Materials Science and Manufacturing:

Industry 4.0 and Integrated Manufacturing Systems

Peter Bosscha
Mechatronics and Micro Manufacturing
Focus Areas: Advanced Materials, Light Metals, Polymers and Composites, Nano Materials

**Focus 1: Light Metals**
- Focus on light metals research
- Beneficiation of abundant South African Mineral resources (Al, Ti)
- Design, develop, manufacture and test and metallic materials, mill products and components though powder metallurgy and casting processes.
- Provide tailor-made innovative solutions for Government and industry across the whole value chain of metal extraction to final manufactured products
- Partner and establish new industries through incubation and transfer of technologies to industrial partners
- Ensure effective and efficient delivery of quality services and products

**Focus 2: Composites and polymers**
- Focus on polymers and composite materials
- Design novel particles resulting in formulations with improved absorption properties and delivery systems, which find use in animal and human health applications.
- Making (bio)polymers which have varied degradation profiles for the packaging industry. Our non-woven facility enables us to manufacture various technical textiles which are tailor-made for the air and water filtration, insulation, and textile industries.
- Making versatile adsorbents for the treatment of water. The manufacturing processes that we develop are unique yet versatile in that they can be used for different application areas.
- Centre for testing in the textile, chemical, leather and footwear, and other specialised testing that is unique to us.

**Focus 3: Nano (National Centre)**
- Focus on Nano Materials
- NCNSM integrates diverse perspectives and expertise of nanoscience and nanotechnology into new knowledge, methods and products through a research programme focusing on polymer nanocomposites, sensing materials, water remediation and catalysis
- Provide expertise in our processing and characterization facilities that provide a competitive edge to industry by enabling scaling up and testing for new product development
Focus Areas:
Industry 4.0, Smart Manufacturing, Sensor systems

Focus 4 and 5: Advanced Manufacturing, Sensors, Mining, Medical solutions

Focus on development of custom sensor systems

This is done based on underlying SET capabilities in two technology platforms, namely electro-optics and ultrasonics and requires the addition of other capabilities either internally or through partnering.

Develop intelligent sensor systems that are connected into advanced information networks.

Focus on materials and integrated solutions for advanced micro-electronics e.g. lateral flow with focus on solutions for Medical, Mining and Mobility applications.

MMM seeks to deliver rapid, cost effective, intelligent solutions that are driven by digitalisation in industry processes through the integration of advanced manufacturing with software and hardware capabilities that provide solutions for health, mobility and mining.
Product Focus

**EM**
- Composite Gas Cylinders
- MOF-based products
- Fuel Cell Electrolysis
- Clean coal Technology
- Cathode for Lithium Ion Batteries
- Energy storage applications
- Battery Manufacturing

**LM**
- Ti CP grade Powder Products
- Ti6Al4V Alloy Powder (Grade 5) Products
- Investment Casting of Titanium products
- Press and Sintered Products
- Metal Injection Moulding Products
- Recycling of Aerospace Aluminum Swarf
- Fibre Metal Laminates for Vehicle Amour Protection
- Out-of-autoclave Composites
- Manufacture
- Industry Support: Selected products development and services

**P &C**
- Bio Plastics for Packaging
- Non Woven filter Bags for High Temperatures
- Drug Encapsulation
- Water Treatment
- Industry support-Testing

**NCNSM**
- Polymer Nanocomposites for Packaging
- Nano Clay Minerals for Cosmetics and Packaging
- Water Remediation

**SST**
- Guided Wave Ultra Sound in rails
- Multi Spectral Imaging systems
- Broadband underwater Data Transfer Technology
- Low Frequency Sonar Transducer
- Gunshot Detection System

**MMM**
- Future Factories-PLM
- Cloudnostics Health Systems
- Environmental Products
- Robotics in Agriculture
- Safety and Security Products
- Transportation systems
- Road Maintenance systems
- Mining Systems
- Printed Bio Sensors

**Example of Breathalyzer**
- PO_4^{3-}
- SO_4^{2-}
- Cr^{6+}
- NO_3^{-}
- F
- BPA
- COD

**Materials Research and Resource Beneficiation**

**Systems Solutions**
Focus on: Industry 4.0 and the Fourth Industrial Revolution

Source: Roland Berger
Main objectives of Industry 4.0

- 10 - 40% reduction of maintenance costs
- 20 - 50% reduction in time to market
- Forecasting accuracy increased to 85+% (9)
- Costs for quality reduced by 10 - 20% (8)
- Costs for inventory holding decreased by 20 - 50% (5)
- 30 - 50% reduction of total machine downtime (2)
- 45 - 55% increase of productivity in technical professions through automation of knowledge work (4)
Integrated Manufacturing Systems
Key Offerings: Industry 4.0

