Implementation of Automated Equipment Monitoring in a Highly Flexible Semiconductor Production Line

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Agenda

- ams AG Overview
- Focus on Maintenance
- Vision for Equipment Monitoring
- Build Up Competency
- Implementation
- Use Cases
ams overview

At a Glance:
- Focus on high performance analog ICs
- Ultra-low power, high accuracy, high integration design expertise
- Specialize in sensors & sensor interfaces, power management, and wireless solutions
- Analog IDM: combining design + best-in-class manufacturing

By the Numbers:
- 300+ analog engineers
- Over 30 years of design experience
- Revenues of 276 million Euros in 2011
- More than 1,200 employees worldwide
- Over 6,500 customers worldwide
Proven manufacturing model

In-house capacity + partnerships: a scalable and robust growth model

Wafer Manufacturing
- Specialty analog processes
- Best-in-class efficiency
- Zero-defect program
- Technology nodes: 0.18µm – 0.35µm – 0.8µm
- 200mm in-house fab
- Multi-source security: TSMC, UMC, IBM

Assembly and Test
- In-house test in Austria and Philippines
- Multi-source assembly locations
- End-to-end fully integrated supply chain
Wafer Manufacturing 200mm Fab

0.35µm / 0.8µm CMOS & speciality processes

Main contributors to Fab operation cost:

- Depreciation
- Facilities/utilities
- Direct and indirect labor

\{\text{Mostly fixed costs.} \quad \text{Little influence by management}\}

- Spares/parts/maintenance subcontracting

\text{Can be tackled by Equipment Maintenance}

Equipment maintenance has high leverage on:

\textbf{Quality}: prevent scrap, yield loss

\textbf{Throughput}: optimize maintenance scheduling
faster failure analysis and repair

\textbf{Cycle Time}: consider future equipment downs for line scheduling
Vision for Equipment Monitoring

**MONITOR** the Fab process equipment
during wafer processing
and **DETECT** abnormal behaviour
before a damage to wafers or equipment occurs.

Trigger action plans to **PREVENT** yield loss or reliability issues.

Plan maintenance actions based on equipment condition
= predictive maintenance.

➔ Implement **Fault Detection and Classification (FDC)** on all production equipment
and prepare for predictive maintenance and virtual metrology
Equipment monitoring implementation (FDC)

Real time monitoring is an autonomous unit for every equipment
Handling of Out of Control Events

1. Continuous raw data collection
2. FDC detects violation
3. Out of control event
4. Hold lot
5. Set lot on hold
6. Send e-mail
7. HOLD LOT C12345.1 Reason: FDC

Real time FDC

workflow manager

MES

E-Mail client
Equipment Maintenance?
Learnings from our experience

1. Standardize work (no FDC required at all):  
   → It reduces equipment variability

2. Look into the „black box“ equipment:  
   → we need to learn the correlation between process and equipment condition

3. Do not (only) monitor data:  
   → We have to monitor equipment behaviour  
   → We have to transform data to information

4. Improve equipment operation and maintenance:  
   → Optimize processes  
   → Rework maintenance procedures and schedules  
   → Optimize equipment requlification
Build Up of Know How in the Team

New Competences Required:

- Statistics beyond SPC: explorative statistics, multivariate analysis, modelling
- Data visualization and knowledge discovery
- Deeper equipment understanding

→ Cooperation with academic partners
→ Cooperation with software solution provider
→ Cooperation with other semiconductor manufacturers
→ Cooperation with equipment manufacturer

Maintenance and Process Engineers need strong support from Key FDC Engineers
Definition of Responsibilities
Drive implementation of new methods and sustain

Resposibility:

Fab Management

Production
- Foremen
- Operator

Production line control

Sustaining
- Process Eng.
- Maintenance

Equipment, single process steps

Yield Enhancement & Process Integration

Process technologies, yield

Modelling, Continuous improvement. Support Maintenance and Process Engineering

APC Core Team

IT

Fab IT

Fab IT infrastructure, software applications

Infrastructure and databases
Use Case 1: Metal CVD
Monitoring the heater performance

Collect temporal data.

Select parameter, set windows for indicator calculation

Indicator: Slope of temperature in green window. One value per wafer.

Data reduction

Start condition: Min(wafer_temperature)
Stop condition: Max(wafer_temperature)
Multivariate Analysis

Two Correlated Indicators

Univariate SPC monitoring window

Valid process regime

Missed Alarms

False Alarms
Use Case 2: Oxide Etch

Magnetic field failure effects contacts

Univariate charts do not allow to identify fault

**Multivariate analysis** with excellent S/N ratio as implemented on etch equipment

![Image of anomaly group](image1.png)

![Image of T2 chart](image2.png)

![Image of Principal Components Graph](image3.png)
Benefits

Achieved results at ams’ 200 mm Fab:

- Uptime improvement
- Cycle time reduction
- Reduction of excursions
- Faster root cause analysis in case of failures

Basis is set for continuous improvement
Acknowledgement

Thanks to ams management, FDC team, equipment and process engineers and to our partners!
Thank you

Please visit our website www.ams.com