detected when the tighter control limits are set. To improve the effectiveness of the FD system, precise classifications and improvement of the FD models were made by deep knowledge and experiences on the tool of ES. With this work, the effectiveness of the system was improved by 30%.

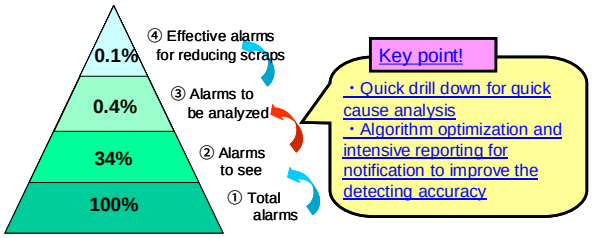
Introduction:
Advanced semiconductor processes strictly ask for the equipment to have the comprehensive and recipe-independent FD system that covers each part of the tool to monitor its health continuously [(4)]. But, as shown in figure 1, when we tried to deploy the same FD models to multiple tools, the ratio of the ghost alarms was high. To improve the effect of the comprehensive FD system, it is necessary to focus on the each FD model of its characteristics and its effectiveness when the model detects a fault. In this work, the approaches to enhance the detecting accuracy of the FD models are evaluated to minimize the ghost alarms and to maximize the effective alarms.

Approaches:
1. Exact copies of the FD models with the same control limit were deployed to the same type of tools.
2. FD models were classified by the characteristics and the objectives of the models as shown in table 1 so that the reported alarm can be easily sorted when the models were running [(3)] .
3. The control limit of each FD model was set tighter than the specification to achieve the best equipment chamber matching (ECM).
4. The effectiveness of each Classified FD model was evaluated by the number of the saved wafers from scrap as shown in figure 2. The class *A* and *C1* showed higher effectiveness than the others. Especially, the Class *C1* was the most effective. Therefore, we defined that the class *C1* is the most important target to improve its detecting accuracy of the FD models.
5. The algorithms of FD models were fine tuned to improve the accuracy of the fault detection.
6. Reported alarms were well analyzed to evaluate the effectiveness.

Results and discussions:
1. Results on the improvement of the algorithm
Figure 3.1 to 3.4 shows typical examples how the algorithms of FD models were fine-tuned. And the tuning gave accuracy improvement of the fault detection.
2. Alarm trend
Figure 4 shows the alarm trend. The alarm rate itself has been improving gradually up to 5% even the number of the FD models was doubled. It should be noted that the alarms of class *C1* described in the approach 4 were reduced significantly.
3. Effective alarm rate
Figure 5 shows that the effectiveness of the FD system has been improved by 30%. This was achieved by the strict classification and the selection of the suitable algorithm for FD models.

Conclusions:
We have improved our comprehensive FD system by classifying and fine-tuning of the FD models. As the results of increased effective alarms, the detecting rate of the faults has been improved and the scrap wafers are reduced significantly.

References:
[1] Shinichi Imai, et al. “Fab-Wide Equipment Monitoring and FDC System, ISSM, 2006
[2] Michael Yu, et al. “Yield Aware Process Control Solutions,” AEC/APC 2007
[3] Ryosei Kawai, et al. “Innovative Framework for a Comprehensive Fault Detection system,” AEC/APC 2007.
[4] Katsuhisa Sakai, et al. “Comprehensive plug and play FD system realized Predictive Maintenance.” ISSM 2008



Figjre 1. Effectiveness analysis of reported alarms

Parameter Class		Characteristics of the variable	Ratio (%)	Objectives of the FD models
A		Both set point and reading are available	20	Tool health monitoring
B		No set point but have specifications	10	Tool health monitoring
C	C1	Recipe independent monitored variable	40	Tool health and process monitoring
	C2	Recipe dependent monitored variable	30	Tool health and process monitoring