- Product Lifecycle Management (PLM) centre of technology
- Cyber Physical System Solutions (Product Development)
- Digital and Mechatronic Systems (Automation)
- Advanced/Smart micro sensors (Nano and Micro Manufacturing Facility)
- Learning Factory (Digital Twin & Simulations)
Industry Engagement: Approach

- I4.0 Roadmap
- Benchmarking
- Trend Analyses

- Industry 4.0
  - Assessment & Benchmarking

- Production Optimisation
- Production Efficiency

- Connectivity, Digitization, Human Centered Automation, Robotics

- Product Lifecycle Management
Technology Building Blocks

- Plant Simulations & Digital Twin
- IIoT gateway and Data Analytics
- Automation
- Integrated Sensors
- Machine Learning
- Augmented Reality
- Robotics
- Reverse Engineering
- Localization of Technologies
Industry 4.0
Product Lifecycle Management (PLM) center of technologies
CURRENT AREA: OUTSIDE
PLM important building block and enabler

The CSIR hosts a Product Lifecycle Management facility where we:

- Help you develop your product and people on our platform to experience the value of PLM.
- Provide advice and support on engineering and PLM.
- Provide training and practice-based knowledge transfer.

Bring your products and people to co-create knowledge-intensive products today and supplier development through PLM services in the cloud tomorrow.

www.csir.co.za
**Value Proposition of I4.0 PLM Center of Tech**

**Key Focus Areas:**
- Design
- Engineering Simulation
- Manufacturing Processes
- Planning and Scheduling
- Service, Maintenance and Support
- Integrated Logistics Services
- I4.0 Technology Support

**Advanced Manufacturing Hub, supporting Industry Transformation to I4.0**

**Services to Industry**
- Benchmark and Roadmaps
- Plant and Product Simulations and optimizations
- Industry Training and Internship Development and Placement
- Technology support in Manufacturing processes, automation and materials
- Access to Cloud services and hosted IoT services
- New product development support
- Digital Twin creation of product and plants
- Access to CSIR national and international networks
- Supply Chain support
- Demonstrators per sector, showing value

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Lloyd’s Register Quality Assurance (LRQA)

ISO 9001:2015
ISO 14001:2016
ISO 13485:2016
Practical Example

- Portfolio
- Product Management
- Development
- Support
- Project Management
Practical Example

Industrialization
### Toolbox Industrie 4.0

#### Products

<table>
<thead>
<tr>
<th>Integration of sensors / actuators</th>
<th>Communication / Connectivity</th>
<th>Functionalities for data storage and information exchange</th>
<th>Monitoring</th>
<th>Product-related IT services</th>
<th>Business models around the product</th>
</tr>
</thead>
<tbody>
<tr>
<td>No use of sensors/actuators</td>
<td>The product has no interfaces</td>
<td>No functionalities</td>
<td>No monitoring of the product</td>
<td>No services</td>
<td>Gaining profits from adding standardized products</td>
</tr>
<tr>
<td>+ Sensors/actuators are integrated</td>
<td>The product sends or receives I/O signals</td>
<td>Possibility of individual identification</td>
<td>Detection of failures</td>
<td>Services via online portals</td>
<td>Sales and consulting regarding the product</td>
</tr>
<tr>
<td>Sensor readings are processed by the product</td>
<td>The product has field bus interfaces</td>
<td>Product has passive data store</td>
<td>Recording of operating condition for diagnostic purposes</td>
<td>Service execution directly via the product</td>
<td>Sales, consulting and adoption of the product to meet customer specifications</td>
</tr>
<tr>
<td>Data is evaluated for analysis by the product</td>
<td>The product has industrial Ethernet interfaces</td>
<td>Data and information exchange as integral part</td>
<td>Prognosis of the functional condition</td>
<td>Independently performed services</td>
<td>Additional sale of product-related services</td>
</tr>
<tr>
<td>The product independently responds based on the gained data</td>
<td>The product has access to the Internet</td>
<td>Data processing in the production</td>
<td>Independently adopted control measures</td>
<td>Complete integration into an infrastructure of IT services</td>
<td>Sale of product functions</td>
</tr>
</tbody>
</table>

