Printed Electronics at Acreo

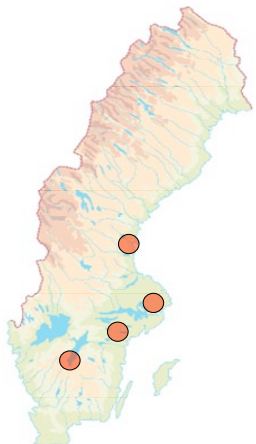
Acreo

Acreo AB is a research organisation that is part of the Swedish ICT Research AB owned by Industry (40%) and government (60%)

The business idea is to contribute to increased competitiveness, growth and entrepreneurship by refining and transferring research results into viable products and processes in electronics, optics and communication technology.

Acreo does this by:

- Technical research
- Contract R&D
- Promoting spin-off companies
- Creating inward investments in development and production



Number of Employees: 140
(110 with univ degrees, 1/3 with PhD degrees)
Yearly turn over: **180 MSEK**

Printed electronics technology platform

Vision

Electronic materials from solution

↓

Low cost manufacturing (e.g. printing) and Novel device functionality

↓

Enable electronic (and bio-electronic) functionality on every object

↓

Ambient Intelligence

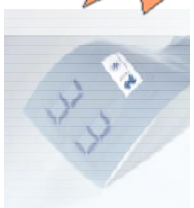
Two different approaches to Printed Electronics

High functionality (e.g. full color flexible video display)

Price driven Development (Others)

Price/Performance

Ambient intelligence

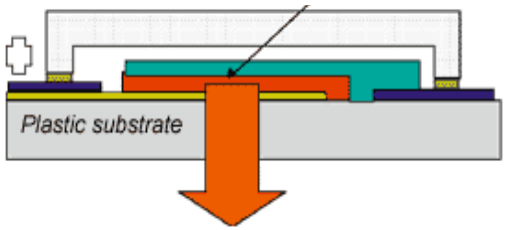


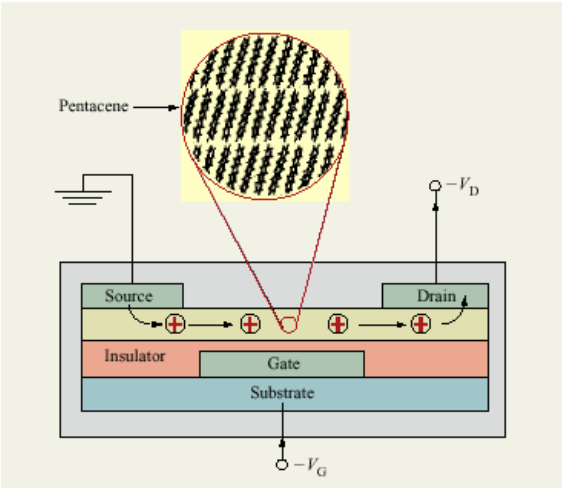
Functionality driven development (Acreo)

Low functionality (e.g. simple one-color text message displays) (Print Today)

“High functionality”

Field Effect Components – Requires thin layers (100 nm) and/or high voltage





Schematic of organic semiconducting p-type thin-film transistor with top contacts.

Example of Paper Surface:

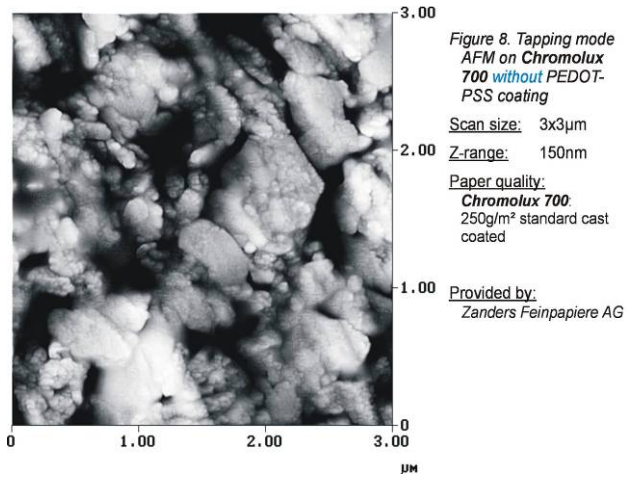


*Figure 8. Tapping mode AFM on **Chromolux 700** without PEDOT-PSS coating*

Scan size: 3x3µm

Z-range: 150nm

Paper quality:
Chromolux 700:
250g/m² standard cast coated

Provided by:
Zanders Feinpapiere AG

Most battery solutions gives basic voltages of 1.5 V

- Put several in series
- Charge pumps

“Low functionality “ approach (or Print Today Approach)

