

Nanomanufacturing upscaling, integration and connecting to digital services

**NNN – A*Star Nanomanufacturing workshop
25-26 February Singapore
Antti Kemppainen**

Outline

1

Introduction

2

Nanomanufacturing

3

Printed and Hybrid Manufacturing

4

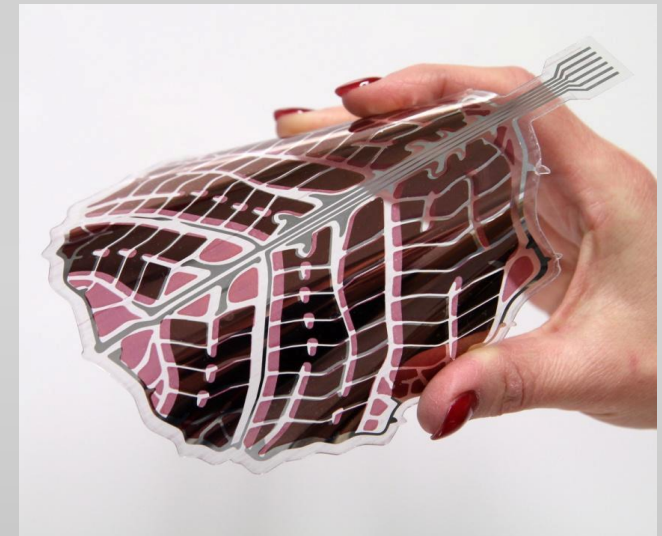
Case Examples

5

Digitalization

6

Conclusions



VTT - Multitechnological applied research organisation

Resources

- Turnover 277 M€ (2014 VTT Group), personnel 2,600 (2015 VTT Group)
- Unique research and testing infrastructure
- Wide national and international cooperation network

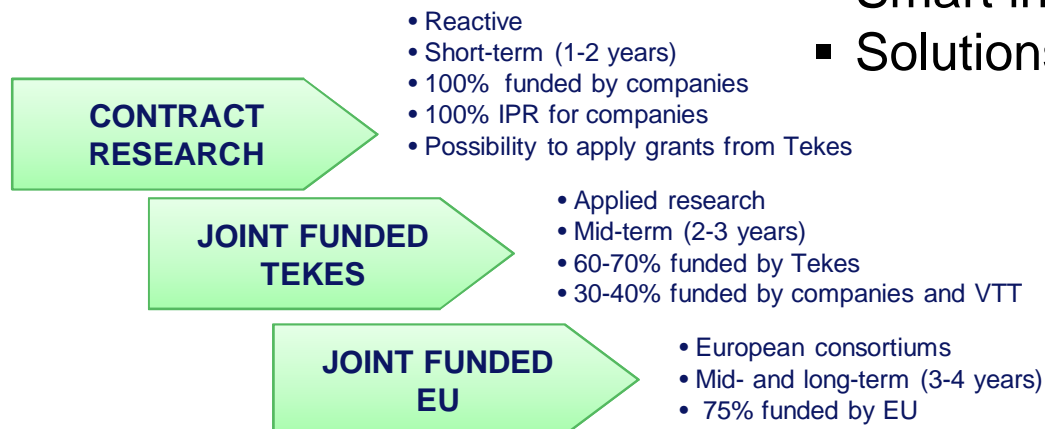
Services and the way of work

- Cross-disciplinary technological and business expertise
- A not-for-profit and impartial research centre
- Offers R&D and innovation services to companies globally

Business areas

- Knowledge intensive products and services
- Smart industry and energy systems
- Solutions for natural resources and environment

How to deal with us!



VTT Knowledge Intensive Products and Services

Technology for Solutions



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Case Examples in Health

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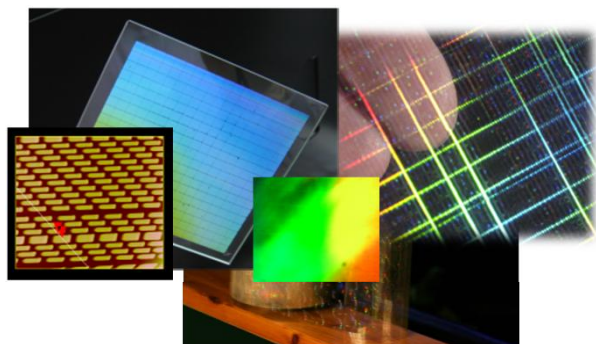
Conclusions



Nanoimprint Lithography (NIL) Applications

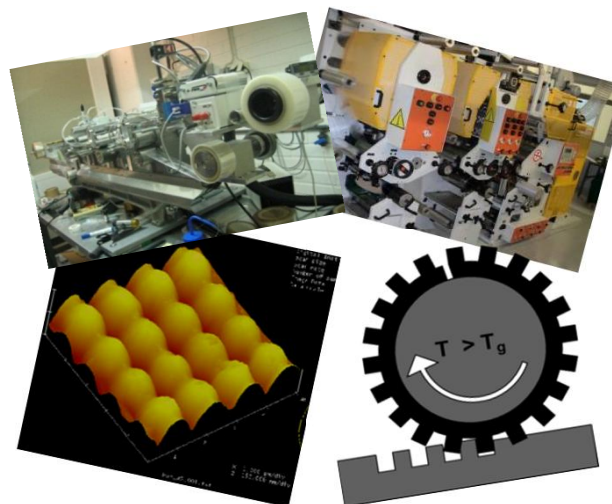
Optics

- ❖ Optical components, lenses, waveguides, holograms
 - ✓ Plastic, glass, high quality
 - ✓ R2R
- ❖ Light redirection surfaces (LDIR)
 - ✓ On glass or plastic
- ❖ Backlight/Frontlight
 - ✓ High quality, high transparency
 - ✓ R2R



