IoT for SECS and Non-SECS Equipment in Semiconductor Backend Manufacturing

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Company Information
Infineon at a glance

Business Segments

- Automotive (ATV): 41%
- Industrial Power Control (IPC): 17%
- Power Management & Multimarket (PMM): 31%
- Chip Card & Security (CCS): 11%

Employees

More than **36,000** employees worldwide (as of Sep. 2016)

- Europe: 15,176 employees
- Americas: 3,691 employees
- Asia/Pacific: 17,432 employees

- 34 R&D locations
- 19 manufacturing locations

Financials

<table>
<thead>
<tr>
<th></th>
<th>Revenue FY 2016</th>
<th>Segment Result</th>
<th>Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 13</td>
<td>3,843 (EUR m)</td>
<td>9.8%</td>
<td>377</td>
</tr>
<tr>
<td>FY 14</td>
<td>4,320 (EUR m)</td>
<td>14.4%</td>
<td>620</td>
</tr>
<tr>
<td>FY 15</td>
<td>5,795 (EUR m)</td>
<td>15.5%</td>
<td>897</td>
</tr>
<tr>
<td>FY 16</td>
<td>6,473 (EUR m)</td>
<td>15.2%</td>
<td>982</td>
</tr>
</tbody>
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Market Position

- **Automotive**: #2
  - Strategy Analytics, April 2017
- **Power**: #1
  - IHS Markit, Technology Group, October 2016
- **Smart card ICs**: #1
  - IHS Markit, Technology Group, July 2017

As of Sep. 2016, more than **36,000** employees worldwide, with **15,176** employees in Europe, **3,691** employees in the Americas, and **17,432** employees in Asia/Pacific.
Worldwide manufacturing sites: frontend and backend

Status: 30 September 2016

Frontend
Backend

Morgan Hill
San Jose
Leominster
Newport
Dresden
Kulim
Beijing
Wuxi
Cheonan
Singapore
Mesa
Temecula
Warstein
Regensburg
Villach
Cegléd
Malacca
Batam

SEMICON EUROPA

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GERMANY
Industry Revolution and Status in Backend
Industrie 4.0

A 'collective term for technologies and concepts of value chain organization' which draws together Cyber-Physical Systems, the Internet of Things and the Internet of Services to enable 4th generation of industrial revolution.

- **Industrie 1.0**
  With steam power from the agrarian to the industrial society

- **Industrie 2.0**
  Using electric power for assembly line and mass production

- **Industrie 3.0**
  Computerization of production

- **Industrie 4.0**
  Intelligent networking of humans, machines and products

Degree of Complexity
Challenges in Backend for IoT
Challenges in Backend Manufacturing

Old and new hardware and interface; non-integrated environment; old and new standards; manual process!
IoT Drives Data and Control Transformation

Main Challenges:
- Robustness
- Wide-ranging of data and control
- Scalability
- Technology

Integration Levels

Non Real-time MES

Paper Based / Manual Recording

Semi Real-time MES

Barcode Reader

Real-time MES, EAF, PCS

Equipment <-> Applications

People <-> Process

Real-time MES, EAF, PCS

IoT, Big Data

Seamless, Connected Info.

Mobile device as active media to connect Information and Things in MFG

Data Trend
Smart Factory @ Singapore
Smart Factory @ Infineon Singapore

**Vision**

- To be **Fast & Agile Manufacturing** with **Smart solutions** through **IoT**, **Automation**, **Big Data**, and **Skills Future**

- To be the **Benchmark Site** to pioneer **innovative Final Test solutions** for deployment to other **Backend sites**
Control @ Manufacturing – 4 Control Layers

Data Analytics
Intelligent analysis to optimise operations

Control Tower
Production overview and control for fast response

Scheduling & Planning
Real-time end-to-end planning and control

Execution Automation
Execution automation & control

IoT (Mobility & Connectivity)
Connecting 4M for data and control

Control @ MFG
Maximise automation and networked information to optimise decision making and full execution control over end-to-end production value network

Operation scenarios control in FAB (MES, FAS, EAS, PCS, Deviation ..)