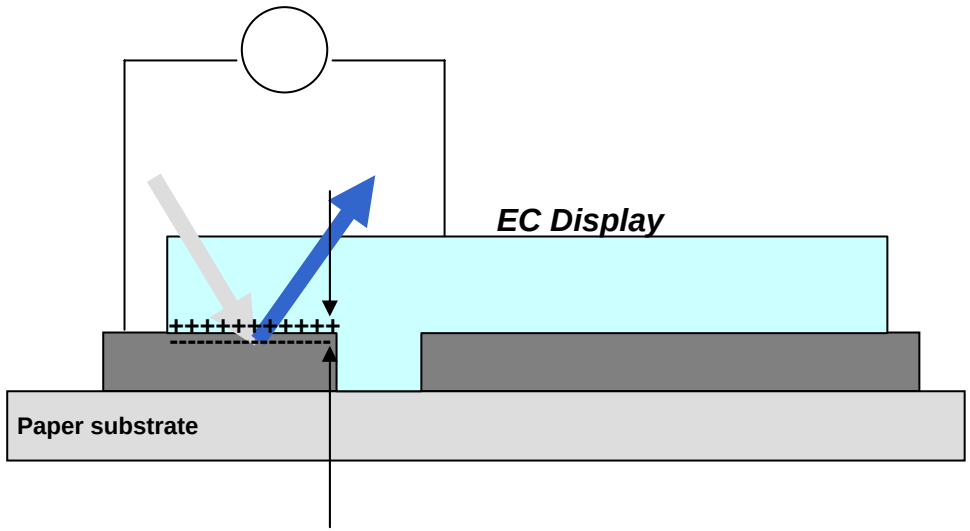
Develop materials and components that require **no critical dimensions to be printed** and thus can be **printed with today's mass printing equipment**

Robust components

Fast time to market

Get money and Industry interest – further development towards higher functionality

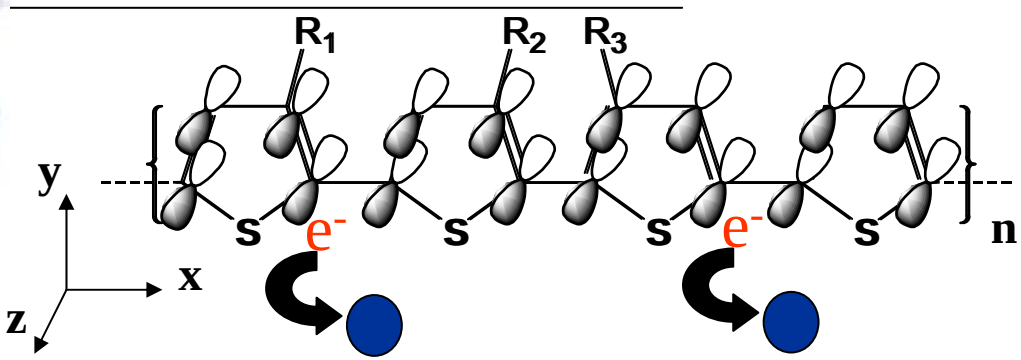
Chemical potential (1-3 V)



Critical dimensions (formed spontaneously at the interface)

