Printed electronics pilot manufacturing environment

Create next generation electronic products today
Pilot factory for upscaling from prototypes to mass manufacturing and material, process, and product verification

Open access, roll-to-roll facilities with several pilot units

Located in Oulu, Finland

Recipient of the international Best Technical Development Manufacturing Awards
We offer

Scale-up from prototypes to mass manufacturing

Materials and components verification

Manufacturing methods testing, development, and pilot manufacturing

Production technology transfer
How we work

Come and test your technology, materials or components.

Find out the technical and economical feasibility as well as mass-manufacturability of a new technology, materials, components, and system products.

We provide you with an open access pilot facilities and professionals and help you in finding commercial value network for volume manufacturing.

We guarantee flexibility and full confidentiality - results are fully owned by the customer.
Wide range of R2R Pilot processes available

- Gravure (frw& rev) printing for patterned thin active material layers
- Flexo printing for thin patterned active material layers
- Screen printing for thicker conductive and insulator layers
- Slot-die coating for continuous material layers
- Lift-off for metal (Al, Ag, Au) patterning
- ITO and metal etching (Paste and wet) for patterning ITO, Al or Ag on PET/PEN
- Die cutting for holes and cuts
Wide range of R2R Pilot processes available

- Hot embossing for microfluidic channels and decorative optical features
- Lamination for barrier film encapsulation and for solvent lamination of microfluidic chips
- Evaporation for thin metal (Ag, Al, Ca) layers
- CO2 laser processing for holes, shapes and channels on plastics
- Electrical testing for resistance measurements of printed layers
- Component assembly for printed hybrid systems
- Injection over-molding for plastic 3D integration
VTT’s roll-to-roll pilot manufacturing environment

- R2R printing lines
- R2R evaporator
- Laser processing
- R2R pilot testing
- R2R pilot assembly
- R2R fed pilot injection over-moulding
Printed components process development and demonstrations

- Organic light emitting diodes, OLED
- Organic photovoltaics, OPV
- Microfluidics
- Etched metal electrodes
- Printed transistors
- Printed biobatteries
- Printed wide-area sensors
- Printed WORM memories

04/11/2015
Hybrid electronics and 3D plastic integration
process development and system demonstrations

- Assembly and bonding on flex process development
- Foil over-moulding process development
- Large-area LED luminaires
- Paper-based systems
- Wirelessly powered sensors
- Printed wide-area sensors systems
- Healthcare sensor systems
Price example – R2R screen printing trial

Printing: conductive silver ink (2 layers), UV-curable insulator, resistive carbon ink (4 layers)

Substrate: 600 m PET roll

OUTPUT: 1 000 pcs

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Materials</td>
<td>3 300 €</td>
</tr>
<tr>
<td>Tools</td>
<td>3 200 €</td>
</tr>
<tr>
<td>Facilities &amp; Personnel</td>
<td>4 600 €</td>
</tr>
<tr>
<td>Testing – Not included</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>11 100 €</strong></td>
</tr>
</tbody>
</table>
System design and prototyping for new product concepts

- Concept specification with customer
- System architecture and manufacturing process flow selection
- Manufacturability and testability design
- Prototype manufacturing & characterisation & testing
- Technical and economical feasibility analysis

Materials
- Science
- Component and material selection

Processes
- Industrialization
- Prototype simulations and design: Electrical, optical, mechanical, thermal, graphical and mould design
- Manufacturing process development
- Manufacturability analysis with design-of-experiments runs

Integration
- Design flow
- PILOT MANUFACTURING
- MARKET TRIALS
- STANDARDIZATION

Products
- Voice of customer
- Assessment of commercial production capabilities and value network
### R2R pilot customer case examples

1. **Organic Photovoltaic process development »**
   - eni

2. **Clean Card Pro printed diagnostics product development »**
   - Orion Diagnostica

3. **Verification of hard coating material R2R processability »**
   - Optitune

4. **Verification of new online topography measurement system »**
   - FocalSpec

5. **Technology transfer of hot-embossing process »**
   - Iscent

6. **Solutions for printed electronics measurement and control »**
   - AsahiKasei

7. **Micro contact printing (μCP) unit testing »**
   - MIROC
Printocent- Efficient ecosystem for Industrialization

