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Automated In Situ Fault Detection in PVD with Quadrupole Mass Spectrometry

Metrology, Sensors, and Analytics

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Thin Film tools were provided with in situ fault detection based on quadrupole mass spectrometry with large sample size statistical analysis. A novel approach to provide the needed sophistication (in processing the sensor results) without compromising the practical needs of the fab worker was demonstrated.

The acquisition of trace data is not the problem. To be useful for process monitoring, trace data must be reduced to figures of merit that concisely describe tool parameter behavior over a process step (or interval) of interest.

Contamination data is inherently noisy and direct interdiction results in many false positive events (Figure 1). For effective use, the signal from the sensor(s) requires:

1. Normalization: the sensor and normal tool variability must be subtracted from the signal such that the result is a consistent measure of the contamination (Figure 2 and 3). The system must have information on tool state to synchronize the algorithm with the operation. This system uses digital and analog I/O to collect this data.
2. Multi-run: the ability to widen the perspective to multiple runs reduces false positives. Single data point excursions are filtered within a run. Even so, the data suggests that excursions at the run level are normal for these systems, and the model must accommodate this condition (Figure 4).

Historically, the few systems that provided advanced capabilities with mass spectrometry have resulted in a highly complex human interface. Once a fault is detected, if the maintenance engineer or technician cannot use the diagnostic system to complete the troubleshooting, a resolution is not probable. This system can be utilized and maintained with basic computer skills. In addition, troubleshooting dialogs that enhanced the interaction with the fab worker were introduced. The system is compatible with the hardware from most instrument companies.

The widespread use of in situ metrology will be an inevitable result of the high value of each product wafer and the increasing complexity of the semiconductor process. Testing process conditions in intervals of several hours leaves the factory in jeopardy of the loss of significant amounts of product in the periods between tests.

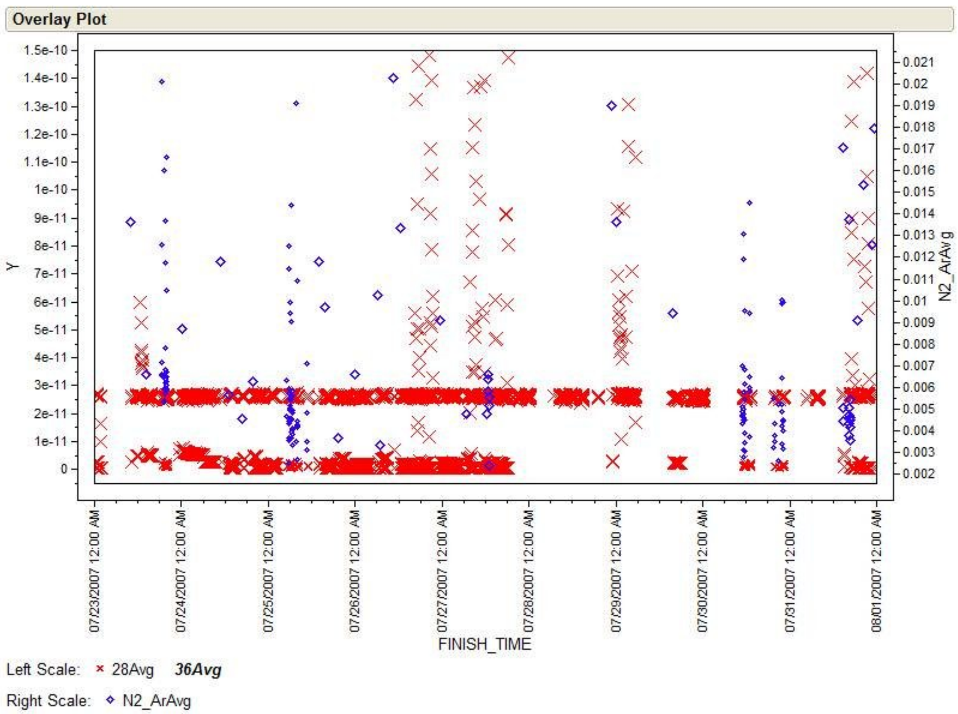

Figure 1: 3 weeks of data for a representative tool.

