Digital Fabrication

a new manufacturing concept

Porto / P, March 04, 2013

MERGE
Cluster of Excellence

Reinhard R. Baumann

Chemnitz University of Technology
Chair of Digital Printing

Fraunhofer Institute for Electronic Nano Systems Chemnitz
Business Unit Green and Wireless
Dpt. Printed Functionalities

Chemnitz Smart Systems Campus → the Printed Electronics Partners

Printing Beyond

- The Manufacturing Technology Printing
- Functional Printing Machinery
- Applications: Printed Smart Objects

Printing
is a general manufacturing technology

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Printing is an additive technology

→ ink is deposited on the substrate only at positions where its functionality is essential

→ no material removal, no lithography is needed

→ valid for digital printing, batch size ≥ 1, setup time ≥ 0

Printing is a continuous manufacturing technology

→ in case of web fed, no batch handling

→ easy flexible substrate handling, fiber or plastic based

Printing is regularly carried out under ambient conditions

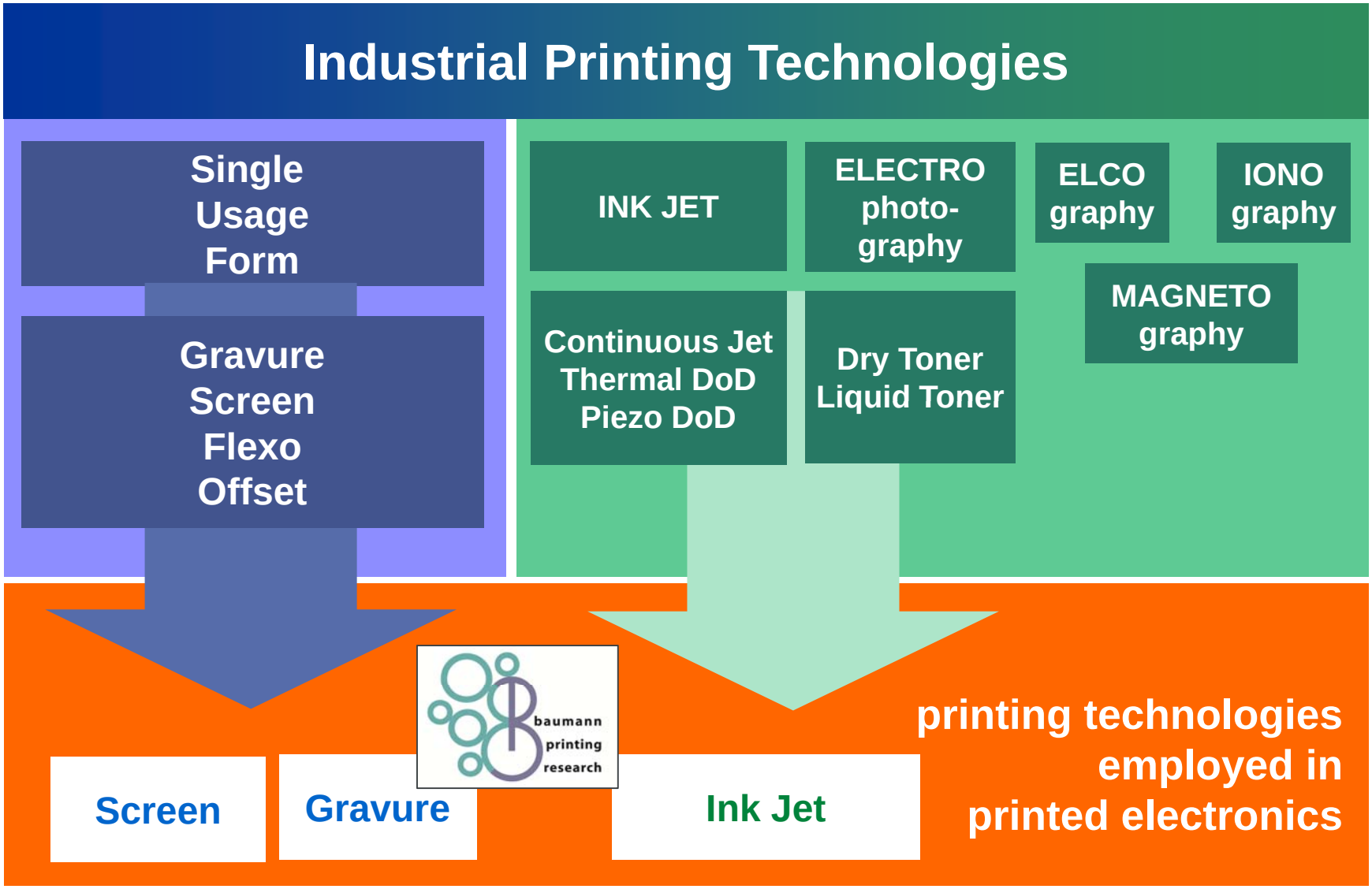
→ no vacuum needed for material deposition

→ clean and/or inert conditions are OK

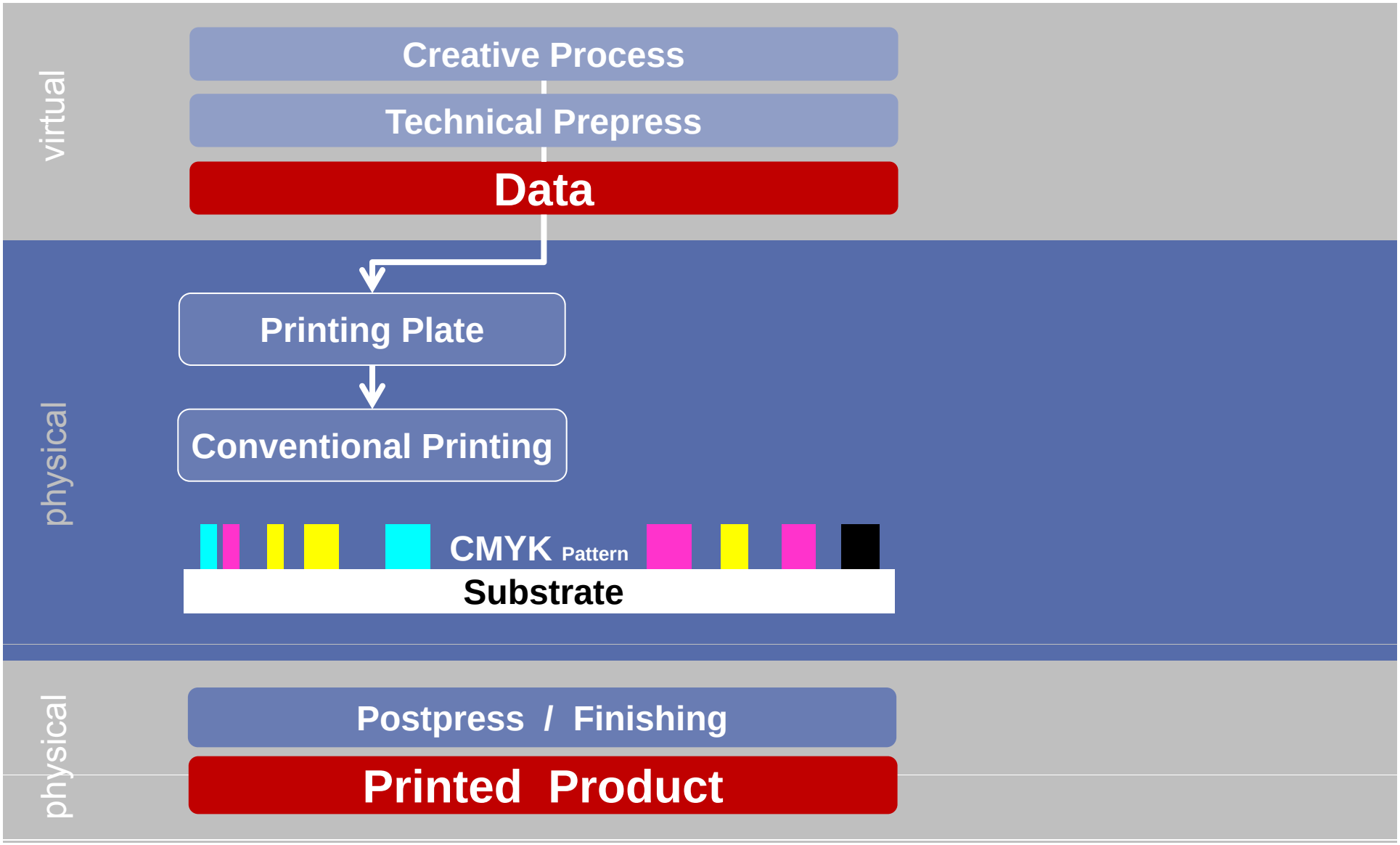
Printing is a highly productive manufacturing technology

Additive Printing Technologies, most employed in

Large Area Electronics Fabrication



Printing Process Chain



Typical Data of Web Fed Gravure Printing

Web width: 800 .... 4.300 mm

Substrate Speed: up to 15 m/s (50 km/h)

Output: up to 200.000 m^2/h

Substrates:

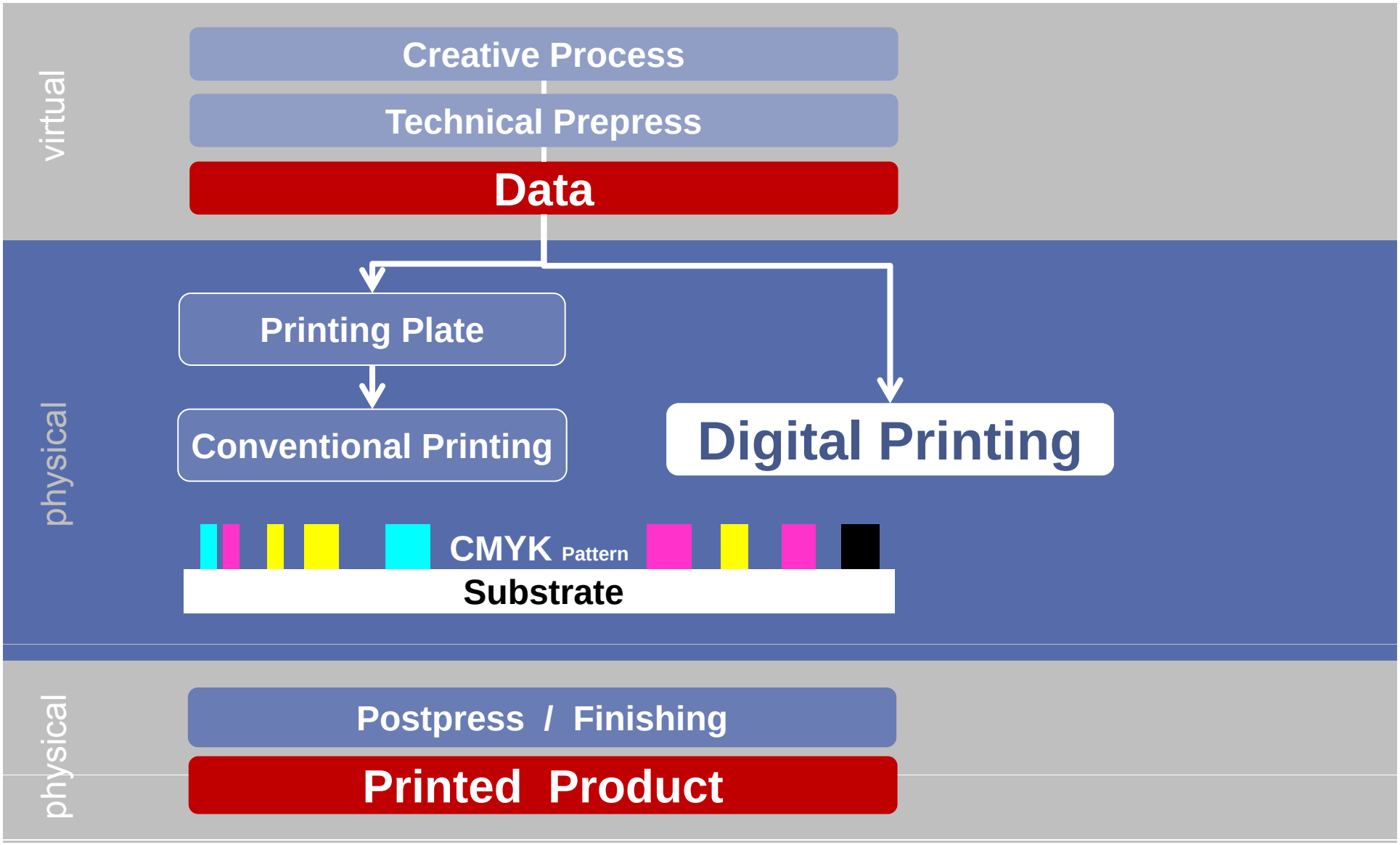
- paper
- carton
- aluminium
- polymer films

} typ. Thickness < 0,5 mm

Configuration:

- simplex or duplex printing
- free configuration of printing system on customer demands / specifications

Printing Process Chain



Industrial Inkjet Printing 2012 @ DRUPA

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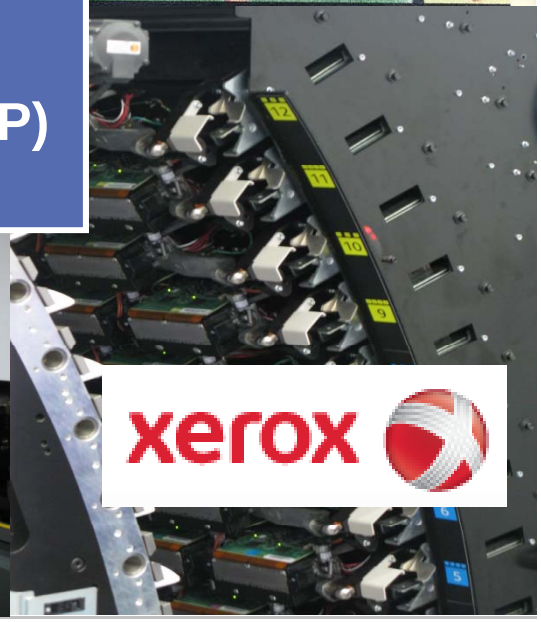
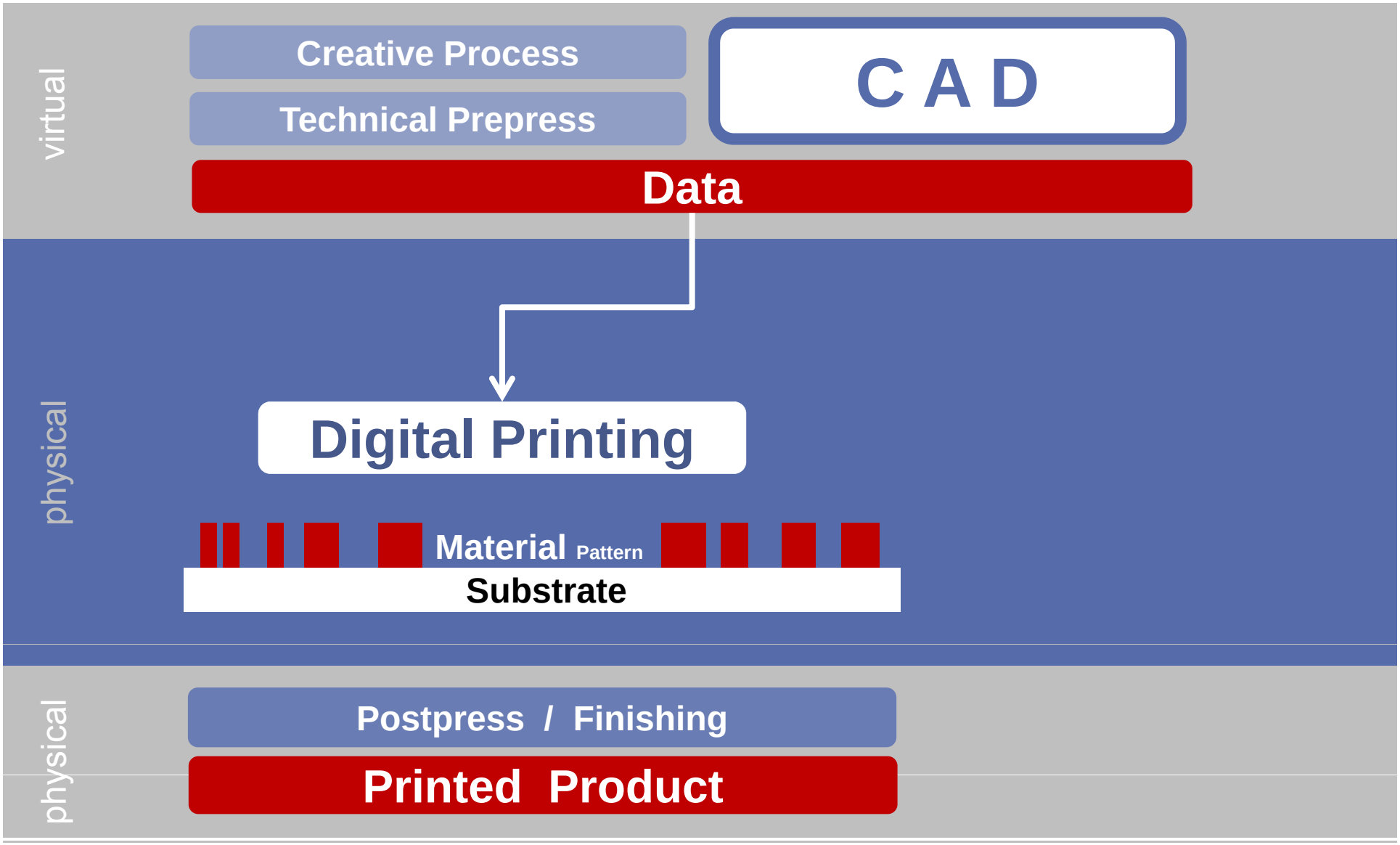
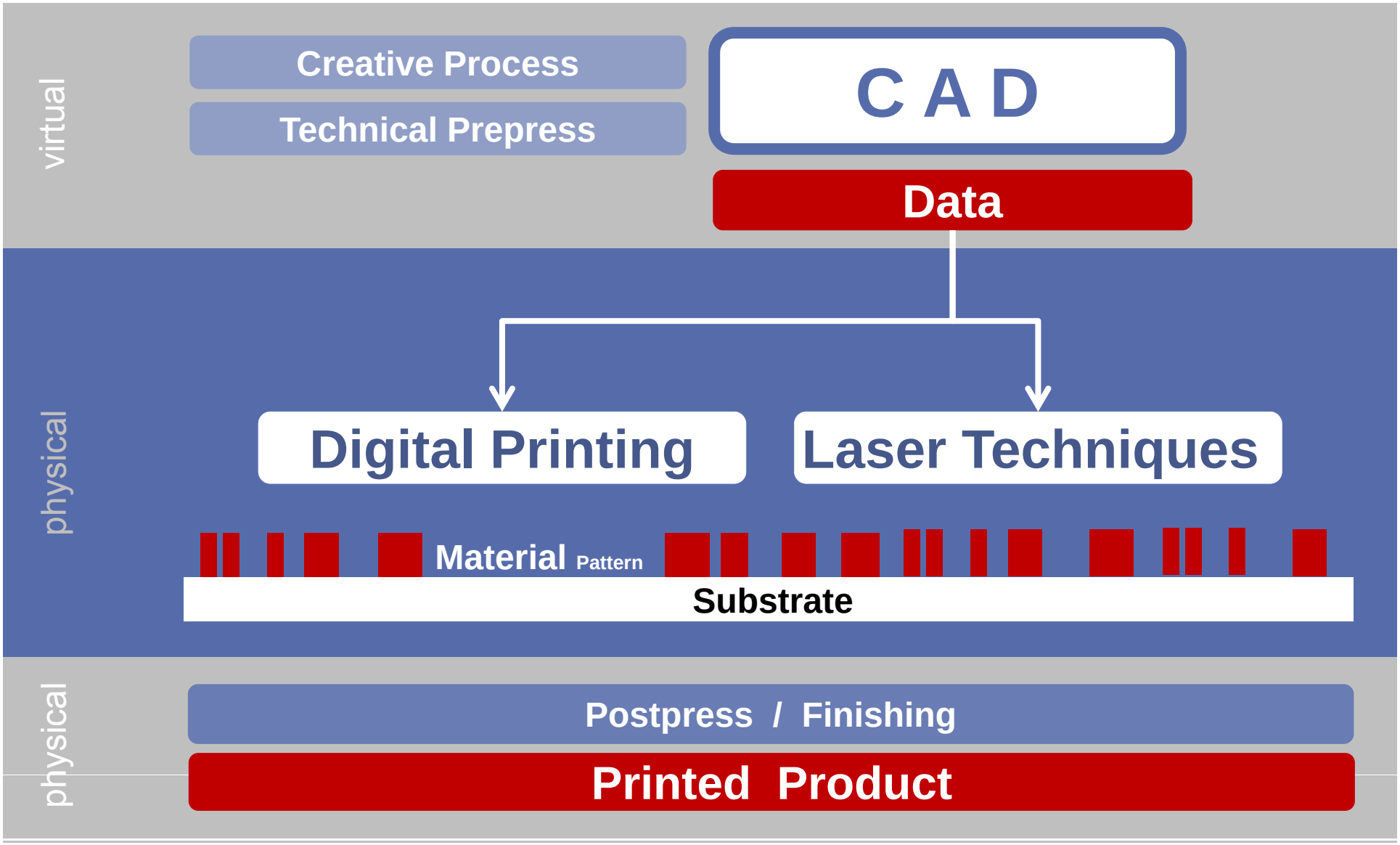
Full Color
e.g. Newspaper
@ web speed 4 m/s (HP)