- Design – Develop – Manufacture
- Industrial Cluster – Research - Education

Founding Members:
Printed electronics pilot manufacturing environment - Create next generation electronic products today

Thank you!
MAXI R2R pilot printing line for multilayer printing

Test bed for verification of new printing/coating units, microfluidics, on-line quality measurements, etc. Multi-layer printing on register

- Four replaceable printing unit slots
  - Forward and reverse gravure
  - Rotary silk screen
  - Flexography
  - Slot die coating
- R2R hot embossing & UV Imprinting
- Lamination
- Die cutting
- Automatic registration system
- Drying (air, UV)
- Plasma substrate treatment
- Max. web width 300mm
- Max. web velocity 30m/min
ROKO R2R pilot printing line for etching

For metal and ITO etching and lift-off processing
And flexible single-layer printing

- Replaceable printing units
  - Forward and reverse gravure
  - Rotary silk screen
  - Flexography
- Plasma (N2, Ar) substrate treatment unit
- Lamination unit
- Drying units (air, UV, IR)
- Max. web width 300mm
- Max. web velocity 10m/min
PICO R2R pilot printing line for high speed printing

- Two forward gravure printing units
- R2R hot embossing unit
- Corona substrate treatment unit
- Lamination unit
- Drying units (air, UV, IR)
- Manual registration system with control cameras
- Max. web width 250mm
- Max. web velocity 120m/min
- Installed in clean room (ISO7)
NICO inert-atmosphere R2R pilot printing line

Printing inks sensitive for oxygen and humidity
Encapsulation under inert gas

- Two replaceable printing unit slots
  - Forward gravure
  - Rotary silk screen
- Lamination (incl. hot) unit
- Drying units (IR)
- Oxygen level on line between 0.01 – 0.1%
- Max. web width 300mm
- Max. web velocity 20m/min
EKRA S2S Semiautomatic screen printer

For fast printing trials and demonstrators in sheets

- Print format max. 300 x 300 mm
- Print material thickness 0.1 – 20 mm
- Print speed 10 - 300 mm/s
- Alignment repeatability ± 12.5 μm @ 6 Sigma
EVA R2R evaporator

For production of thin conductive layers on web

- Metal thin film evaporation
  - Silver
  - Aluminium
  - Calcium
- Nitrogen atmosphere
- Max. web width 320mm
- Max. web velocity 2m/min
Laser processing for cutting, welding, drilling of plastic substrates

For cutting, welding, drilling of plastic substrates

- Laser sources
  - Nd:YAG (250 W and CW-Fiber)
  - CO2
- Max. width 300mm
TESLA R2R pilot testing machine

For functional testing of printed layers

- Continuous stop-and-go testing process
- Spring probe contact to the tested layer
- Resistance measurement (2-wire/4-wire)
- Range 10 mΩ to 10 MΩ ±0.5 %
- Up to 100 testing channels
- Max. web width 300mm
- Typical time 40 s/50 channels
EVO R2R pilot component assembly on flex

For assembling and bonding components of flex

- Continuous stop-and-go assembly process
- Flex, silicon and conventional SMD components
- Die attach, flip chip, multichip
  - Chip-size down to 100 µm, up to 100 mm
- Adhesives dispensing & stamping
  - ICA, ACA, NCA and flux dipping
- Adhesive curing by thermo-compression and UV
- Highest accuracy ± 10 µm @ 3 Sigma
- Die pick from wafer, waffle pack, gel pack
- Continuous web, sheet substrate, lead frame, wafer
- Individual process parameters for each interconnect
- Max. web width 200mm
- Max. web velocity case dependent
ENKELI- Functional foil over-moulding for structural integration

For hybrid in-mould integration to enable seamless integration of novel optical, electrical, and mechanical features into 3D plastic products.