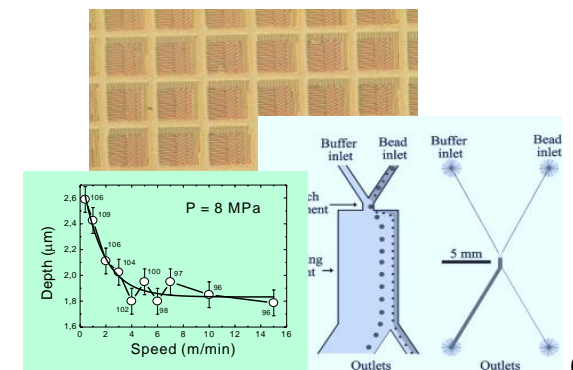
Surface modification

- ❖ Antiadhesion surfaces
 - ✓ Nanofeatures
 - ✓ Functional coatings
 - ✓ Surface properties
 - ✓ R2R
- ❖ Antireflection surfaces
 - ✓ High aspect ratio NIL structures
 - ✓ R2R



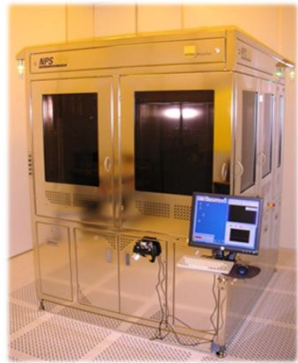
Electronics/Bio

- ❖ Electrical components, electrodes, TFT
 - ✓ R2R manufacturing
 - ✓ Flexibility, conductivity
 - ✓ Plastic, nanofiber, paper
- ❖ Electrically conductive transparent electrodes
 - ✓ R2R NIL and nanoink filling
 - ✓ Low cost, high volume
- ❖ Fluidic devices
 - ✓ R2R manufacturing



NIL process tools

NIL (planar tools)



NPS 300 (cleanroom)

- ✓ Stamp size up to 50 mm
- ✓ Substrate 200mm
- ✓ S&R, UV and Thermal
- ✓ Sub-20 nm

Obudcat Eitre 6

- ✓ UV NIL
- ✓ Sub-20 nm
- ✓ Substrate 200 mm



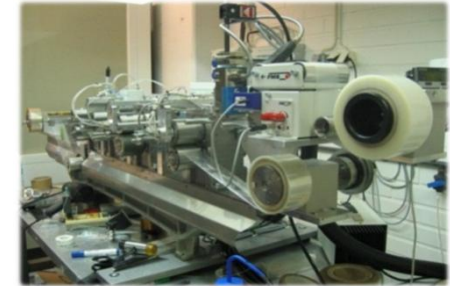
Madag P2000 hot press

- ✓ Temp up to 300 °C
- ✓ Max load 20 kN
- ✓ Substrate A4

NIL R2R tools

R2R Napa tool

- ✓ Web 50 mm
- ✓ 2 x NIL, 1 x coating
- ✓ Max temp 200 C
- ✓ Pressure 2510 N/cm
- ✓ Small master mold possible



PICO (cleanroom)

- ✓ Web 200 mm
- ✓ NIL, 2 x coating
- ✓ 100 m/min
- ✓ Sleeve mold



Maxi (cleanroom)

- ✓ Web 300 mm
- ✓ NIL, 4 x printing, lamination
- ✓ Sleeve mold
- ✓ Automatic registration