Table 1. Classification of FD models by their characteristics

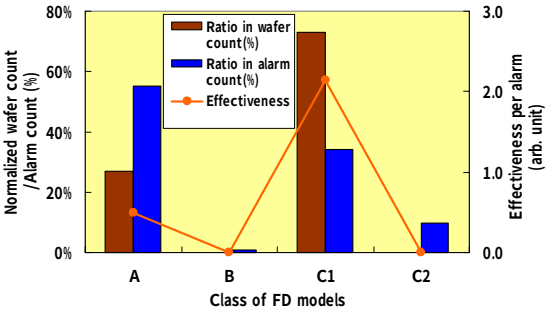


Figure 2. The effectiveness variation on saved wafers by classifications

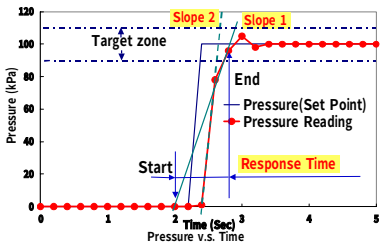


Figure 3.1 An example of a modification of the FD algorithm
"From the slope to the response time"

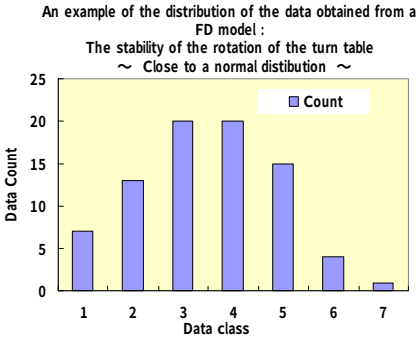


Figure 3.2 Sample data that can be statistically controlled

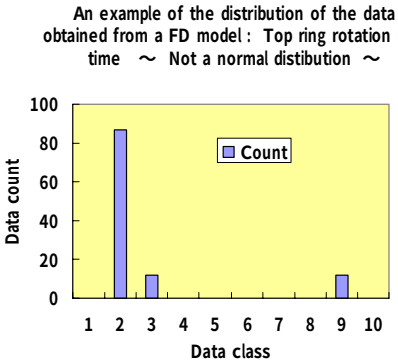


Figure 3.3 Sample data that cannot be statistically controlled

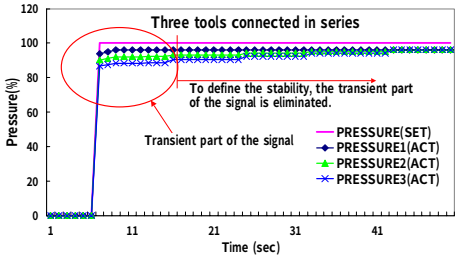


Figure 3.4 How to define the stability

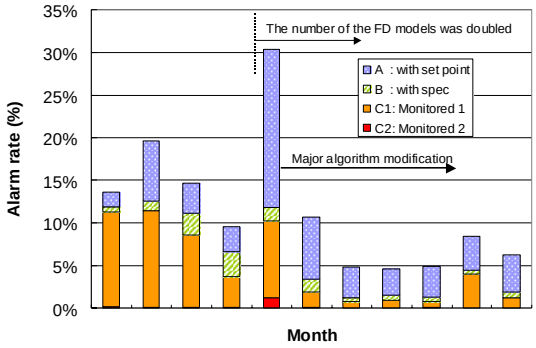


Figure 4. Alarm trend

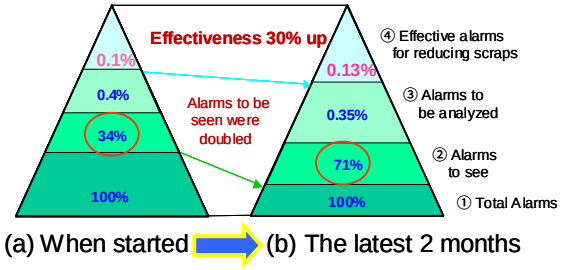


Figure 5. Improvement of effectiveness