ENGEL Victory:
- 2 injection units: Screws $\varnothing 40\text{mm} \& \varnothing 30\text{mm}$
- Clamping force 120 tn
- 2-shot moulding capability with rotation plate of 700mm
- Wide range of thermoplastics including special high-temperature grades
- Foil integration options:
  - In-Mould-Labeling (IML) by manual inserting.
  - In-Mould-Decoration (IMD) as transfer printing by a foil roll-to-roll feeder
Customer case examples
Case ENI – Development of roll-to-roll printed inverted organic solar cells

- ENI, Italian energy company actively making research and development on renewables conversion of solar energy.
- ENI is developing photovoltaic cells, modules and panels based on organic materials and or polymer to reduce the cost of producing electricity from solar.
- VTT is ENI’s research partner in developing fully roll-to-roll printed inverted organic solar cells based on ENI’s materials.
Orion Diagnostica and VTT jointly transferred old swabs and reagent bottles based hygiene monitoring system to a new-generation, fast and easy-to-use integrated test device which is produced by printing the reagents on a textile.

Clean Card® PRO is a new-generation hygiene test for monitoring the effectiveness of cleaning of surfaces which come into contact with food. The test detects protein residues, the presence of which indicates inadequate cleaning.

VTT acted as a partner in product development, ramp-up production, and technology transfer of the production process.
Case Optitune – Verification of the roll-to-roll processability of a new material

- Optitune offers revolutionary coating technology for cost-effective and environmentally friendly light management solutions for solar, touchscreen, electronics, and construction industries.
- Processability of Optitune's new hard-coating material has been verified in VTT's R2R environment.
Case Focalspec – New process control unit verification

- Focalspec has developed a new type of on-line topography measurement system for the monitoring and control of printed electronics production.
- The system is based on novel Lateral Chromatic Imaging technology.
- The first pilot system has been installed in the VTT MAXI R2R pilot line for gain practical information and experience on measurement needs for various types of materials, printed functionalities and processes.
Case Iscent – Production technology transfer

- VTT has been developing hot-embossing process for pilot machines with max 300 mm wide WEB for optical decorative features and microfluidics.
- VTT specified hot-embossing process and tooling for up-scaling from 300 mm to 1200 mm wide WEB and executed technology transfer to Iscent.
Case Asahi Kasei, Offcode and Coatema – New solutions for printed electronics measurement and control

- Together with VTT, Offcode has developed the ARCOS21 online system for registration and quality-measurements.
- VTT’s MAXI line has been used for testing and demonstrating the system’s capability to detect details in the range of 10um and registration accuracy close to 20um.
- Coatema, manufacturer of high-performance coating and laminating production lines utilises Offcode’s system in their new machines.
- Asahi Kasei’s high-accuracy gravure unit performance has been verified in MAXI line.
Case MIRDC – MAXI as test bench for new roll-to-roll processes, methods and units

- National Chung Cheng University (CCU) and Metal Industries Research and Development Centre (MIRDC) in Taiwan have been developing micro contact printing (μCP) method for high-precision printing.
- Their μCP unit was shipped from Taiwan, installed and tested in VTT’s MAXI line and shipped back to Taiwan.
Service offering and roll-to-roll pilot infrastructure

Best Technical Development Manufacturing Awards
Additional slides
## Comparison of printing processes

<table>
<thead>
<tr>
<th>Method</th>
<th>Recommendations &amp; notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravure (frw &amp; rev)</td>
<td>When thin (50 nm → 2 µm) layers of e.g. active material and high registration accuracy is needed. Higher starting costs and long delivery times with printing cylinders</td>
</tr>
<tr>
<td>Flexography</td>
<td>When thin (50 nm → 2 µm) layers of e.g. active material and not high registration accuracy needed. Cheaper tooling</td>
</tr>
<tr>
<td>Rotary screen</td>
<td>Recommended for conductor, insulator and passive printing due higher layer thickness 1-100 µm. Moderate tooling costs and lower printing speed 2-5 m/min</td>
</tr>
<tr>
<td>Inkjet</td>
<td>Recommended to biomaterial printing and special cases needing higher accuracy, flexibility and nano-particle inks. Nozzle clogging, low printing speed, substrate-dependences</td>
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<tr>
<td>Hot embossing</td>
<td>Microfluidics and optical features. In-house sleeve welding expertise</td>
</tr>
<tr>
<td>Reverse Offset</td>
<td>High resolution printing targeting for sub 5 µm line widths</td>
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TECHNOLOGY FOR BUSINESS