Trends in Nano/Micro Technologies

Panelists:

Christian Woegerer, Profactor GmbH, Austria
Leo Schranzhofer, Profactor GmbH, Austria
Adrien Brunet, Karlsruhe Institute of Technology, Germany
Timm Bostelmann, University of Applied Sciences, Germany

Moderator:

Victor Ovchinnikov, Aalto University, Finland
Primary trends

- Patterning methods
  - X-ray
  - Multipatterning
  - Nanoimprint

- Functional and technological materials
  - 2D materials: graphene, MoS$_2$
  - Quantified doping

- Device design
  - FinFET
  - FPGA

- Device simulation
  - Prediction of functional properties
  - Process step simulation
Secondary trends

- **Science development**
  - Cryogenics
  - Quantum technologies

- **Micrometrology**
  - AFM
  - Near-field microscopy

- **Process equipment**
  - PC control
  - Robotics

- **Social effect – economics, health, environment …**
  - Is life possible without PC and mobile phones?
  - Tomography
Panel subtopics

- Nano - hype is over?
  *Christian Wögerer*

- Nano safety and the potential risks of using nanomaterials
  *Leo Schranzhofer*

- How much heterogeneity a universal FPGA can cope with and how application-domain-specific optimizations might change the game
  *Timm Bostelmann*

- Priorities on Advanced Manufacturing of Multi-Material Multi-functional Products. The conclusions of the 4M experts toward 2020
  *Adrien Brunet*
Major output

- Panelists should be from different universities or companies. In our case, two persons were from Profactor GmbH.

- Panelists should have a list of questions to audience (home task) to facilitate discussion.
LEADING INNOVATIONS

CENICS 2016
28.7.2016 – Nice
Christian Wögerer
Trends in Nano/Micro Technologies

Thesis:

• Nano - hype is over and promised too much
• Integration of products of our daily live is sometimes successful realized
• To less attention on Manufacturing and Integration from the beginning
• Nano is only an “enabler” for micro products

Roadmap Overview

VC1 - Lightweight multifunctional materials and sustainable composites
- Transportation
- Packaging
- Energy
- Construction and buildings
  - Textile and sport sector
  - ICT

VC2 - Nano-enabled surfaces for multi-sectorial applications
- Plasma and Vacuum Engineered Surfaces
- Wet Engineered Surfaces

VC3 Structured Surfaces
- Construction and buildings
- ICT (Nanoelectronics, photonics, sensors)
- Transportation
  - Textile and passive funct.
  - Energy (PV batteries, harvesting)
  - Medicine (Bio-sensors, Lab on a Chip, regen. medicine)

VC4 Alloys Ceramics, Intermetallics
- Energy Harvesting & Conversion
- ICT Functional Packaging

VC5 Functional Fluids
- Construction and building
- Transportation
  - ICT (Thermal & Electrical Management)
  - Medicine & Pharma

VC6 Integration of nano
- Direct manufacturing
- Finished net shaped
- 3D structures for nanoelectronics & photonics
- Catalysis and filtration
  - Semi finished

VC7 Infrastructure for Multiscale Modelling and Testing
- Complex Adaptive Systems for complete product design

Cross Sectorial Non-Technological Actions
## From Nano to Production – Pilot Lines in 2017

The Value Chains are:
- **VC1** - Nano and micro printing for industrial manufacturing
- **VC2** - Nano-enabled, depollutant and self-cleaning surfaces
- **VC3** - Manufacturing of powders made of functional alloys, ceramics and intermetallics
- **VC4** - Lightweight multifunctional materials and composites for transportation

<table>
<thead>
<tr>
<th>Pilot Line ID</th>
<th>Title of the Pilot Line</th>
<th>Value Chain</th>
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| Pilot Line | Nanostructured surfaces and nanocoatings, divided into:  
- Pilot 1a: Nanostructured antimicrobial, antiviral surfaces for medical devices, hospitals, etc.  
- Pilot 1b: Nanocoatings for mechanically enhanced surfaces | VC2 |
| Pilot Line 2 | Manufacturing of lightweight multifunctional materials with nano-enabled customised thermal/electrical conductivity properties | VC4 |
| Pilot Line 3 | Printed microfluidic MEMS and biological applications divided into:  
- Pilot 3a: Nozzles, filters, sensor applications and multi-use chip  
- Pilot 3b: Bio-medical/bio-physicals sensors, actuators and other devices | VC1 |
| Pilot Line 4 | Non mainstream Micro-Electro-Mechanical Systems and Architectures related to:  
- Pilot 4a: Advanced CMOS compatible digital fabrication  
- Pilot 4b: Cheap flexible hybrid or full polymer MEMS ecosystems | VC1 |
Trends in Nano/Micro Technologies

Trends from my view:

• Additive Manufacturing of Micro/Nano based Products
  Freedom of Design, Flexibility of fabrication, Process integration and shortening the value chain

• Multi-material hybrid Products
  Nanotechnologie enables new Hybrid multi material products

