Automotive Semiconductor and Sensor Manufacturing in Europe
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Automotive Semiconductor and Sensor Manufacturing in Europe

1. Robert Bosch Semiconductor and Sensor activities
2. Consequent use of IT Tools
3. Smart Automation
4. Summary
Absolute Value of Semiconductors per Average Car

<table>
<thead>
<tr>
<th>Year</th>
<th>$ per Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>$200</td>
</tr>
<tr>
<td>2010</td>
<td>$390</td>
</tr>
<tr>
<td>2020</td>
<td>$740</td>
</tr>
</tbody>
</table>

Source: Bosch
Today’s Perspective

- Safe
- Clean
- Economical

- Active Front Steering
- Fuel Cell
- Lane keeping support
- EHB
- Hybrid
- Emergency Brake
- ESP
- Gasoline-DI
- ACC
- TCS
- Diesel-DI
- Navigation
- ABS
Center of Competence for Semiconductors and Sensors
## Key figures

<table>
<thead>
<tr>
<th>150 mm Module (SOP 1995)</th>
<th>200 mm Module (SOP 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,100 m²</td>
<td>4,600 m²</td>
</tr>
<tr>
<td>1,400 Wafers/day</td>
<td>1000 Wafers/day</td>
</tr>
</tbody>
</table>

Technologies:  
- BCD1, 2, 3, 3s, 4, 4s  
- CMOS, Bipolar, PSC bipolar, MOS  
- Pressure sensors  
- Inertial sensors  

Process: ≥ 0.5 μm  

Technologies:  
- BCD4, 4s, 6, 6sCu  
- Advanced CMOS, HVCMOS  
- Power MOS  
- Pressure sensors  
- Inertial sensors  

Process ≥ 0.18 μm
Ramp up 200mm Waferfab Reutlingen

![Chart showing Waferstarts/d from 2009 to 2014](chart.png)
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Process Control @ Bosch Reutlingen:

**APC** (Advanced Process Control)

- **FDC** (Fault Detection and Classification)
  - Maestria, EPT, …
- **R2R** (Run to Run control)
  - ProcessWorks, …
- **SPC** (traditional Statistical Process Control)
  - MES (PROMIS), …

Based on:
- integrated tool metrology,
- external sensors at tool,
- sensors of fab facility.

Based on stand alone metrology
( traditional measurement on monitor or production wafers ).

FDC and R2R complete traditional SPC to form a fast feedback process control.
APC@Bosch

Wafer process flow

Tool n-1
internal metrology

Metrology n-1

Tool n
internal metrology

Metrology n

Tool n+1
internal metrology

Run to Run

R2R-Controller

Product specific data:
Product name, actual layer, technology, ...

FF-Loop (feed forward)

Process-Parameter

Equipment settings

FB-Loop (feed forward)

Fault Detection

FDC - Strategies

Benefits R2R:

Without R2R-Control

With R2R-Control

Benefits FDC:

reduction of manual inspections

Optimization of runtime per wafer

decrease of inline scrap of wafers

enhanced tool qualification

APC loops in production

Benefits FDC:
FDC data processing:

Data Collection (e.g. 50 parameters per second)

Computing Indicators

valuation

Indicator A exceeds an upper limit and triggers an alarm.

emails, tool message, hold lot ...
**Example for FDC:**

**Situation:** Success of resist strip is controlled by a visual inspection

**Change:**
- FDC is a reliable monitor for an effective strip step.
- The succeeding visual inspection step can be saved.
- Inspected wafers were increased from former 3 visual to now 25 with FDC per lot.

**Controlled parameters:**
- Forward power, reflected power, gas flows, plasma signals,
- Machine handling parameters (pin lifter), chuck temperature, duration.

**OCAP:**
In case of limit violation lot is put on hold.

**Benefit:** 150 k€ savings per year due to the annulling of visual inspection steps and increase of inspection quality from sample to 100%.
Why R2R @ Bosch

- **Main focus: Reduction of variance**
  - Modern processes do not run without (Litho-)R2R systems.
  - Litho is main focus.
  - Cpk improvement is measure of R2R-implementation.

- **Minimize time and risk of engineering tuning**
  - Manual tuning always is prone to errors.
  - Manual tuning is time consuming
  - R2R corrects 24h/7d w/o an engineer

- **Reduction of test wafers**
  Many tunings are based on test wafers but could also be done automatically based on product measurements.
Example for R2R: Poly CD (Gate Length)

<table>
<thead>
<tr>
<th>Without R2R-Control</th>
<th>Controlled with R2R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process 1</td>
<td>Process 2</td>
</tr>
<tr>
<td>(61% decrease of sigma with R2R)</td>
<td>(87% decrease of sigma with R2R)</td>
</tr>
<tr>
<td>( \sigma = 0.030 )</td>
<td>( \sigma = 0.077 )</td>
</tr>
<tr>
<td>( \sigma = 0.012 )</td>
<td>( \sigma = 0.010 )</td>
</tr>
</tbody>
</table>

Example for R2R: Poly CD (Gate Length)
Today: Several analysis tools that cover the applications and requirements
Tomorrow: Data of various measurements from wafer start up to final test in one analysis tool
Example: Correlation PCM vs Functional Test Parameter
Example: Tracing of a combination of different identities
FDC
- Successfully implemented in 150mm & 200mm fab on most tool types
- Benefits proven in respect to cost, throughput and quality

R2R
- Implementation started in the litho area for 200mm.
- Significant reduction in variation achieved for critical CDs

EDA
- System running, Roll-Out started September 2013
- Faster Analysis capability already demonstrated

Learning:
- Control of tools and processes, even elder ones can be improved
- All applications need experts to come from data to useful information
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Smart automation in a running Fab

Connection of virtual World and real Word

Cyber-system in virtual world

Who am I?

What to do next?
Which recipe to load?

MES

MTS

RTD

Who is next?
Pull-principle

Where to go?

Physical products in real world
Fully automated FSI-bay:
Extension of Automation in Lithographie and Implant

Transport belt
Machine loading with Helping-Robot (HeRo)
I/O-port

Ramp up of automated production in E2013
Summary

- The consequent use of IT-Tools in Waferfabs can considerably increase the quality and cost effectiveness. But the value ad of such IT Tools becomes only reality if experts transform the data consequently into useful information.

- Smart automation is a cost effective approach to increase the productivity and OEE in a running Waferfab.
Thank you for your attention!!!