Joep Stokkermans
Nexperia

Smart Manufacturing: the organization towards organism
Smart Manufacturing & Maintenance

“The organization towards organism”

Joep Stokkermans
Innovation Manager
Nexperia Industrial Technology & Engineering Center
Introducing

Nexperia is a dedicated global leader in Discretes, Logic and MOSFETs devices. We became independent at the beginning of 2017.
A new force in Discretes, Logic & MOSFETs

With a long history, broad experience and a global customer base.

Key Facts

- A dedicated company for Discretes, Logic and MOSFETs with leadership positions in all product areas
- Over 1.1 billion US$ revenues (2016)
- More than 12% market share
- High volume production of 85 billion units annually
- 11,000 Employees supporting customers globally
- 2 own frontend, 3 own backend manufacturing sites
- Over 60 years of expertise in semiconductors, the former Standard Products division of NXP
- Headquarters in Nijmegen, The Netherlands
- CEO: Frans Scheper, heading a successful and established leadership team
Nexperia: high-volume for low-cost

- Nexperia manufactures and sells 85 billion of standard products each year: Diodes, transistors, logic, zener, regulator, picogate products

- Extremely cost driven market, continuous price erosion
- Assembly costs are ~75% of total for Discretes products
ITEC Brief

- ITEC established in 1991, >25 year semiconductor equipment development experience
- >80 employees: Service & Supply in Asia, R&D in Europe
- Strong flex base with technology partners in Netherlands high-tech equipment development region
- Installed base >2300 systems providing 60-70Bpc products/year
- >3500 tools connected to AWACS Factory Automation

Hong Kong office  Netherlands office

nexperia
ITEC VISION

ITEC delivers the world’s most competitive solutions for high volume, low cost manufacturing

- ITEC fuels Nexperia’s business success by maximizing quality output at lowest cost per unit, and leading the path towards smart manufacturing

- ITEC grows its partnership with NXP as a trusted solutions provider for cutting edge technology

- ITEC develops people to be experts and leaders in a global high-tech environment coupled to tangible business results
# ITEC benchmark solutions

For Best in Class semiconductor manufacturing

<table>
<thead>
<tr>
<th>ADAT3 Assembly Platform</th>
<th>Parset Test platforms</th>
<th>Inspection Platforms</th>
<th>Smart Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
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</table>
| - Lowest Cost of Ownership  
  - Process Portability  
  - Thinner wafers  
  - Flip Chip iso wires  
  - Placement accuracy  
  - 360° optical inspections  
  - Predictive Maintenance  
  - Versatility/ flexibility  | - Lowest Cost of Ownership  
  - Multi-site testing  
  - Higher pincount  
  - Integrated digital / analogue functions  
  - Test Platform consolidation/ wide Test coverage  | - Lowest Cost of Ownership  
  - Higher Resolving power  
  - 3D imaging  
  - Infrared inspections  
  - Integration in IT infrastructure for traceability  | - Full die level traceability  
  - Big Data analytics  
  - Data fusion  
  - Autonomous loops/ Machine learning  |
| **Leading in high volume Small Die Pick & Place** | | **Best-In-Class Mold Defect and In-Tape Inspections** | **Leading in Industry 4.0 for mass production** |
# ITEC Core Competences

OEM Technology Platforms- 8 University Coop Projects in The Netherlands and Hong Kong

<table>
<thead>
<tr>
<th>Design &amp; control</th>
<th>Motion Control</th>
<th>Mechatronics Robotics</th>
<th>Precision Mechanisms</th>
<th>Additive Manufacturing</th>
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</thead>
<tbody>
<tr>
<td>Imaging</td>
<td>High Resolution Imaging</td>
<td>Compressed sensing</td>
<td>Opto-mechatronics Adaptive optics</td>
<td>3D measurement Structured light</td>
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<tr>
<td>Data Intelligence</td>
<td>Connectivity Sensors</td>
<td>Signal Processing</td>
<td>Data Science</td>
<td>Autonomous Systems Learning</td>
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<td>Process Technology</td>
<td>Materials</td>
<td>Interconnect Technology</td>
<td>Multi-Physics Simulation</td>
<td>Virtual Prototyping</td>
</tr>
</tbody>
</table>
State-of-the-smart in Nexperia
Why Smart Manufacturing?

If you can’t **SEE** it... you can’t **MEASURE** it.
   If you can’t **MEASURE** it... you can’t **MANAGE** it.
      If you can’t **MANAGE** it... you can’t **CONTROL** it.

If you can’t **CONTROL** it... you can’t **IMPROVE**.