Roll to roll printed electronics today example: Organic PhotoVoltaics printing

<https://www.youtube.com/watch?v=sGbAVkkn9Os>



VTT Roll-to-roll pilot manufacturing environment



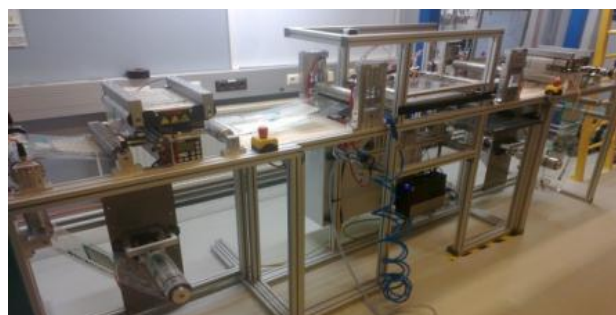
MAXI - In-air roll-to-roll pilot line



NICO - inert roll-to-roll pilot line



PICO - in-air roll-to-roll pilot line



TESLA - functional testing



ROKO - in-air roll-to-roll pilot line



ENGEL - Injection moulding



EVO - R2R assembly and bonding



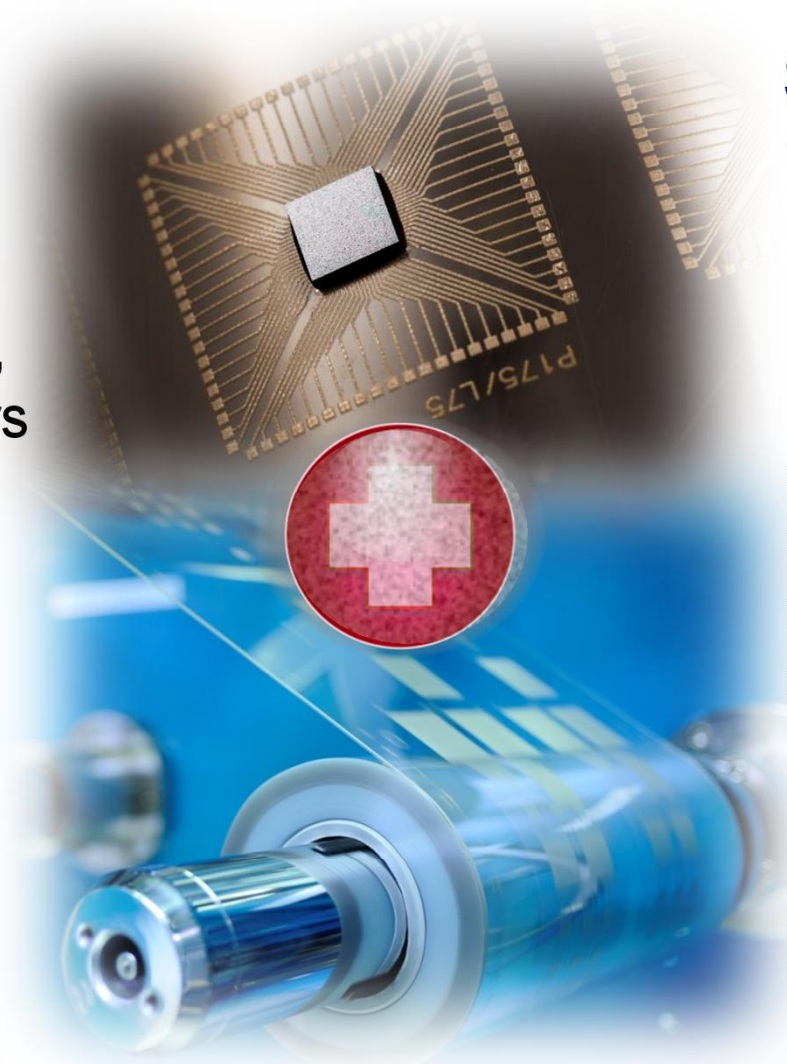
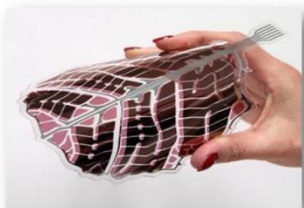
Best Technical Development
 Manufacturing Award
 2012 Berlin, 2012 Santa Clara,
 2013 Berlin, 2013 Tokyo

Hybrid systems

Combining large area and silicon

Large Area Functionality

- Nanostructures
- Capacitive, radiation, (bio)chemical sensors
- Displays
 - LED /OLED
 - Electrochromic
- Energy harvesters
- Antennas

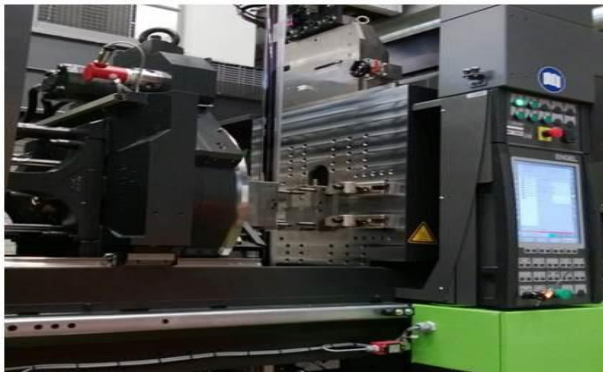
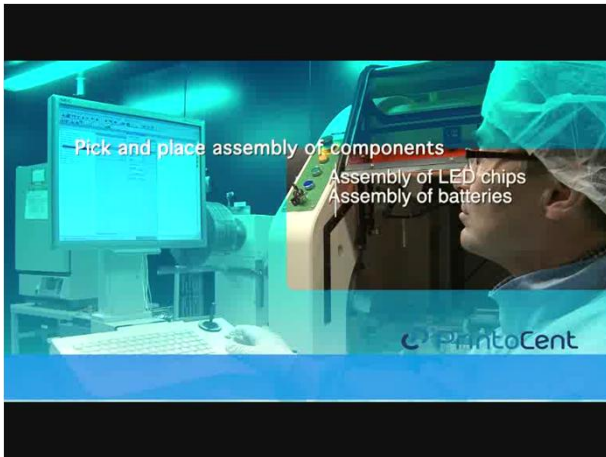


Silicon Chip (IC)

- Sensors
 - Accelerometer, MEMS
 - Camera, UV, Microspectrometer
 - Radar, Ultrasound
- Microcontroller / CPU
- Power management
- Memory
- Connectivity
 - Radio & Baseband
 - IR Transceiver



R2R manufacturing for Printed Hybrid Systems



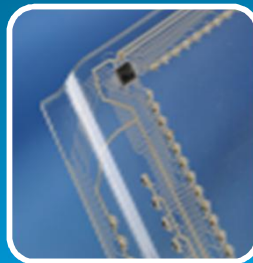
Printed components

- Printed solar cells, OLEDs,
- Microfluidics, sensors
- Biobatteries



Flexible electronics

- Flexible hybrid electronics
- Chip-on-foil: RFID, NFC, MCUs, LEDs
- Batteries, displays, energy harvesting, connectivity