Conjugated polymers

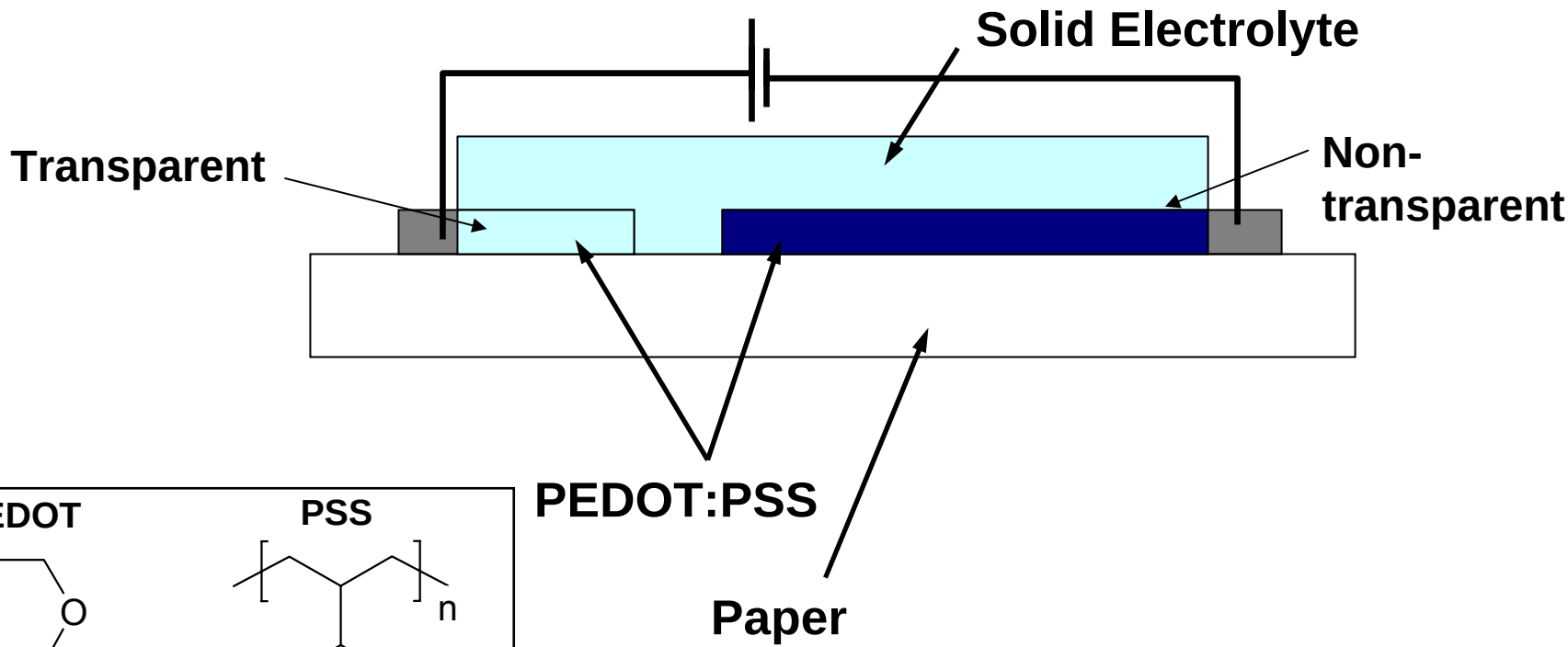
- Long aromatic molecular chains
- One dimensional conductors and semiconductors

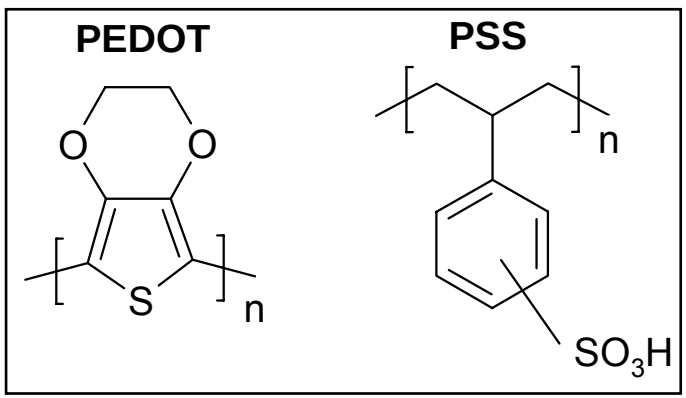


Can be used for:

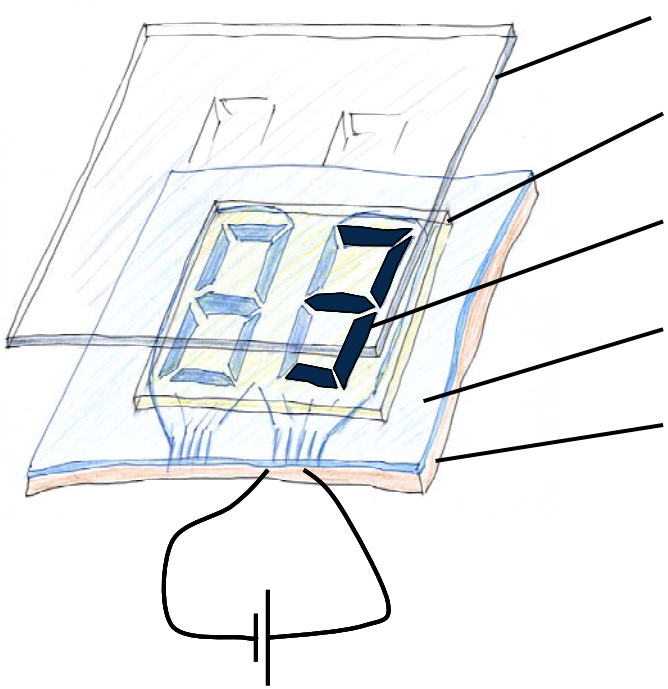
1. **Conducting inks**
2. **Switching inks (bistable)**