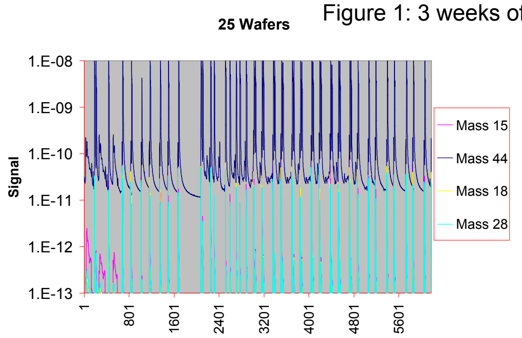

Figure 2: Normal variation of trace data before filter.

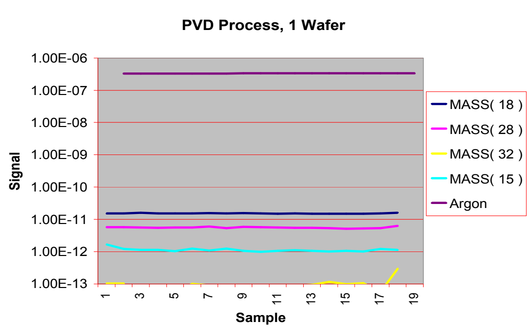

Figure 3: the data has had excursions caused by wafer transfers removed.

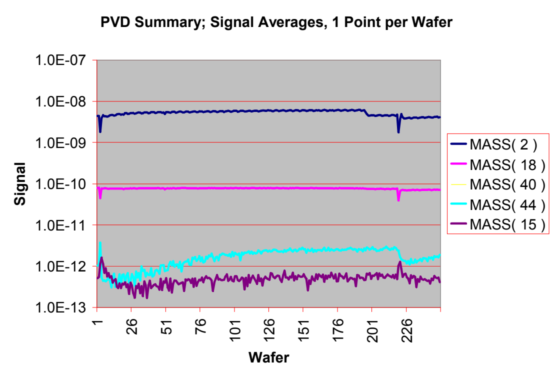

Figure 4: multi-run data for a normal tool after data filtering.

In Situ Host Compared to the Current Alternatives

The table compares In Situ Host with current alternatives. System Type A (an example is TWARE32™) is a class of software designed for use by humans. System Type B (an example is Fabguard™) is a class of software designed for automation.

Attribute	System Type A (TWARE32™)	System Type B (Fabguard™)	In Situ Host™
Leak-checking/ Troubleshooting[1]	•		•
Easy to Use[2]	•		•
Easy to Maintain[3]	•		•
Recipe Matching[4]		•	•
Integration with External Signals[5]		•	•
Sophisticated Normalization of Data[6]		•	•
Statistical Process Control[7]		•	•
Integration with Fab Database[8]			•
Compatibility with Multiple OEM Hardware[9]			•
Automated Setup Verification[10]			•
Multi-Run, Multi-Chamber Perspective with Visual Display[11]			•

1 The addition of automation to software like Fabguard™ has encumbered the system with a level of complexity with has been shown to hinder use by maintenance technicians and engineers.

2 In Situ Host is fully compartmentalized from the OEM software. Because of this, the ease of use is not impaired.

3 Automation software is not designed to facilitate the maintenance of the hardware. In Situ Host automates the system without reducing the serviceability.

4 This attribute allows the RGA recipe to change in response to a chamber parameter or recipe change.

5 It is useful to include external signals in the processing of the data. An example is the transfer chamber on a cluster tool. If the algorithm includes the state of the gate valves, changes in measurement can be assigned to an attached reactor.

6 Normalization allows the measurements to be independent of instrument sensitivity changes and inlet pressure changes.

7 The use of SPC allows sophisticated multi-run automated reaction to out of control conditions.

8 Since In Situ Host is designed to integrate with the Fab's database in lieu of an independent dedicated database, the Fab personnel do not have to learn new tools. In addition, the time required for implementation is significantly reduced.

9 In Situ Host can communicate with several OEM hardware units simultaneously. Imagine choosing the best instrument for each application, instead of being forced to use a single vendor's hardware.

10 The setup of these systems can be complex. Once a configuration is established, a model is created. A comparison of the current setup and the model is automatically executed, assuring reproducible results.

11 It can be difficult to identify a problem when monitoring at a short-term display. In Situ Host continuously updates 250 run (10 lots of 25 wafers) summaries for each of the modules. The most recently active module's results are displayed.

*Fabguard and TWARE32 are Trademarks of Inficon. Inficon product attributes are used for comparison.

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