Plastic integrated systems

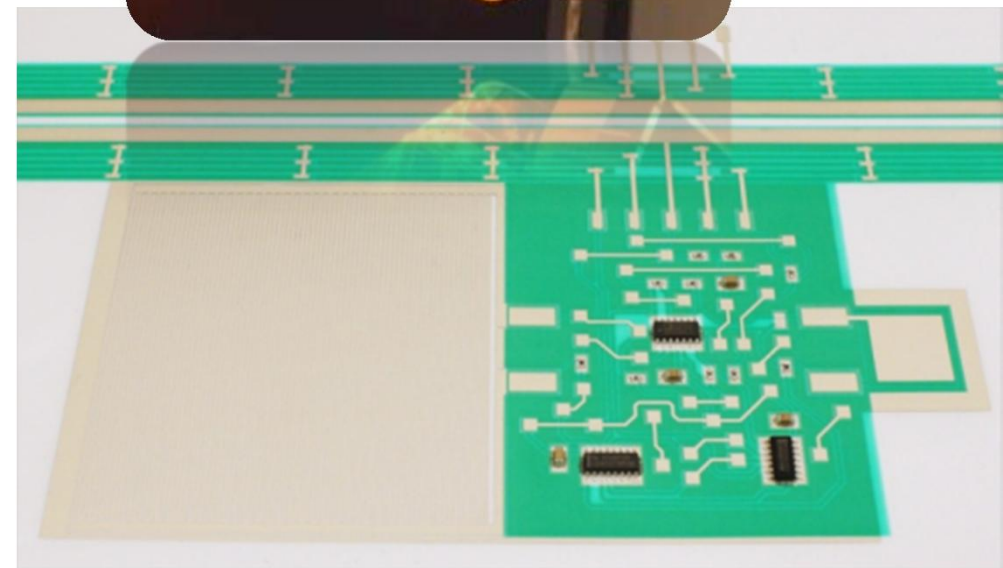
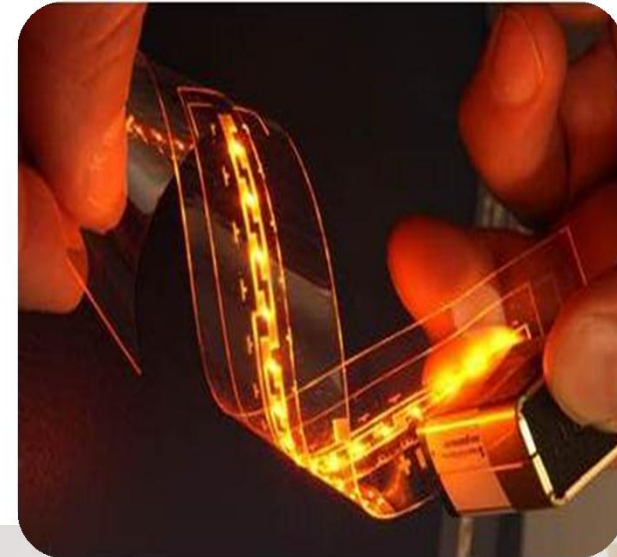
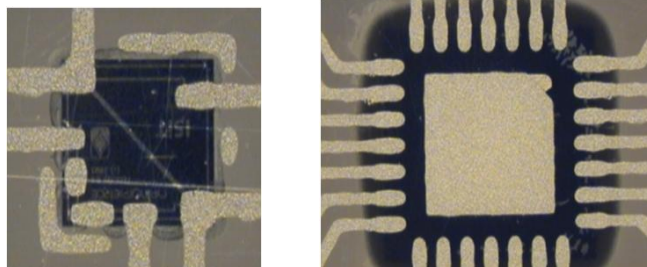
- In-mould labeling of functional foils
- 3D integrated devices
- Optics, mechanics and electronics integrated

Printed hybrid systems

Case LED chip integration

- 300 μ m x 300 μ m x 100 μ m chip
- Bending radius 20 mm
- ACA bonding
- >40 000 bendings without measurable degradation

Microprocessors, other chips



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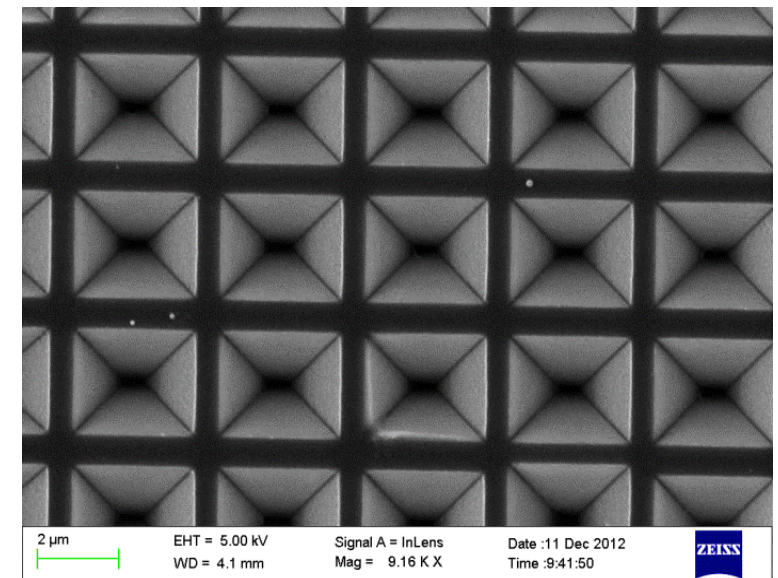
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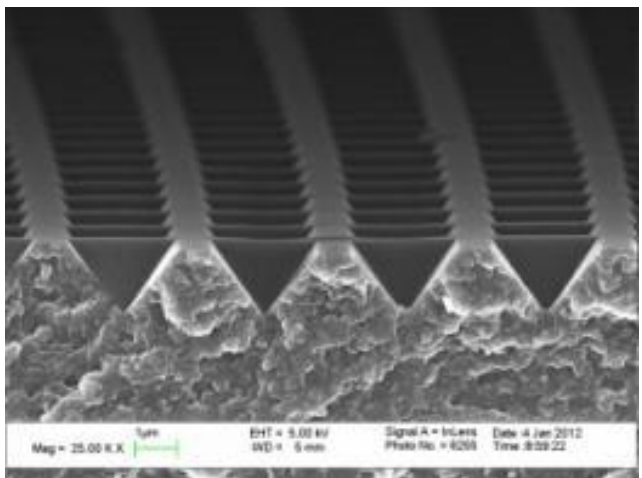
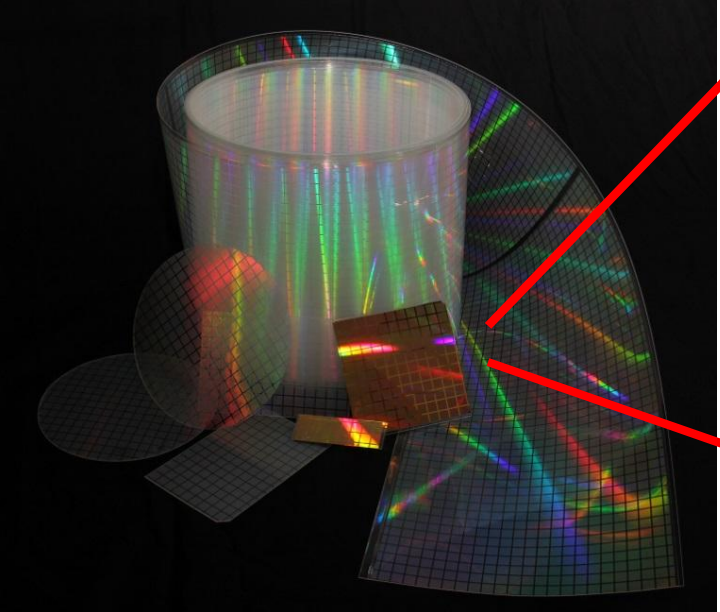
Conclusions