#### Production

<table>
<thead>
<tr>
<th>Data processing in the production</th>
<th>Machine-to-machine Communication (M2M)</th>
<th>Company-wide networking with the production</th>
<th>ICT infrastructure in production</th>
<th>Mon-machine interfaces</th>
<th>Efficiency with small batches</th>
</tr>
</thead>
<tbody>
<tr>
<td>No processing of data</td>
<td>No communication</td>
<td>No networking of production with other business units</td>
<td>Information exchange via satellite communication</td>
<td>No information exchange between user and machine</td>
<td>Rigid production systems and a small proportion of identical parts</td>
</tr>
<tr>
<td>Storage of data for documentation</td>
<td>Field bus interfaces</td>
<td>Information exchange via email/telecommunication</td>
<td>Central data servers in production</td>
<td>Use of local user interfaces</td>
<td>Use of flexible production systems and identical parts</td>
</tr>
<tr>
<td>Analyzing data for process monitoring</td>
<td>Industrial ethernet interfaces</td>
<td>Uniform data formats and rules for data exchange</td>
<td>Internet-based portals with data sharing</td>
<td>Centralized/decentralized production monitoring/control</td>
<td>Flexible production systems and modular designs for the products</td>
</tr>
<tr>
<td>Evaluation for process planning/control</td>
<td>I/machines have access to Internet</td>
<td>Uniform data formats and interdivisionally linked data servers</td>
<td>Automated information exchange e.g. order processing</td>
<td>Use of mobile user interfaces</td>
<td>Component-driven modular production of modular products within the company</td>
</tr>
<tr>
<td>Automatic process planning/control</td>
<td>Web services (M2M software)</td>
<td>Inter-divisional, fully networked IT solutions</td>
<td>Suppliers/customers are fully integrated into the process design</td>
<td>Augmented and assisted reality</td>
<td>Component-driven, modular production in value-adding networks</td>
</tr>
</tbody>
</table>

#### Machine-to-machine Communication (M2M)

- No communication
- Field bus interfaces
- Industrial ethernet interfaces
- I/machines have access to Internet
- Web services (M2M software)
Benefits to Industry

• Access to software while collaboration with PLM center of Technology (1-3 years), for both OEM **AND** their suppliers
  – Requirements management, CAD, CAM, Plant Simulation Software, service lifecycle management
  – Some software specialized and very expensive – Providing services to industry so they don’t have to purchase software
• Discounted cost for software after 3 years – based on your need we can give estimated costing
• Next steps
  – Create a case study for capital goods industry to act as a showcase for other members
PLANT SIMULATION

Need:
• Production Optimisation
• Logistics and Supply Chain Management
• Value Stream mapping

Key Interventions
• Building Digital Twin of Plant
• Live Simulation of Plant
• What if Scenarios?
• Cost Modeling
• Energy Management
MMM CASE STUDY: AEROSPACE

Company: (confidential)
Customers: Aerosud, Denel, Airbus

Need:
• Roadmap needed to prepare for I4.0 and increase market share in Aerospace industry local and global
• Automate and digitize internal processes
• Regulatory compliance to latest Aerospace standards

Key Interventions
• Technology roadmaps for company (completed)
• I4.0 and PLM Assessment
• Mapping and Digitization of key processes
• IoT architecture and sensor installations
• Development of automated quoting system
**MMM CASE STUDY: PHARMACY DISPENSING**

**Need**
- Localization of technology
- New functionality to handle sachets
- Lower costs and support
- Modular and scalable solution
- Platform that are adaptable for various scenarios
- Industry 4.0 ready – backwards integrates
Company: (confidential)
Customers: Health Sector

Need:
- Service and maintenance support for large amount of products in the field
- New innovative product development
- Regulatory compliance required for ISO 13 485
- Collaborative platform between operating divisions
- New plant design and commissioning
- Enterprise optimization

Key Interventions:
- New product development
- Plant simulation and optimization
- Regulatory requirements integrated into PLM
- Service Lifecycle Management systems for medical device
CSIR Learning Factory Concept

- Advanced robotics
- Sensors
- Vision systems
- IoT
- Additive manufacturing
- Micro-manufacturing
- Industrial analytics
- Cyber-security
- PLM
Thank you