• Highly customized Products on Small Lot sizes
  Miniaturized sensors in the micro range, flexible in design and material, from very large to small lot sizes
Trends in Nano/Micro Technologies

Some points to be discussed

• What are the drivers for this Trends? - How important is “Industry 4.0” for New Micro/Nano Trends? (CPS Cyber physical systems) – Cheap, simple and easy to manufacture sensors are needed? Industry 4.0 is more than Software

• Which role is Europe playing against US and Far East. What are the strength of Europe against his competitors?
Europe and APAC regions are projected to have the highest growth in this market in the upcoming years due to the extensive research and development activities under process in various universities and research centers in this sector.
Panel:
Trends in Nano/Micro Technologies

CENICS 2016
Adrien Brunet
What is 4M2020?

Coordinated Support Action

“Advanced Manufacturing of Multi-Material Multi-Functional Products Towards 2020 and Beyond”

Start date: 1st September 2013

End date: 31st August 2016

Our Vision: Promote and facilitate cross-fertilisation between advanced manufacturing platforms to create alliances based on interrelated research and product demonstration activities.
4M2020 roadmap

**Long Term (>2022)**
- In-line control & inspection solutions of novel materials for modular, updatable, reconfigurable and disassemblable products (RIA/TRL3-4)
- Multiscale and multiphysics modelling technologies for novel material systems and products performance and robustness (RIA/TRL3-4)

**Mid Term (2019-2022)**
- Integration of nano particles and aggregates into new and precise micro- and macro-engineering tooling and processes (RIA/TRL5-6)
- Pilot line for 3D-manufacturing, process, analytical and material interface control and modelling of products integrating hybrid and structured materials (IA/TRL6-7)
- Pilot lines for standardized manufacturing of hybrid and structured materials with customized properties (IA/TRL7-8)

**Short Term (2015-2018)**
- Pilot lines for standardized manufacturing of hybrid and structured materials with customized properties (IA/TRL7-8)
- Integration of novel multi-materials into modular, automated and reconfigurable production lines (IA/TRL5-6)
- Multi-materials, multi-scale and 3D-shape closed-loop control strategies for micro- and nano-manufacturing (RIA/TRL3-4)

**Tool**
- Modular, updatable and reconfigurable manufacturing solutions for micro/nano-enabled miniaturized products (RIA/TRL3-4)
High priority products

Customised health monitoring

In-line metrology

Micro-parts for wearable devices

Flexible screens

Fuel cell for electric cars

Energy efficient buildings

Micro-gas turbines and bearings

μ-connectors
Questions

- Would you agree with the conclusion of 4M2020?
- Why should we use nanoparticles?
- Why should we develop multimaterial devices?
Nano Safety
Nanosafety

- Ways into the body
  - Aerosols respirable
  - Penetration through skin
  - Uptake over digestion

- Mostly unknown hazardness of nanomaterials

- Large differences between bulk and nanomaterial
  - Large surface to volume ratio
  - Catalytically function of nanomaterials
  - Possible penetration through various tissue

- Detection of Nanomaterials
  - Usually cost and time consuming
Problem Solving

- Declaring clearly about the content
- Creating a certain awareness for users
- What can be done on acute contamination
- Avoiding formation of aerosols of smaller particles (below 500nm)
- Avoiding unnecessary use of nanoparticles in consumer goods (TiO2 in chocolate, etc.)
How much Heterogeneity can Universal FPGAs cope With and how Might Application-Domain-Specific Optimizations Change the Game?

Timm Bostelmann

FH Wedel
University of Applied Sciences

CENICS 2016
Observations

Observation I

Universal FPGAs get more and more heterogeneous.
- Versatile DSP-Blocks
- Various Memory-Blocks and Interfaces
- Sophisticated I/O-Cores
- Powerful Microcontrollers

Observation II

Many applications only use a small part of those special resources, if they use them at all.
## Implications

### Direct Implications

- Applications can benefit from special functions in reconfigurable logic.
- Different applications demand different functions.
- Low area-costs make function-overload possible.
- Efficiency is hampered by unused function-blocks.

### Indirect Implications

We might sacrifice universality in FPGAs and create application-domain-specific reconfigurable logic to...

1. remove unused special functions.  
   → increase the device-utilization
2. integrate even more special functions and routing structures.  
   → increase the speed and power-efficiency
Approach

Provide a designflow for the optimization of reconfigurable architectures.

1. Architecture Design Tool
2. HDL Implementation of the designed Architecture
3. Statistical Analysis of the Block Utilization
4. User Interaction
5. HDL Implementation of the given Applications
6. Synthesis and Technology Mapping
7. Placement, Routing and Timing-Analysis
8. Statistical Analysis of the Routing Utilization
What do you think?

1. Which of your applications are or could be accelerated by FPGAs?
2. Is heterogeneity in universal FPGAs really a problem?
3. Is it reasonable to optimize reconfigurable logic for application-domains?