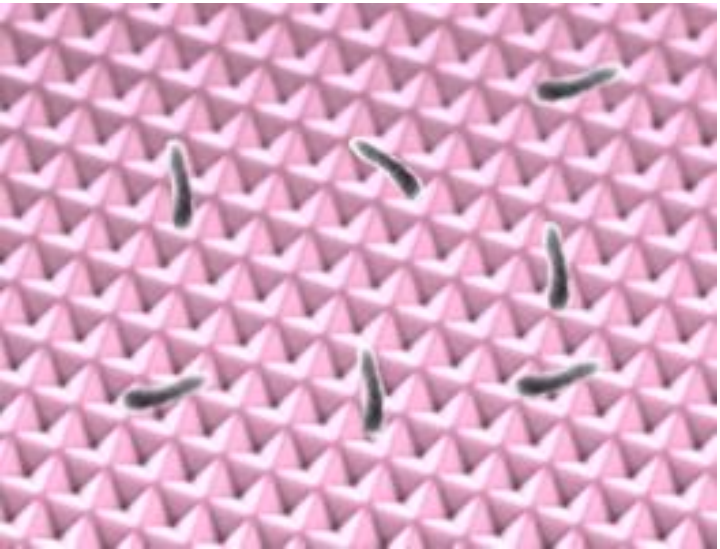
Case: Food monitoring – Listeria contamination

Roll-to-roll mass-manufactured low-cost photonic platform

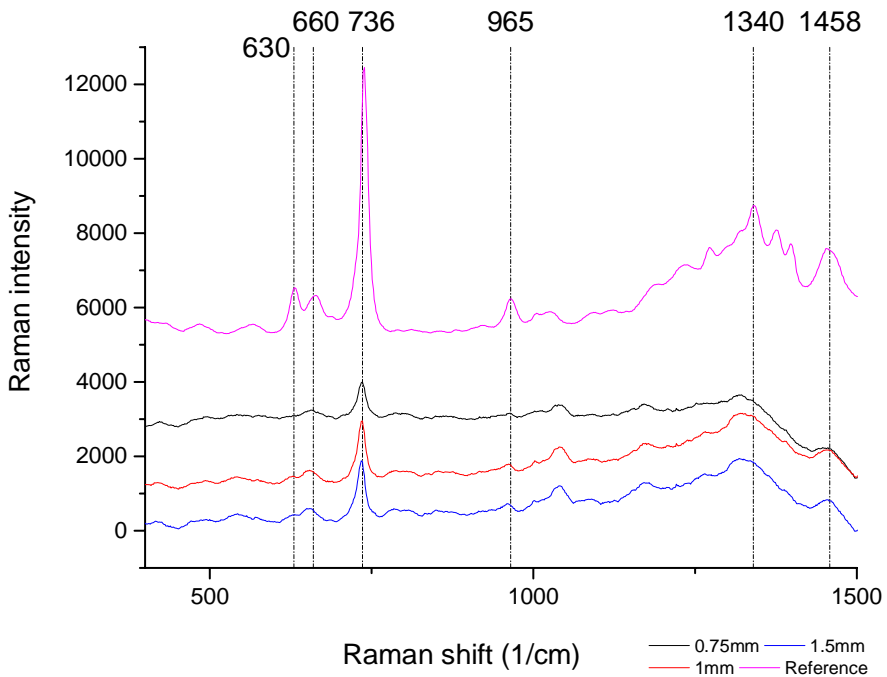
SERS - Sensor nanostructure



Listeria on sensor surface (illustration)