Printing Process Chain



Digital Fabrication Process Chain



Digital Fabrication - basic topics

Opportunities

Digital **F**abrication → product run length **1**

→ change over time **0**

Typical **DF** Technologies → Digital Printing

→ Laser Processing

→ their chaining

→ chaining with analogue technologies

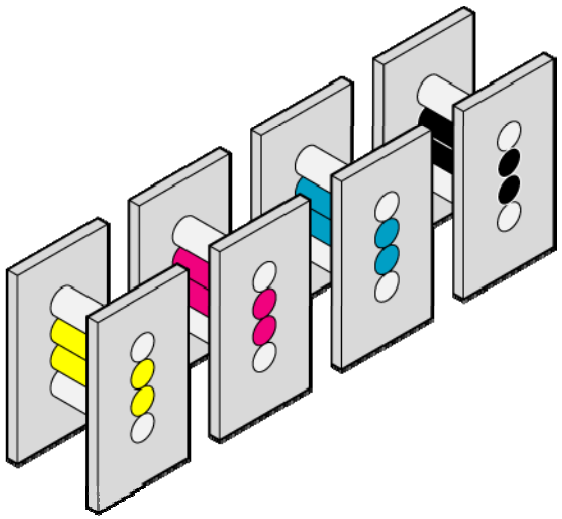
Printing Beyond

- The Manufacturing Technology Printing
- **Functional Printing Machinery**
- Applications: Printed Smart Objects

Printing Functionality Separations

Functional Layers

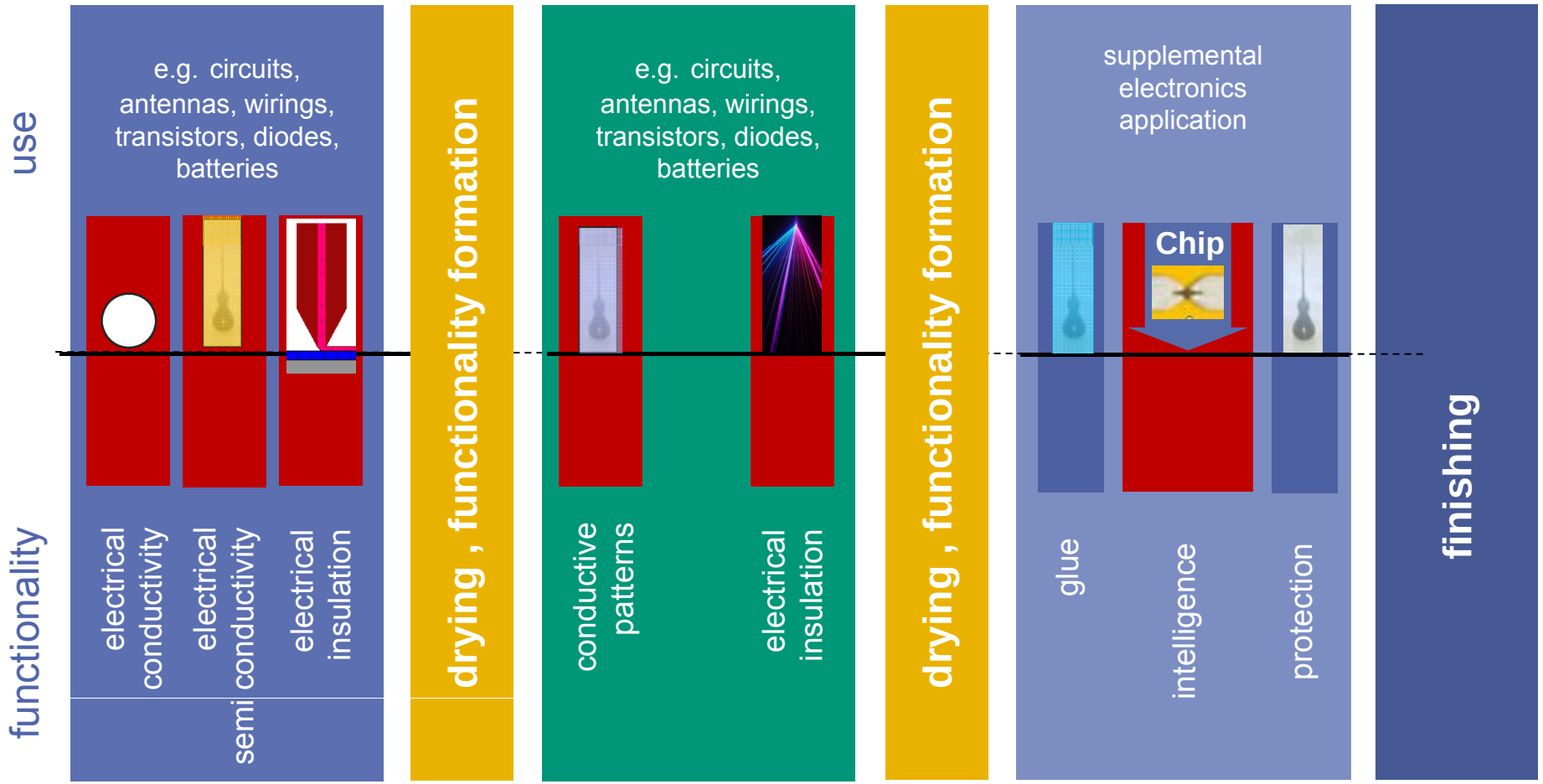
Conductivity
Dielectic
Semi-conductivity
Conductivity



1 functionality separation per functional material:

„Information, at which position on the substrate which functional material has to be deposited“

Digital Hybrid Manufacturing Systems



printed functionalities by printing functionality separations

printing competence in Chemnitz

Chemnitz InkJet Technikum → Lab2Fab

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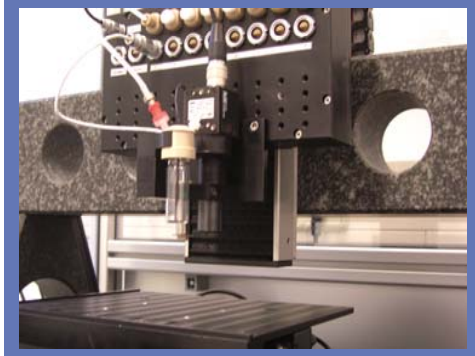
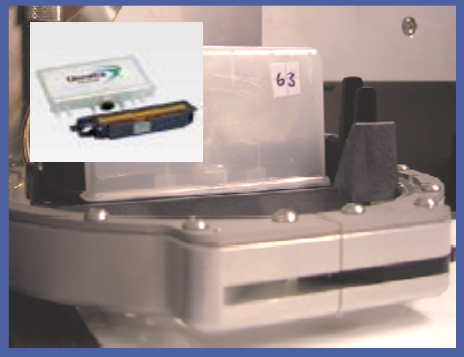


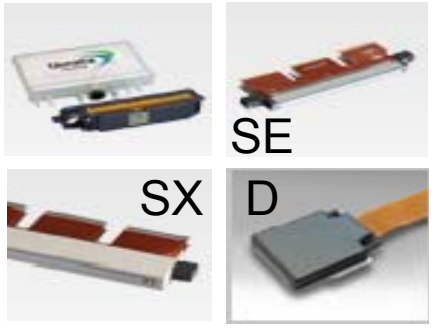
Autodrop
Microdrop

1
XYZ



DMP2831
Dimatix

16
XYZ



DMP3000
Dimatix

16 / 128
XYZ

INERT
Dimatix
XAAR

16 / 128
XYZ

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printing competence in Chemnitz