- Peter Drucker
Nexperia production lines in Guangdong (China)
15 components of the smart factory of the future

1. Smart Supply network
   - Transparency over supplier inventories and vehicle logistics allows for automatic and optimized supply decisions

2. Next-gen manufacturing systems
   - Manufacturing systems make automated and smart decisions (e.g., production scheduling), offer intelligent machine applications, seamless engineering integration and allow for remote visualization, monitoring, control, and alerts

3. Cloud storage/processing
   - Data storage and application processing on secure cloud servers

4. Data analytics
   - Advanced decision algorithms & real-time analytics

5. Cybersecurity
   - Encrypted data and protection mechanisms against cyber threats

6. Intellig. sensors/actors
   - Sensors deeply integrated in machines wirelessly stream data and have an own analytics engine (edge analytics)

7. Cyber physical systems
   - Interconnected systems and social machines control physical entities

8. Smart maintenance
   - Machine maintenance becomes integrated (autonomous) aided by predictive algorithms and remote assistance systems

9. Mobile workforce
   - Workers are equipped with mobile devices and augmented reality devices to process real-time information

10. Self-driving vehicles
    - Material is handled via autonomous vehicles and intelligent transportation units

11. Intelligent products
    - Products carry relevant information for machines to make decisions

12. Additive manufacturing
    - 3D printing allows for rapid prototyping and rapid spare part printing

13. Robotics
    - Use of flexible robots augments intelligence, automates certain processes and creates new forms of worker-robot interaction

14. Advanced materials
    - New materials such as nano-materials as well as integrated computational materials engineering (ICME)

15. Responsive manufacturing
    - Individual manufacturing steps are designed for customer interaction so that products can be tailored-made for customers

NEXPERIA Factory Automation – Portfolio Smart Manufacturing

SENSE

3. E-map info
6. Test data
6,7. AOI data

THINK

3. Data fusion

ACT

2. Traceability
4. Screening/ auto Lot on Hold
2. Bottleneck identification
2. Auto Batch Scheduling

...

4,8. Predictive maintenance
1,8. Spare part supply

Nexperia portfolio
Plan

Nexperia portfolio
Plan

Connectivity

quality

6

Equipment data

productivity

2

OEE/ uptime

planning

8

maintenance info

12

lot tracking
Bottleneck detection (BIM)

Automatic Bottleneck Identification

- Loss % estimation, pareto, ...
- Recommendation on solution, repair time, ...
- HeadsApp to responsible supervisor

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<th>Count</th>
<th>Minutes</th>
<th>Error description</th>
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<td>20.26</td>
<td>Sequential PRS skipcount exceeded</td>
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<tr>
<td>40-144</td>
<td>36</td>
<td>6.76</td>
<td>Total PRS skipcount exceeded</td>
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<tr>
<td>40-108</td>
<td>1</td>
<td>2.18</td>
<td>Spark not completed</td>
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<tr>
<td>40-206</td>
<td>4</td>
<td>1.96</td>
<td>Die found outside ROI</td>
</tr>
<tr>
<td>40-51</td>
<td>1</td>
<td>1.22</td>
<td>Z-motor not ready</td>
</tr>
</tbody>
</table>
Predictive Maintenance

Maintenance now in use
• These routine are sub-optimal. Most parts are fixed too early or too late.

Predictive maintenance
• Increase of reliability by monitoring the condition of the equipment/module/part
• Predict errors & cost focused: “right part at the right time” info from machines needed in a central place (AWACS)
• Reduce cost & Increase quality
Auto-batch animation

Genetic algorithm at work

Demo:
- 423 orders
- 52 machines
- 292 kind of products
- 15 different settings per order
- 10 days planning window

Fitness

\[ \text{Fitness} = \alpha \times \text{Setup times} + \beta \times \text{Process times} + \gamma \times \text{Lateness} \]

Goal is to minimize the fitness
From organisation towards organism

THE HEALTH SENSORS YOU BUILT INTO OUR SMART WATCH PROTOTYPE AREN’T WORKING.

ACCORDING TO YOUR STUPID SENSORS, MY HEART IS GOING TO STOP BEATING IN...

YAY ME!
Organizations transform to organisms

What will change over the next decade?

• Organism
  • “A system or organization consisting of interdependent parts, compared to a living being”
• Industry 4.0 enables self-organization of manufacturing systems
• In the end, “knowledge rules” are embedded in systems and reside in the factory “sub-conscious”

People take decisions, manage and optimize processes

Computers take decisions, manage and optimize processes
SNAP - Smart Network for optimal Planning

What is SNAP about

- Dedicated Program to Automate, Integrate and Optimize the planning processes of Nexperia BE Operations. It is a collaboration initiative of Nexperia Discretes Planning and SCM Hamburg, ITEC and the Eindhoven University of Technology.