Spectral detection



Roll to roll processing at Nanocomp facilities

Roll to Roll UV embossing line

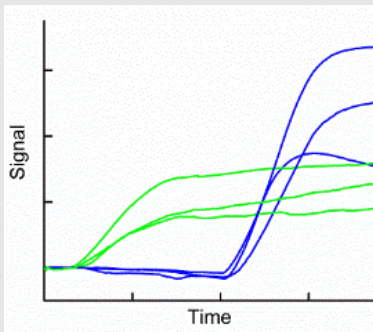
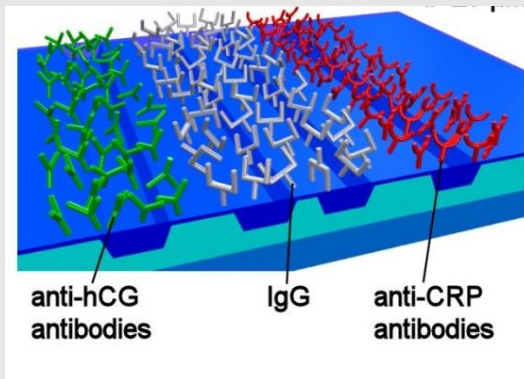


High volume die-cutter



Case: Personalized Health Monitoring

Pregnancy & Infection Chip

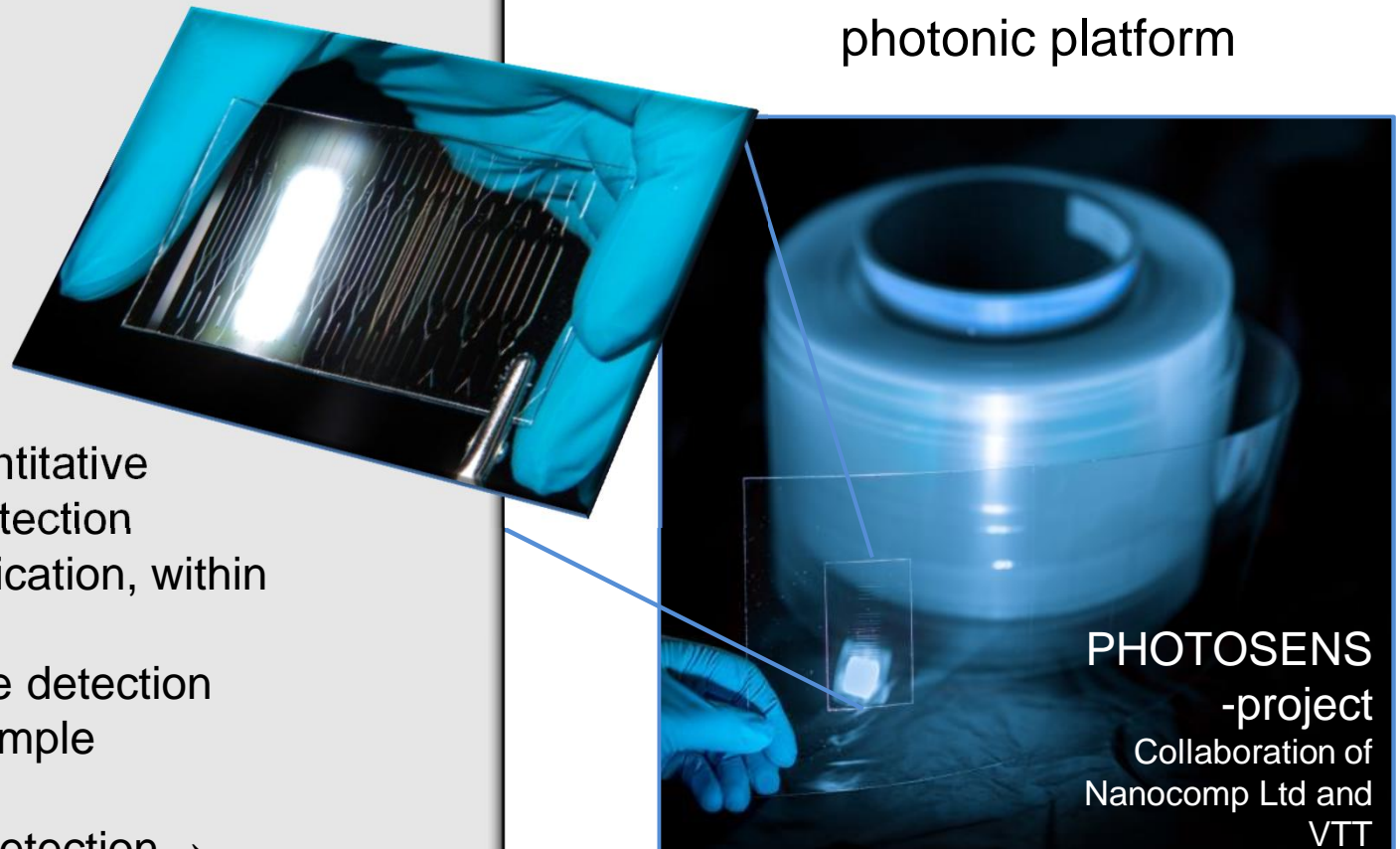


Demonstration of multi-analyte detection

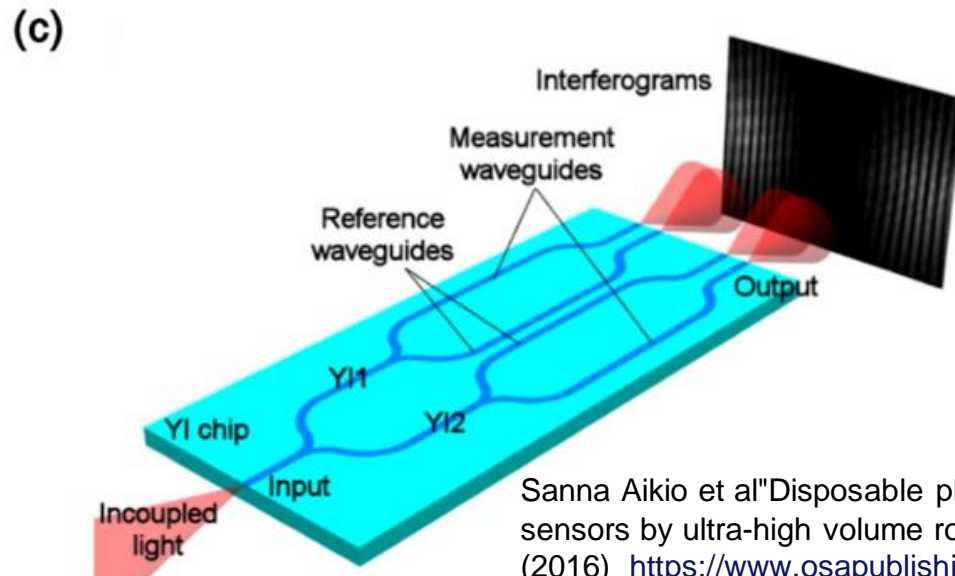
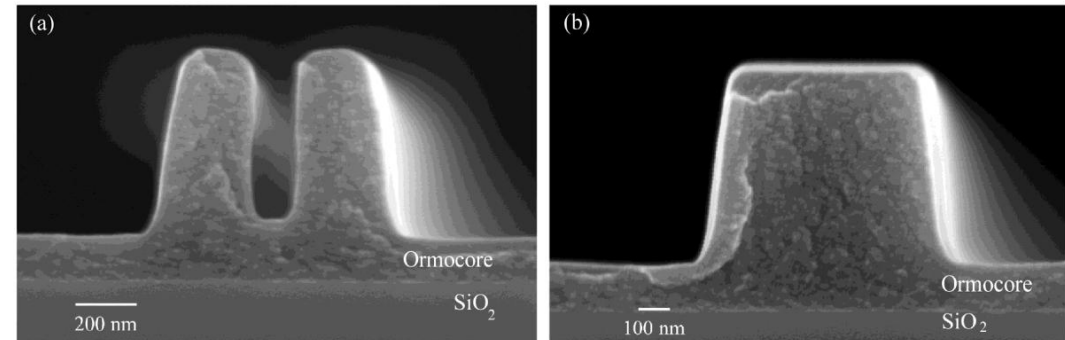
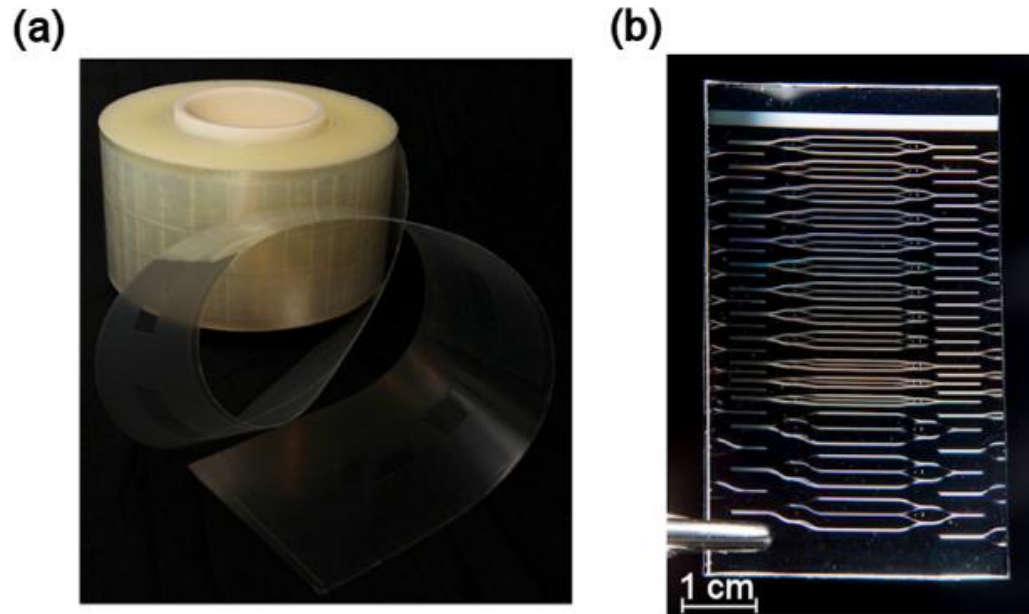
Benefits

- ✓ (Semi-)Quantitative