Chemnitz InkJet Technikum → Lab2Fab

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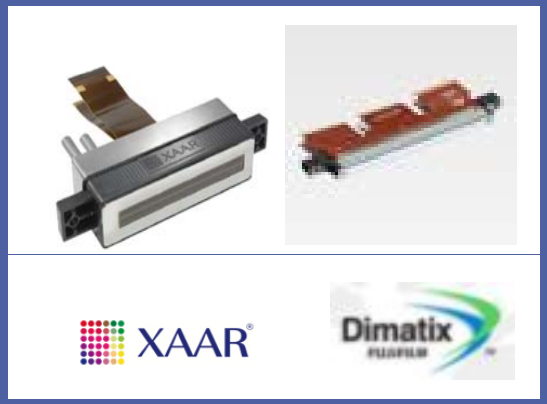
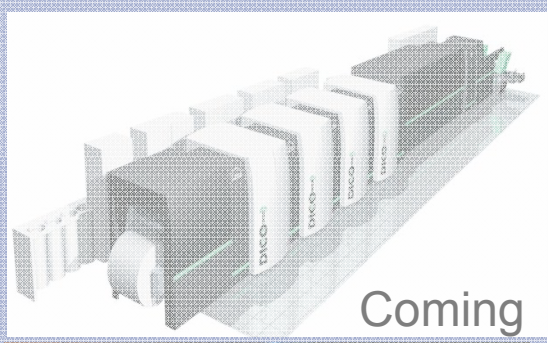


gravurMAN
(Xaar printheads)

1001
R2R

MicroFlex
(Dimatix SCANPAQ)

2 x 2 x 256
R2R



DICOweb
manroland

4 over 4 offset
Web fed

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printing competence in Chemnitz
gravureMAN → digital fabrication system

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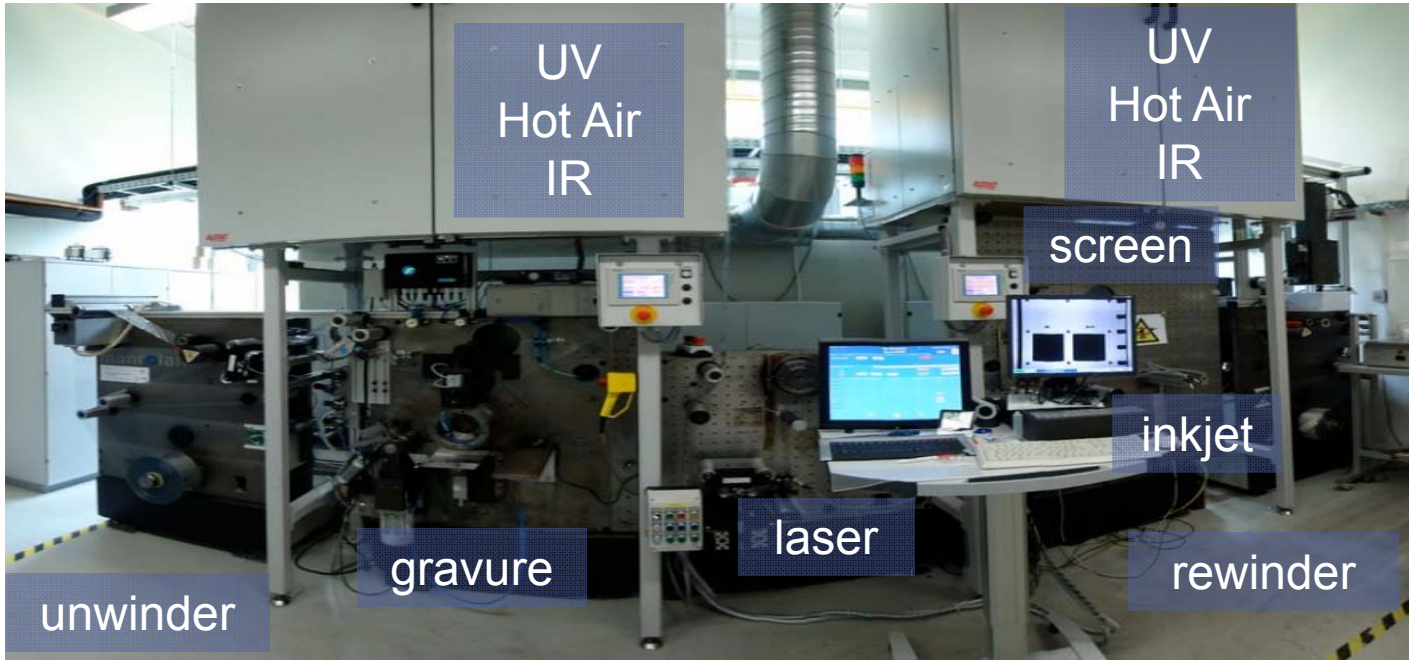
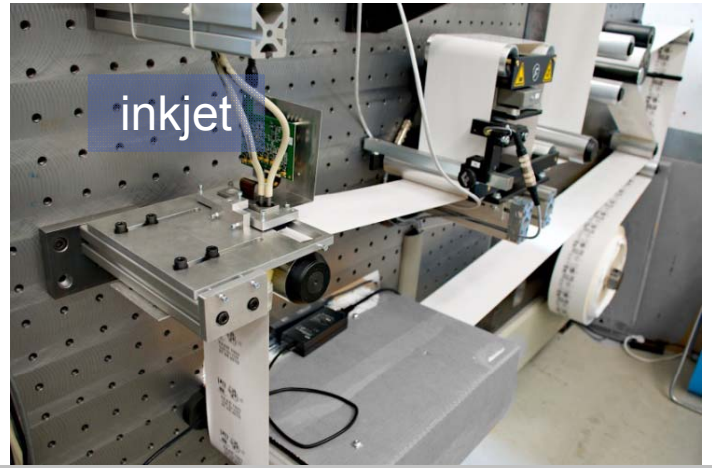
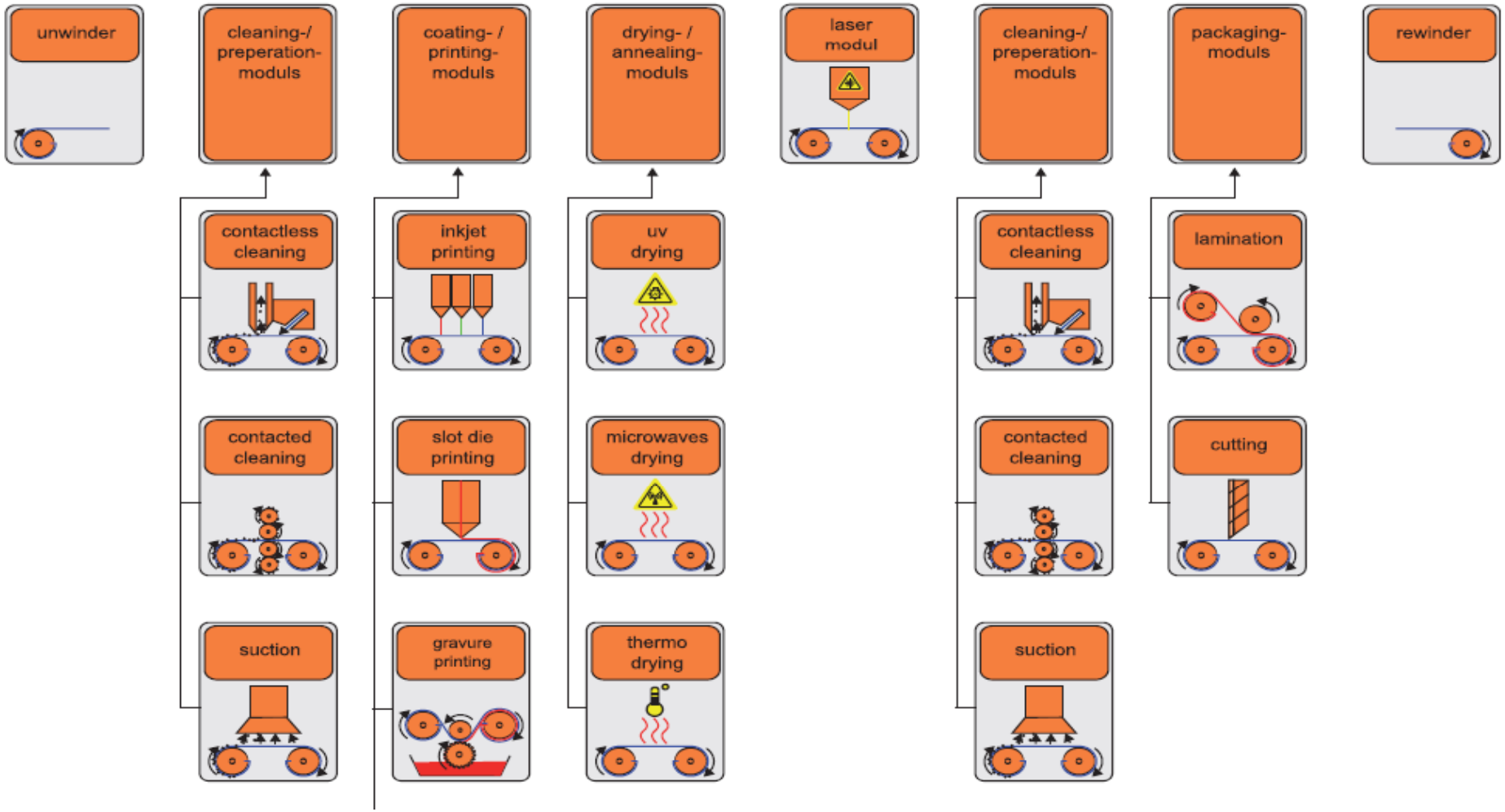




the modularity concept

adapt the manufacturing system to the product



microFLEX: R2R Micro Manufacturing Machine

Machine Design & Setup

www.3d-micromac.com

Process & Applications

www.enas.fraunhofer.de/en/departments/PF
www.tu-chemnitz.de/mb/DigiTech

Santa Clara, CA, USA

Industrial Inkjet Technology

www.dimatix.com

Austin, TX, USA

Ink & Photonic Sintering

www.novacentrix.com

microFLEX™
the key features

3D MICROMAC
First Choice in microMachining

→ R&D and Production
→ Modular Setup
→ Hybrid Technology
→ R2R / R2S / R2P
→ One Side Wall
→ Controlled Atmosphere