- The ambition of SNAP is to realize a blueprint of a best-in-class Smart Manufacturing Network that provides the most fit Manufacturing and Maintenance schedules for the Nexperia factories.

- SNAP will deliver autonomous dynamic scheduling mechanisms to interlink, control and optimize manufacturing and maintenance scheduling loops. Real-time state information of production lots and equipment is collected by AWACS and used as feedback signals.
SNAP

Questions and challenges to the Academics and Institutes

• Future steps

  1. Convergence of IT systems and machine automation into manufacturing networks

  2. Computer Learning for manufacturing networks

  3. Quantum computing: tackle complexity by increased computing power
SNAP

Equipment integration in the manufacturing network
Objective

Total time

Operations time

Downtime

- Maintenance delay
- Repair time
- Change of consumables
- Out of spec input
- Facilities related

Non-scheduled time

- Unworked shifts
- Installation, modification
- Off-line training
- Shutdown/startup

Uptime

Engineering time

- Process experiments
- Equipment experiments
- Software qualification

Manufacturing time

Productive time

- Regular production
- Work for 3rd parties
- Engineering runs
- Rework
- Scrap

Standby time

- No operator
- No product
- No support tool
- Module down

Objective

Productive time

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( SEMI E79) Availability efficiency = \frac{\text{uptime}}{\text{total time}}
Computer learning for manufacturing networks
What algorithms do we need in learning to “play manufacturing?”

• AlphaGo time-line
  • May 2015: 5-0 victory over European Champion Mr. Fan Hui
  • March 2016: 4-1 victory over World Champion Mr. Lee Seedol
  • October 2017: 100-1 starting from random play, AlphaGo Zero beat its predecessors in 3 days.

3 hours
AlphaGo Zero plays like a human beginner, forgoing long term strategy to focus on greedily capturing as many stones as possible.

19 hours
AlphaGo Zero has learnt the fundamentals of more advanced Go strategies such as life-and-death, influence and territory.

70 hours
AlphaGo Zero plays at super-human level. The game is disciplined and involves multiple challenges across the board.
What can Quantum computing bring?

Quantum computing: tackle complexity by increased computing power

- A quantum computer behaves as a very powerful parallel processor
- N qubits have the computing power of $2^N$ classic bits.
- Quantum supremacy at $N = 50$
Quantum computing impact on engineering
What do experts tell us?

• Microsoft
  • “Quantum computing could solve problems that would take today’s computers eons in the time it takes to grab a cup of coffee.”

• IBM
  • Medicine & Materials:
    Untangling the complexity of molecular and chemical interactions leading to the discovery of new medicines and materials
  • Supply Chain & Logistics
    Finding the best solutions of ultra-efficient logistics and global supply chains
  • Artificial Intelligence
    More powerful machine learning when data sets are very large

• Google
  • Quantum Supremacy could be months away...
Questions and answers

• Thank you for your attention

Acknowledgement:
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TU/e Industrial Engineering & Innovation Sciences

Rick van den Dobbelsteen, Jelle Adan
Nexperia Industrial Engineering & Technology Center
EFFICIENCY WINS.
Conservative manufacturing meets fast-paced IT

The industrial internet promises a complete convergence of IT systems and machine automation

IoT Analytics – Quantifying the connected world

Convergence of IT and automation

<table>
<thead>
<tr>
<th>1970s</th>
<th>1980/90s</th>
<th>2000s</th>
<th>Today</th>
<th>future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainframe</td>
<td>ERP</td>
<td>Internet, ERP modules, MES, etc.</td>
<td>Integrated architecture</td>
<td>S-layer architecture</td>
</tr>
<tr>
<td>Information technology</td>
<td>Industrial automation</td>
<td>Fieldbus protocols, TCP/IP</td>
<td>Robotic</td>
<td>PLC</td>
</tr>
<tr>
<td>Direct digital control</td>
<td>Remote I/O</td>
<td>Logical Controller</td>
<td>( \text{nternet of Things} )</td>
<td></td>
</tr>
</tbody>
</table>

ERP = Enterprise Resource Planning  MES = Manufacturing Execution System  SCADA = Supervisory Control and Data Acquisition  PLC = Programmable Logic Controller  I/O = Input/Output signals  Source: IoT Analytics