- ✓ Realtime detection
- ✓ Fast quantification, within minutes
- ✓ Multi-analyte detection
- ✓ Complex sample matrices
- ✓ Label-free detection → simpler test
- ✓ Reduction in reagent costs

Roll-to-roll mass-manufactured low-cost photonic platform



Waveguide sensor

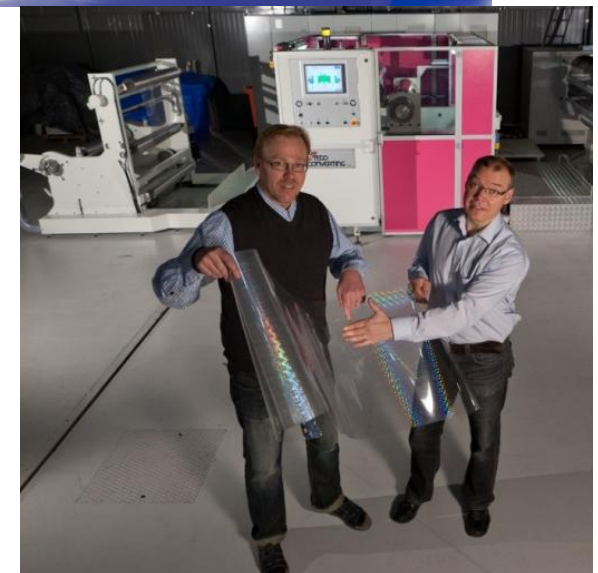


Marianne Hiltunen, et al. "Polymeric slot waveguide interferometer for sensor applications," *Opt. Express* 22, 7229-7237 (2014)
<https://www.osapublishing.org/oe/abstract.cfm?uri=oe-22-6-7229>