microFLEX: the Copper Setup

3D MICROMAC
First Choice in microMachining

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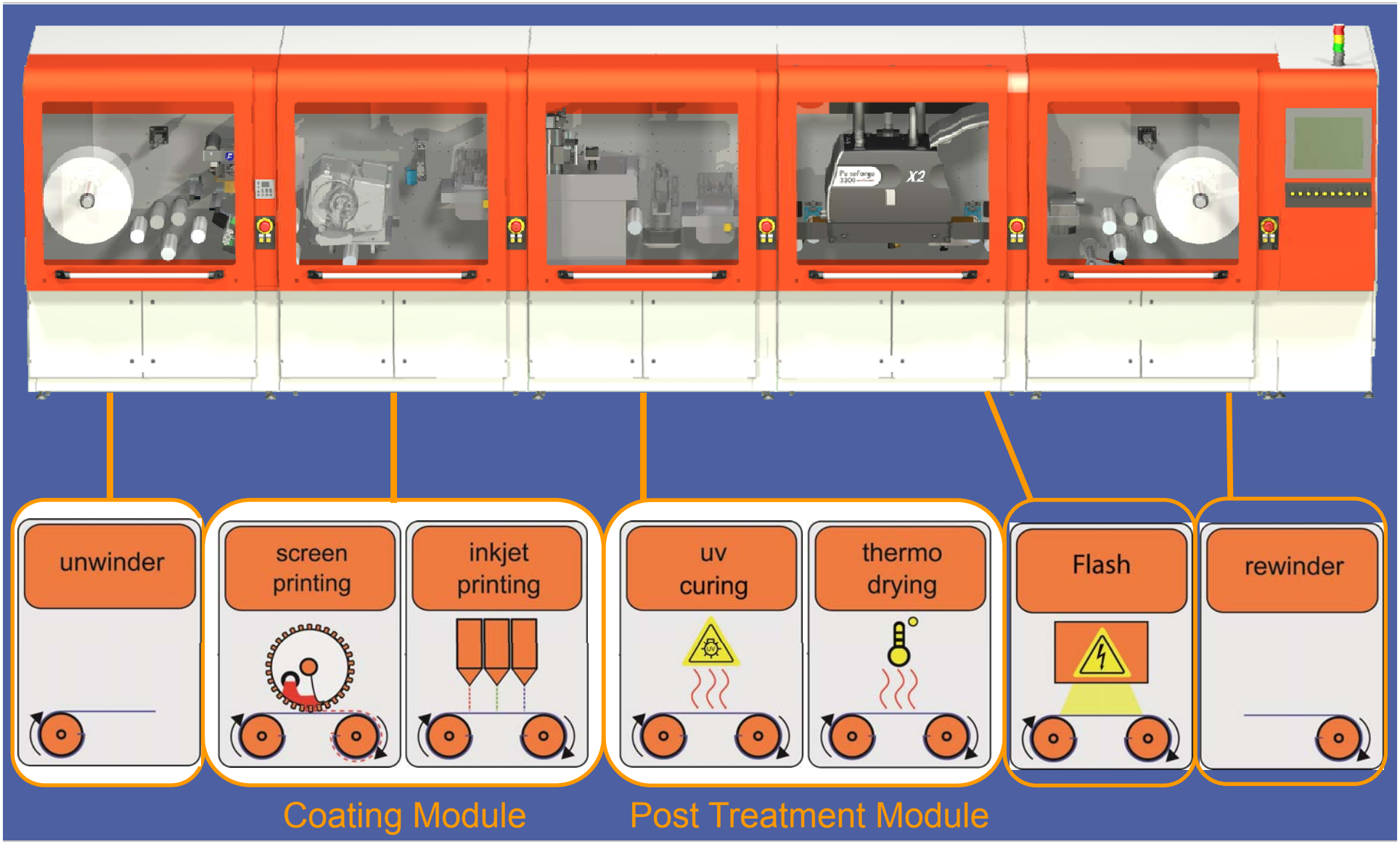

microFLEX
Our Setup & Process, May 2012

3D MICROMAC
First Choice in microMachining

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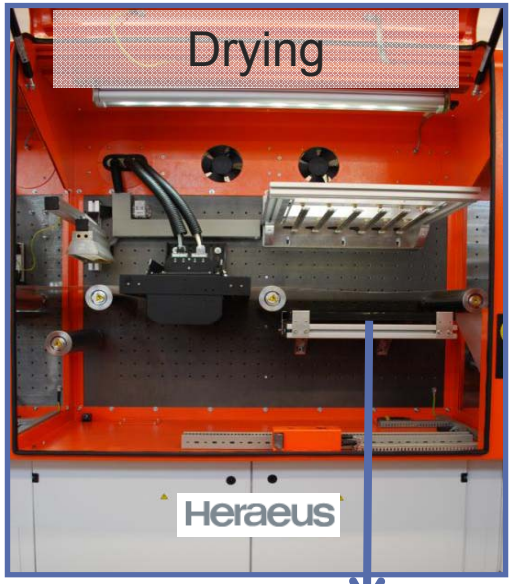
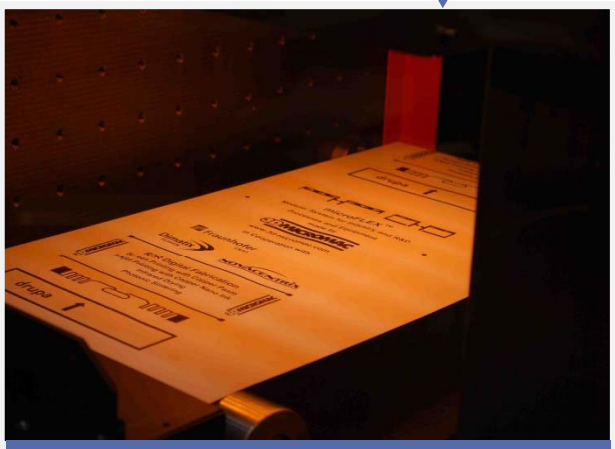
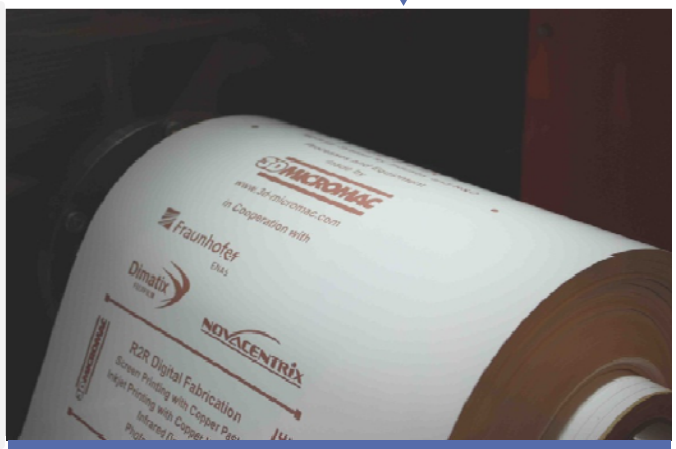


Screen/Inkjet Printing



IR Drying



Conductive Copper Pattern

microFLEX: Copper Setup → the RESULT

printing competence in Chemnitz micro FLEX

Micromachining for Industrial Applications and R&D

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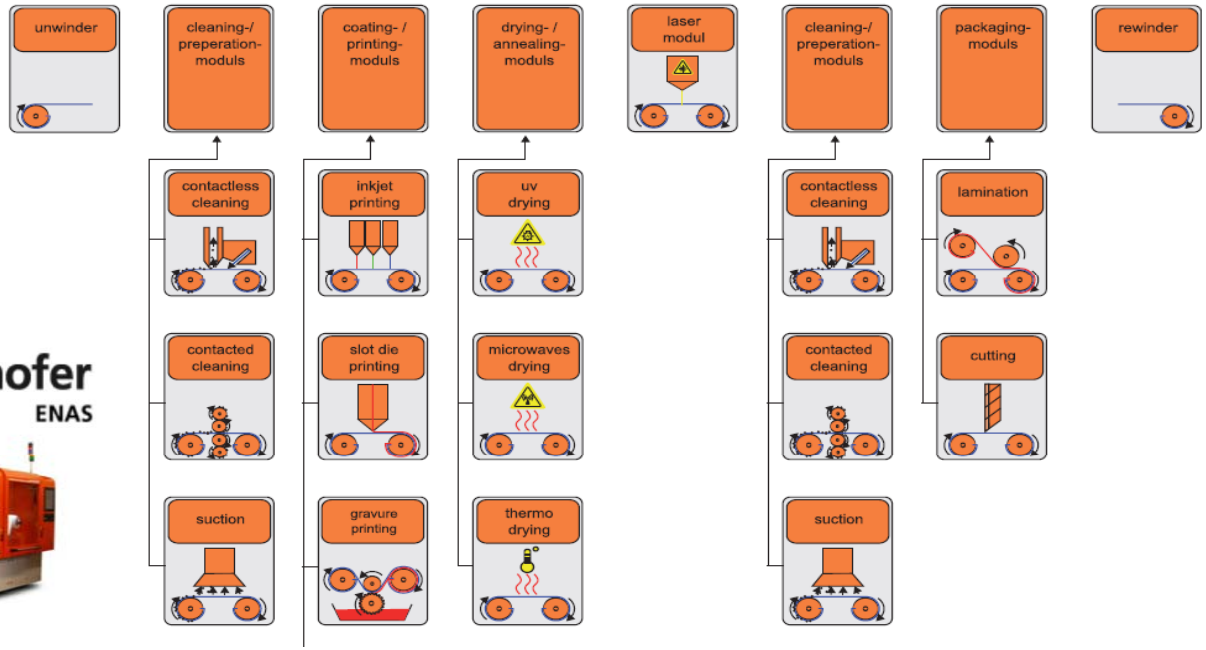
Fraunhofer ENAS



printing competence in Chemnitz **micro FLEX**
Micromachining for Industry and R&D