Comprehensive & robust connectivity to 4M (man, machine, material, method)

Operation Intelligence (planning & reporting)

Automated scheduling, dispatching, reporting

Automated EA job, FA job, process violation control

TOS BE, EAF (machine, robotic, sensor, device, AHHS, reader, UI)

Close Loop Control

Prediction (analytical)

Intelligent analysis tool

Enabler

Control Layer
Integration Framework Solution
Integration Solution

Challenges in Backend Manufacturing

Old and new hardware and interface; non-integrated environment; old and new standards; manual process!
Integration Solution

Requirements and Challenges summarized - the Technical View:

- Flexibility to integrate smallest up to highly complex “data providers and consumers” – simple sensors like IoT devices and complex multimillion Euro production equipment
- Flexibility to use wide range of interfaces, including new interfaces developed in the future
- Suitable for Frontend Fabs and Backend Fabs in the same way
- Handling of near-equipment operational scenarios – validation, control, and data processing
- Collection and handling of wide-range data in “real-time” and support for manual production, semi-automation and full automation
- High availability and robustness
- Configuration, Control and Monitoring of from a handful up to thousands of equipment instances / connections
- Support of small production island setup up to cross-factory scale
- …
Integration Solution

Fundamental Question: Hardware Box or Software Solution? And how?

We decided for the Software Solution as generic Framework…

… to meet the requirements. Reasons:

• Generic and flexible integration framework
• Combination of advantages of centralized and decentralized approach
• Fast and affordable development and enhancement possibilities
• Out-of-the-box support of various communication standards through libraries
• Unified automation interface(s) from Factory Automation perspective
• Expandability and customizing over pluggable software modules and configurable event handling
• Extensive management features

...
Generic IoT Framework

Multiple Consumers
Factory Automation

Execution System

Equipment Automation Framework

MES
RMS
SPC / APC
Equipment Monitoring
Wafer Mapping
Strip Mapping

TIBCO

Equipment Communication

Kernel

Factory Logic (Operation Scenarios)

SEMI

Equipment Logic (Equipment Type Automation Scenarios)

Context Store

Equipment Dictionary

SECS, Non SECS
FTP, File

SECS, Non SECS
SECS, Non SECS

I/O

SECS

TCP/IP

Controllers,
Sensors

Multiple Interfaces

Extendable Architecture

Assembly Equipment
Test Cell Equipment
MSP Equipment
ASRS
Transport System

I/O Device EST-PT2

SECS

TCP/IP

Controllers,
Sensors

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Equipment Connectivity and Benefits
Equipment Connectivity Growth and Benefits

**Integrated functionalities**

**SECS equipment:**
- Normal GEM capabilities

**Non-SECS equipment:**
- Test result collection
- Inspection result collection
- Transfer test parameters to start process
- Recipe file transfer
- Remote tool-stop

**Benefits**

- Real-time and non real-time control
  - Paperless manufacturing – seamless data collection
  - MES – data validation at transaction
  - SPC – post process parameters control
  - APC – in process parameters control
  - Recipe Management – input control
  - OEE – equipment performance tracking
  - Remote tool-stop – violation control
Connectivity Roadmap to Realize IoT

Load and Go Automation
Applications
- MES auto WIP track-in/out
- Job Management

Tool & Recipe Control
Applications
- Recipe management
- Marking management
- Equipment remote stop
- Mapping management
- Machine parameters

Process & Violations Control
Applications
- Input parameters control
- SPC metrology data
- APC for real parameters

OEE Management
Applications
- EQ performance management
- Alarm management

Engineering Data Collection
Applications
- MES paperless recording
- Sensor integration for APC

Real-time SPC/APC Control
Real-time Tool Control
Real-time Data Collection
Level 1
Hardware Integration
Level 2
Other Interface
Level 3
SECS/GEM Interface
Real-time Job Control

Lesson Learned and Summary
Summary

• Lesson Learned
  – To realize IoT for legacy and standard interfaces with combination of old and new world, approach of using generic connectivity framework (software) can be more practical and cost effective.
  – Collaboration with other industry associations to combine the strengths.
  – Connectivity is first and fundamental step of Smart Manufacturing to fulfil the ultimate goal: harvesting the data with advanced data analytic and closed-loop control.
  – Adopting of SEMI SECS/GEM in Backend Test, particularly Tester is still far from expectation as compare to Backend Assembly. The capability need to be escalated for higher integration and automation, for e.g. integrated scanner; integrated sensor; equipment and process parameters; readable recipe etc. and finally load-and-go.
Summary

• Moving Forward for Smart Manufacturing (expectations)
  – What SEMI could further do?
    • Continue to promote SECS/GEM, EDA, RaP etc. standards
  – What equipment vendor could do?
    • Adoption of industry standards i.e. SEMI, OPC etc. as part of the equipment capability
  – What software solution provider and integrator could do?
    • Adoption of interface standards in the integration solution framework
  – What semiconductor manufacturer could do?
    • Connect and harvest

⇒ SEMI–OEM–Software–Manufacturer forming an effective IoT ecosystem
Internet of Things (IoT)
Connects Tomorrow’s Manufacturing.