Sanna Aikio et al "Disposable photonic integrated circuits for evanescent wave sensors by ultra-high volume roll-to-roll method," *Opt. Express* 24, 2527-2541 (2016) <https://www.osapublishing.org/oe/abstract.cfm?URI=oe-24-3-2527>

Upscaling to industry: Iscent optical effects on plastic or on paper

- **Attraction:** Optical effects visible with naked eye
- **Authentication:** Hidden images as micro code and read by microscope
- **Sustainability:** No additional coatings needed, environmentally friendly and food safe
- **Compact production technology** to be multiplied worldwide
- www.iscent.fi



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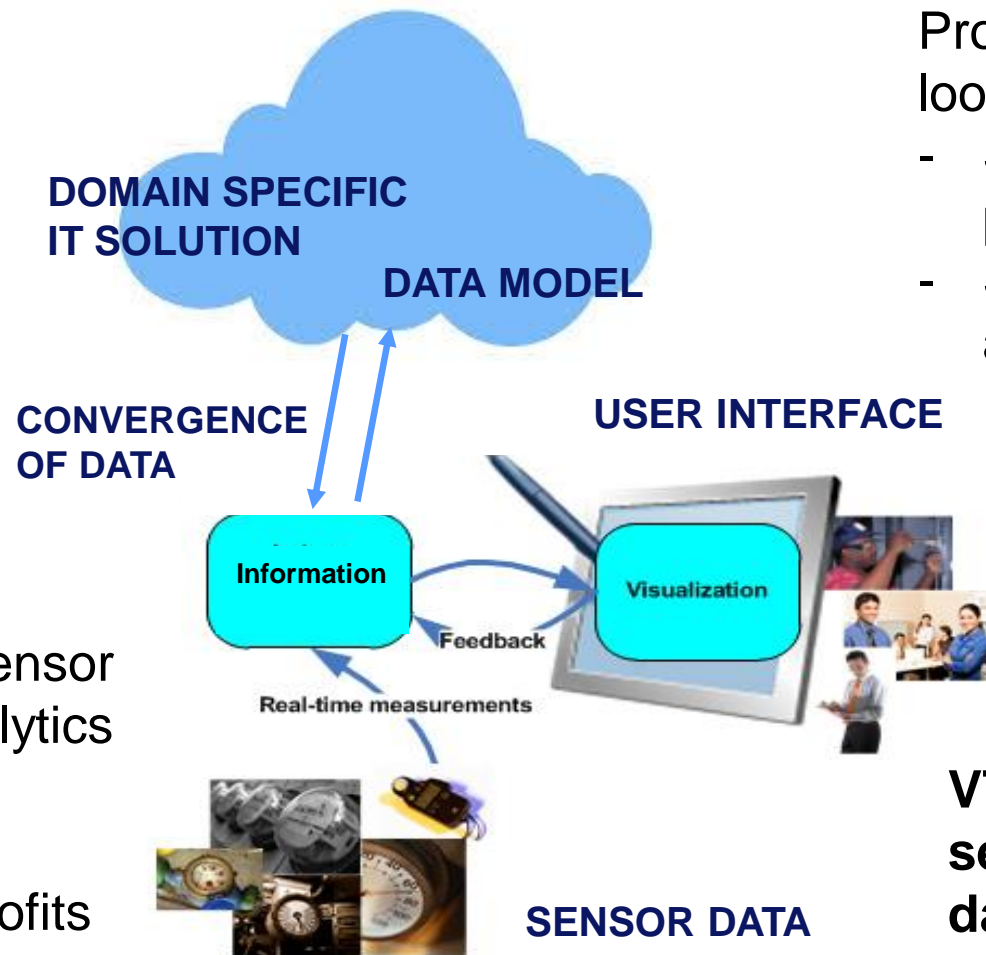
Mobile health and wellness service concept dose coach for MS disease medication

- Measures the medication level from serum sample by immunoassay
- Asks for symptoms and side effects to evaluate effect of medication
- Collects data to cloud service

- VTT's one-stop shop for creating new diagnostic solutions for the customers:
 - ✓ reagent development
 - ✓ development of analytical devices
 - ✓ personal health solutions



New business models based on sensors enabling digitalization



Product companies are looking for service business

- Sensor data from products to cloud
- Service based on data analysis

Extracting useful information from Big Sensor Data through Data Analytics is expected to be most profitable business segment, 60-90% of profits will come on data.

VTT provides software services for analytics and data visualization

Digital service engineering - VTT focus areas

Drivers



Digitalization



IoT



Business model renewal



Need for speed

Enablers

Policy making, regulation, impact assesment

Cloud

Local intelligence

Ecosystem orchestration, strategy

Networking

Sensing and actuating

Business methods, mechanism design

Connectivity

Physical reality

Domain semantics

Data analysis, modelling, simulation, decision support

Security, confidentiality, trust

Challenges



Architectures



Data analysis



UI technologies



Cyber security

Conclusions

- Nanomanufacturing upscaling has been proved in several cases
- Applications can be found e.g. in optics or biosensors
- In system integration printed and hybrid manufacturing technologies can be utilized
- It important to consider also digital services that are built on top of the sensor system



TECHNOLOGY «» FOR BUSINESS