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for Organic Photovoltaics

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Bundesministerium für Bildung und Forschung

EPIO

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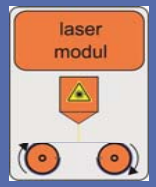
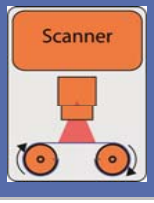
Laser Patterning





- **Batch size >1**
- **Change over time 0**

- **PROTOTYPING, but**

Ready for Digital Fabrication

Printing Beyond

- The Manufacturing Technology Printing
- Functional Printing Machinery
- **Applications: Printed Smart Objects**

The Vision :
printed smart objects for the internet of things

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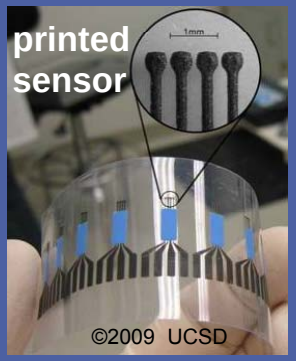
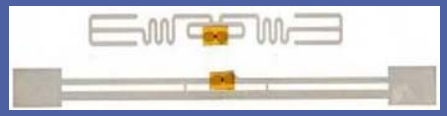
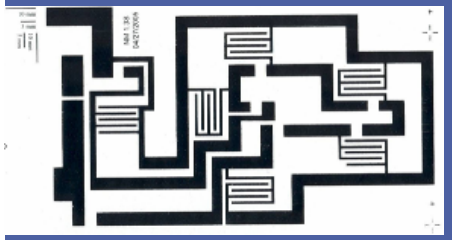
perceiving the neighborhood and its own state



communication with a computer system



RFID technology
near field technology



printed keyboard

interaction with the user

printed signage elements

Printed power source

Memory
- Thin film memories
- Printed memories

Silicon electronics
- Communication protocol
- Measurement functionality

Digital logic
- Organic FETs
- Electrolytic transistors
- High frequency rectifiers
- Power amplifiers

Sensors
- Pressure sensors
- **Keyboards**

Display
- Electrochromic
- Electrophoretic (e-ink)
- EL
- OLED

Power sources
- Batteries
- Solar cells
- Fuel cells

Passive components

Antennae
- UHF & microwave dipoles

Printing Functionalities Beyond Color

→ activities in Chemnitz so far

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Color Cyan Color Magenta Color Yellow Color Black	Process Colors
Gloss & Protection	Coating
Electric Power **Adapted Dielectric Properties** **Electrical Conductivity** **Electrical Semi-Conductivity** Electro-Luminescence / Light Emission	Circuitry
Sensing Environment	Sensors
Surface Modification **Surface Protection** **Catalysis** **Porosity (filter, membranes)**	Process Support
Intelligence via Si-Chip and / or Supplemental Electronics Geometric Shape / **Laser Patterning / Cutting**	Hybrid Tech

Conducting Inks Made From Particles

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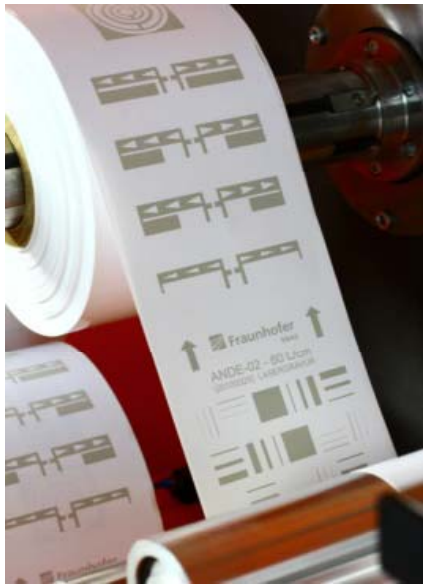
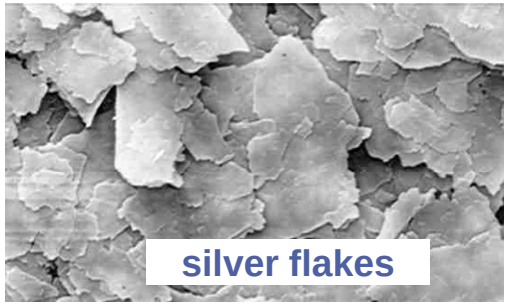
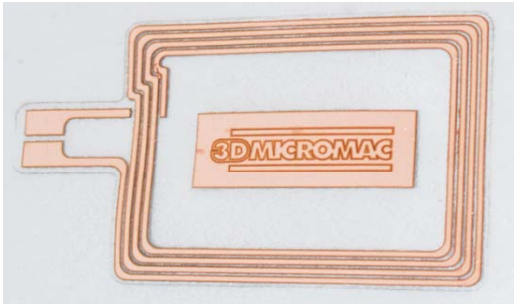
RFID antennas and Keyboards

applying Silver and Carbon flakes filled Inks

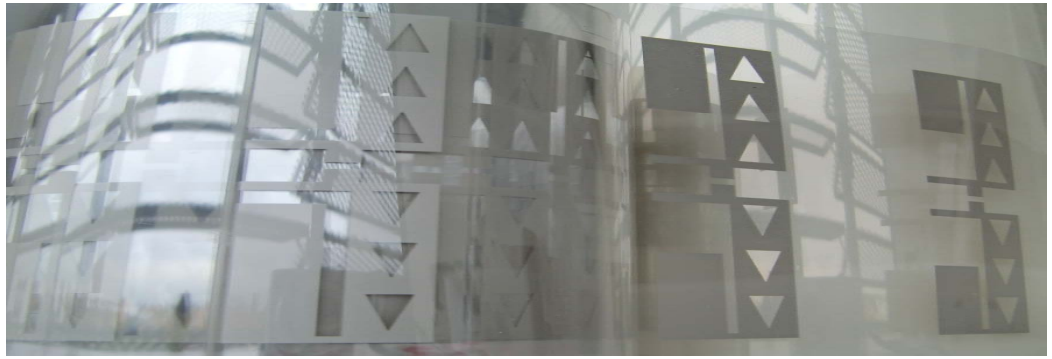


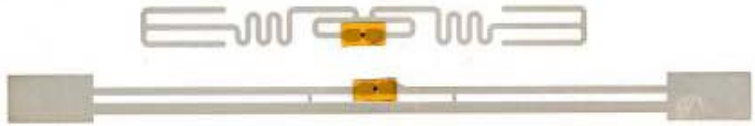




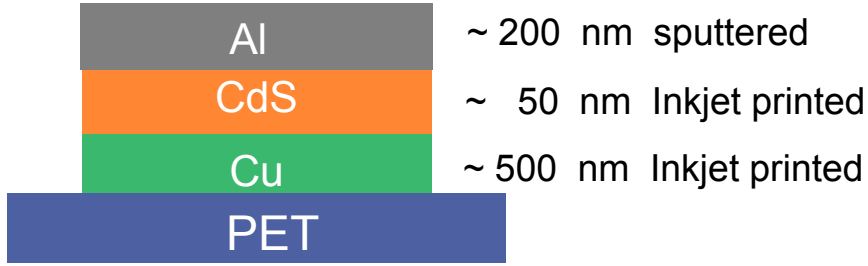
printed on web fed

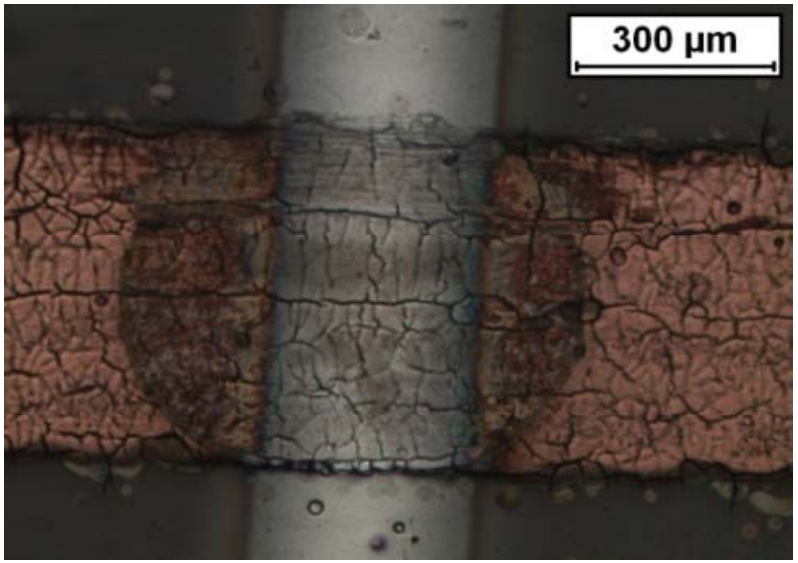
LABORMAN &
MICROFLEX ®

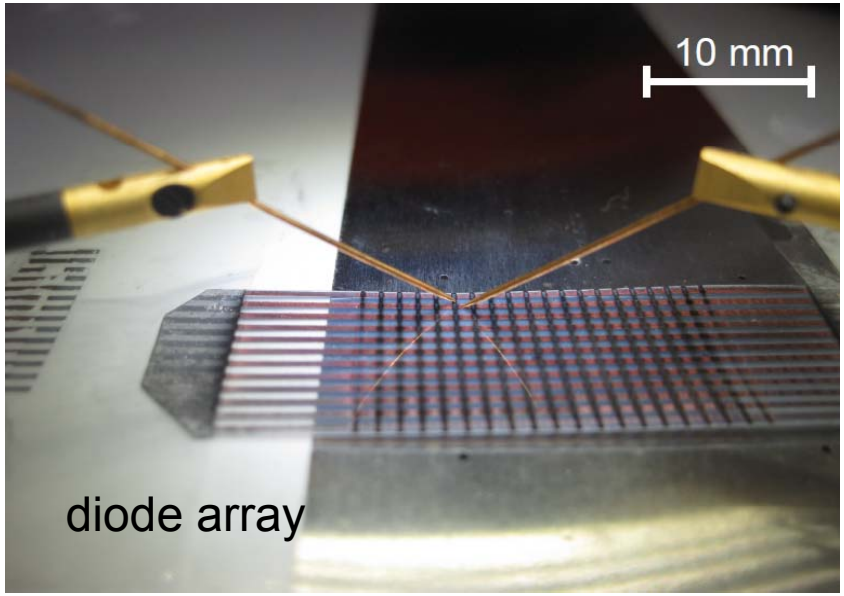




Inkjet printed **Schottky Diode** on PET
photonic sintering @ room temperature







N. Marjanovic *et al.*
J. Mater. Chem., 2011, 21, 13634

Printing Flexible Batteries (Zn/MnO_2)

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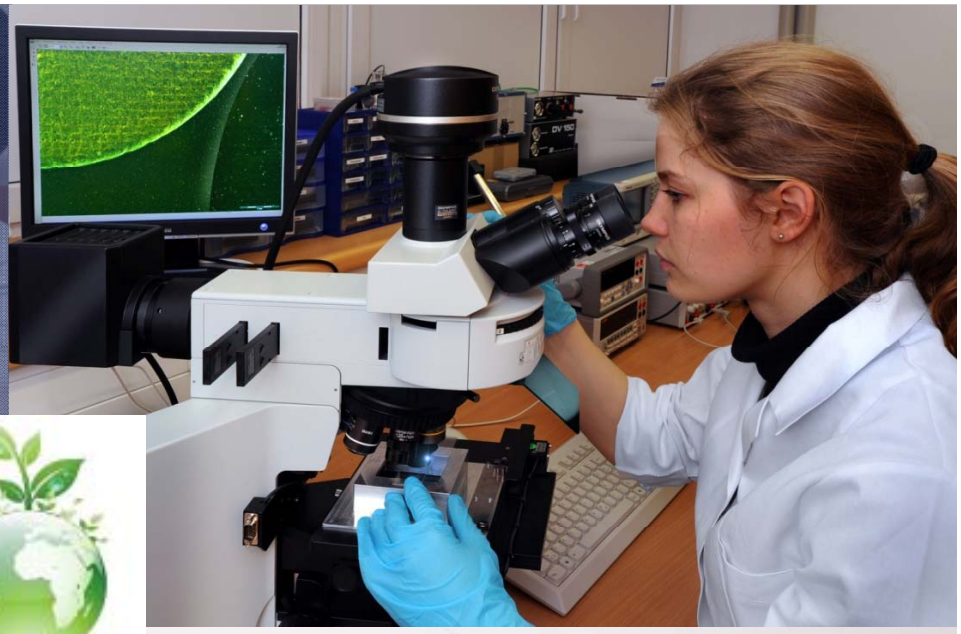
- single cell of 1.5 V nominal voltage
- discharge current: 200 µA (constant)
- cut-off voltage: 0.9 V
- capacity: > 5 mAh/cm² (adoptable)
- thickness: < 1 mm
- weight: approx. 0.8 g



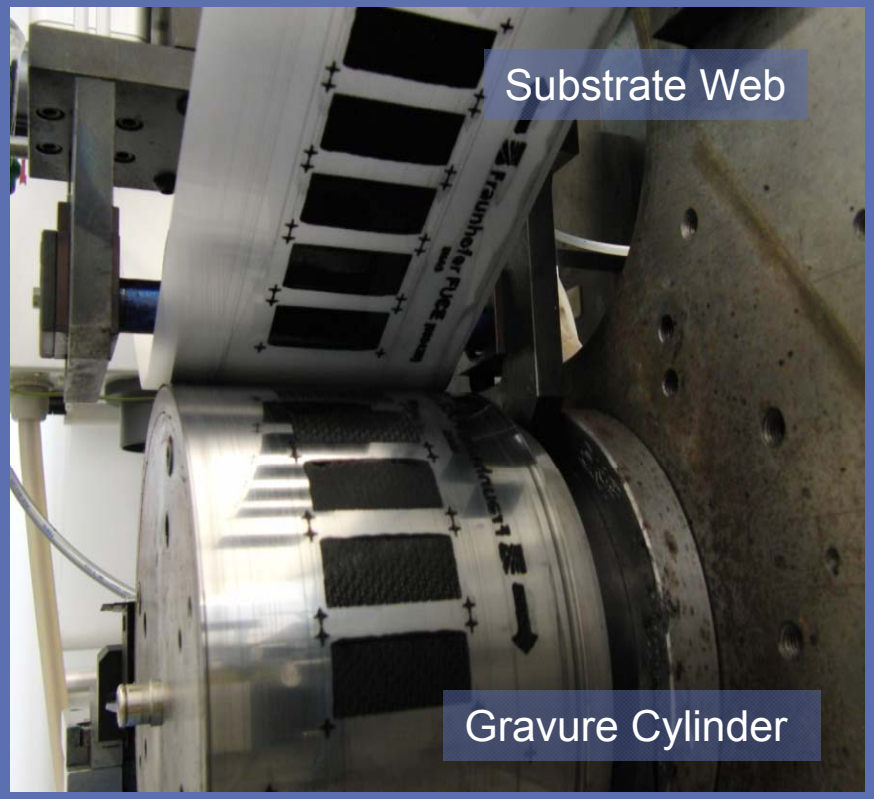
in coop with printechnologics

1,5 V … 6 V capacity > 5 mAh/cm²

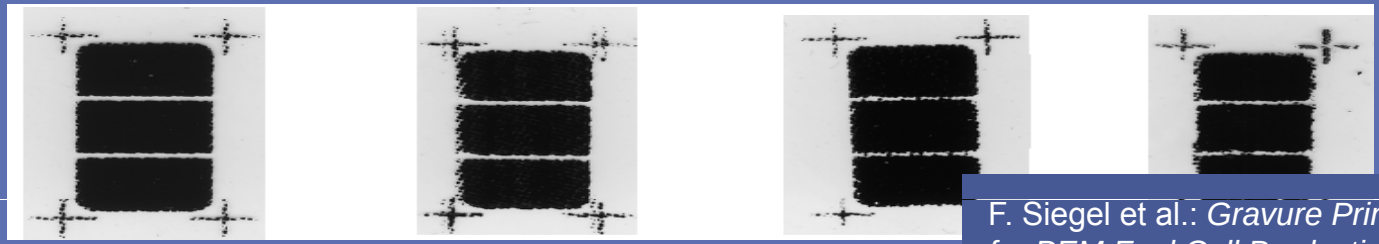
All Printed Flexible Batteries Xmas 2011

1000 integrated batteries shipped → integration in printed products

Gravure Printed Fuel Cell Membranes



Gravure Cells



SolviCore
Fuel Cell Technologies

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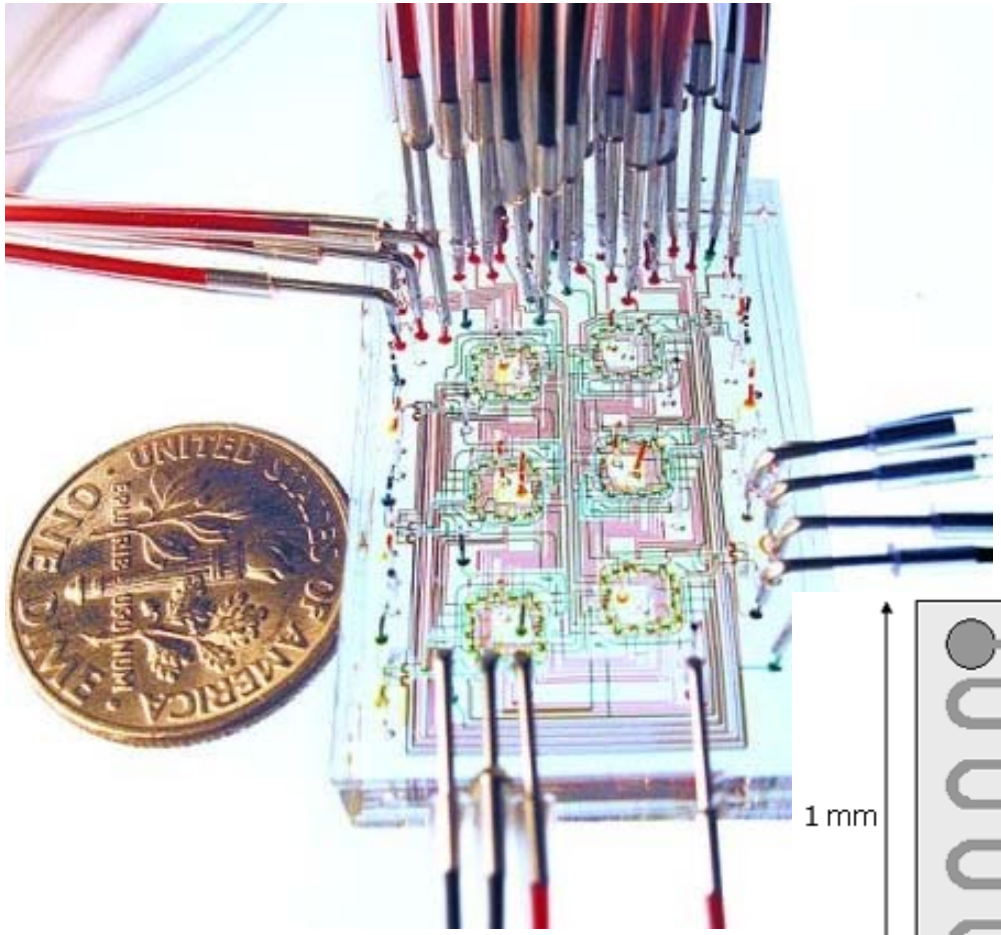
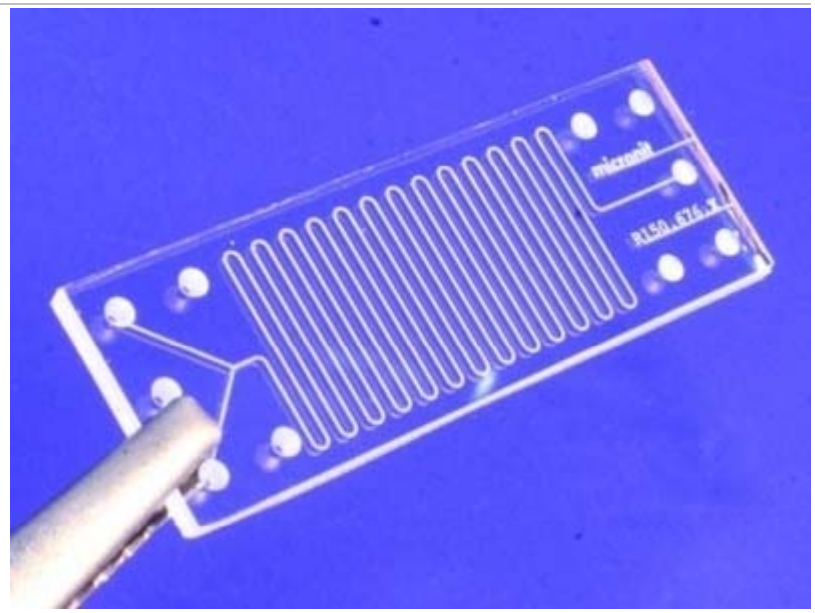
Fraunhofer IZM

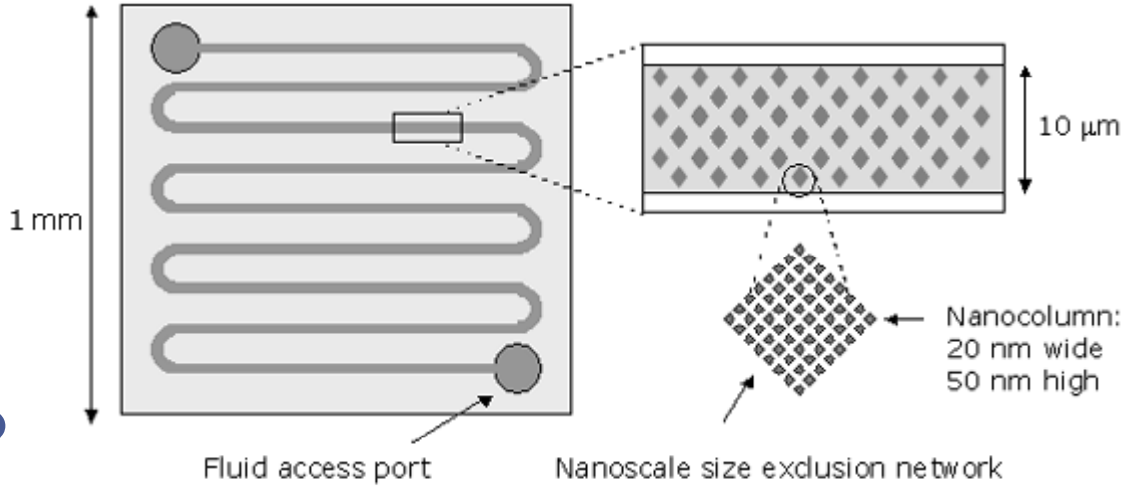
F. Siegel et al.: *Gravure Printing of Thick Film Electrodes for PEM Fuel Cell Production* . **Proc. iarigai, Budapest 2011**

Lab-on-Chip → analysis of body fluids

source of figures: http://gmwgroup.harvard.edu/research_microfluidics.html

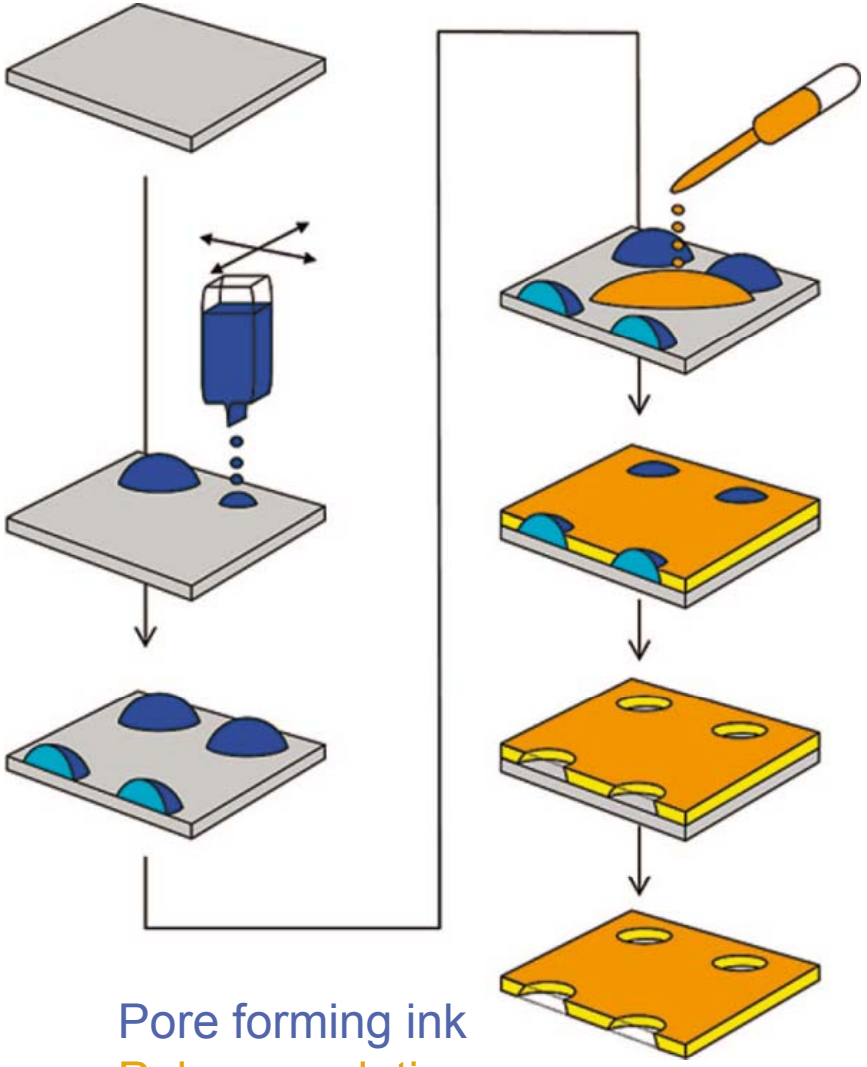


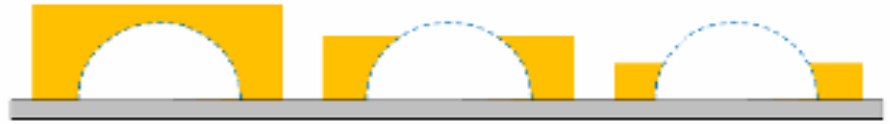


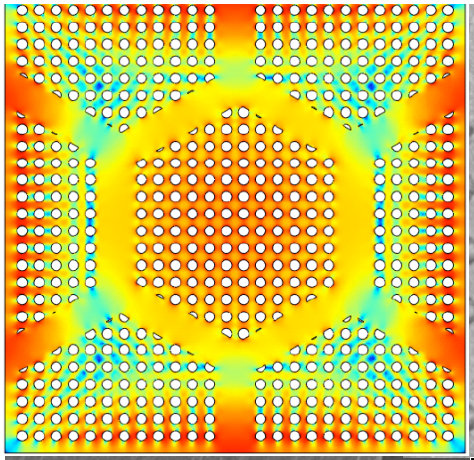


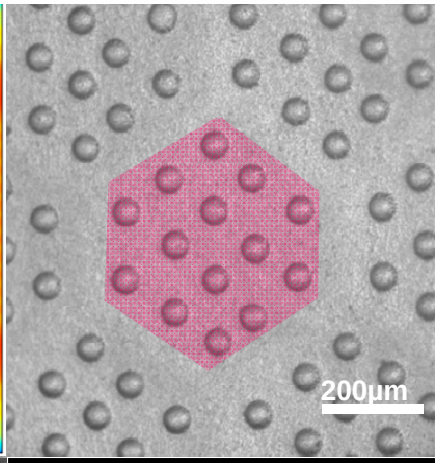
µ and nano filter ?

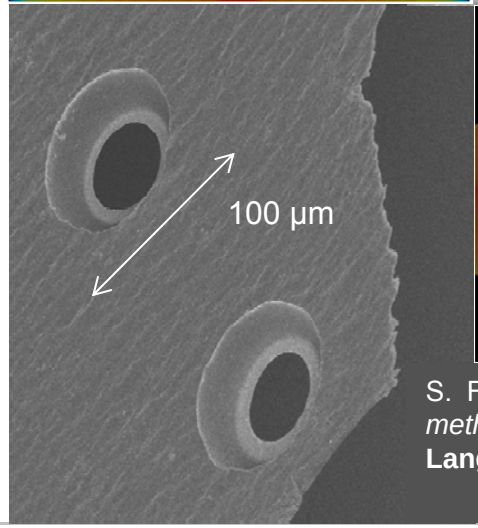
Printed Polymeric Microsieves

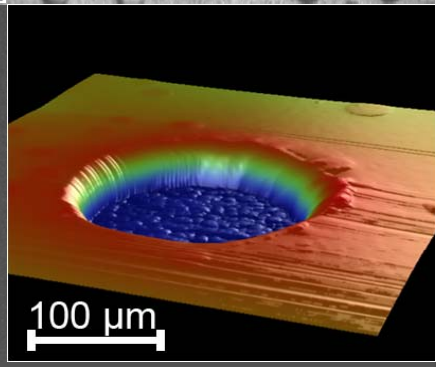












S. F. Jahn et al.: *Inkjet fabrication method for polymer microsieves.* **Langmuir, 2009, 25 (1), 606–610.**

German Patent DE102006016063.0

Printed Functionalities

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Prof. Dr. Reinhard R. Baumann
reinhard.baumann@enas.fraunhofer.de