Electrochemical components: Optical effects





Printed displays



Protective coating

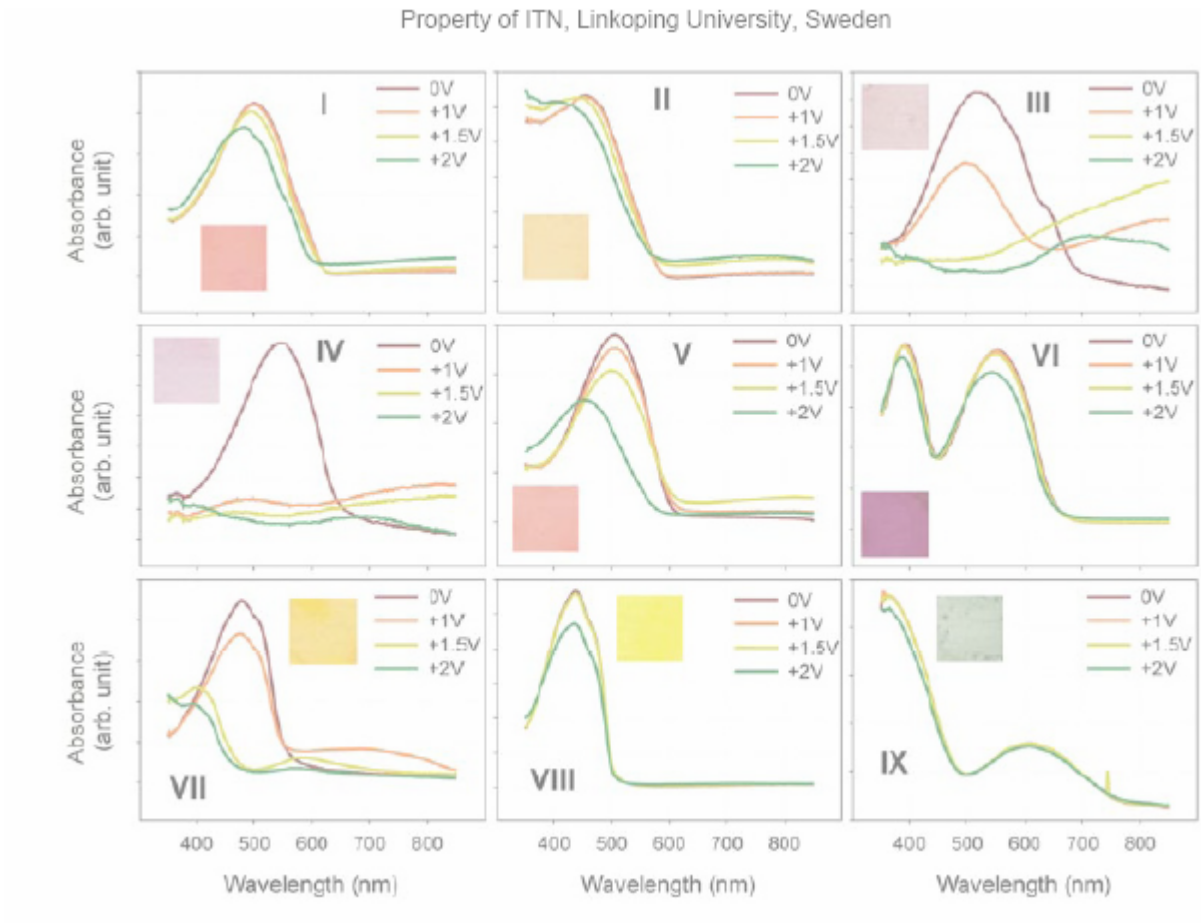
Printed electrolyte

Patterned electrochromic polymer

Conducting polymer coating

PE-coated fine paper

Other colors - Note R&D stage

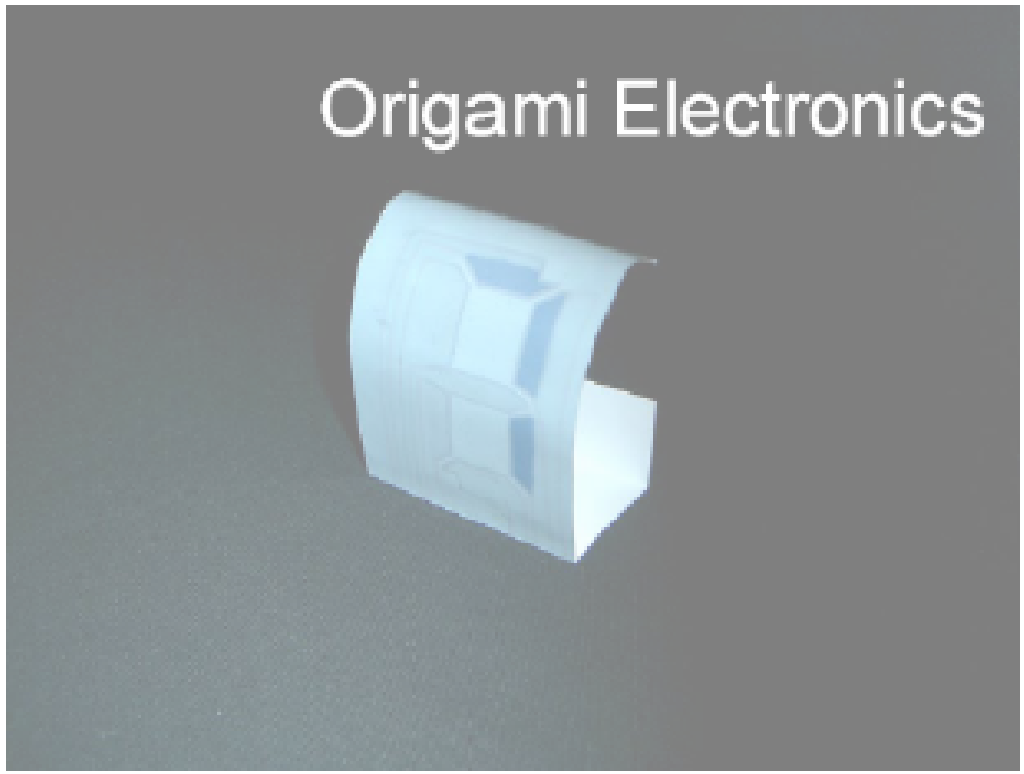


Demonstrators

Shelf labels (7-segment Display)

Indicators

Demonstrator

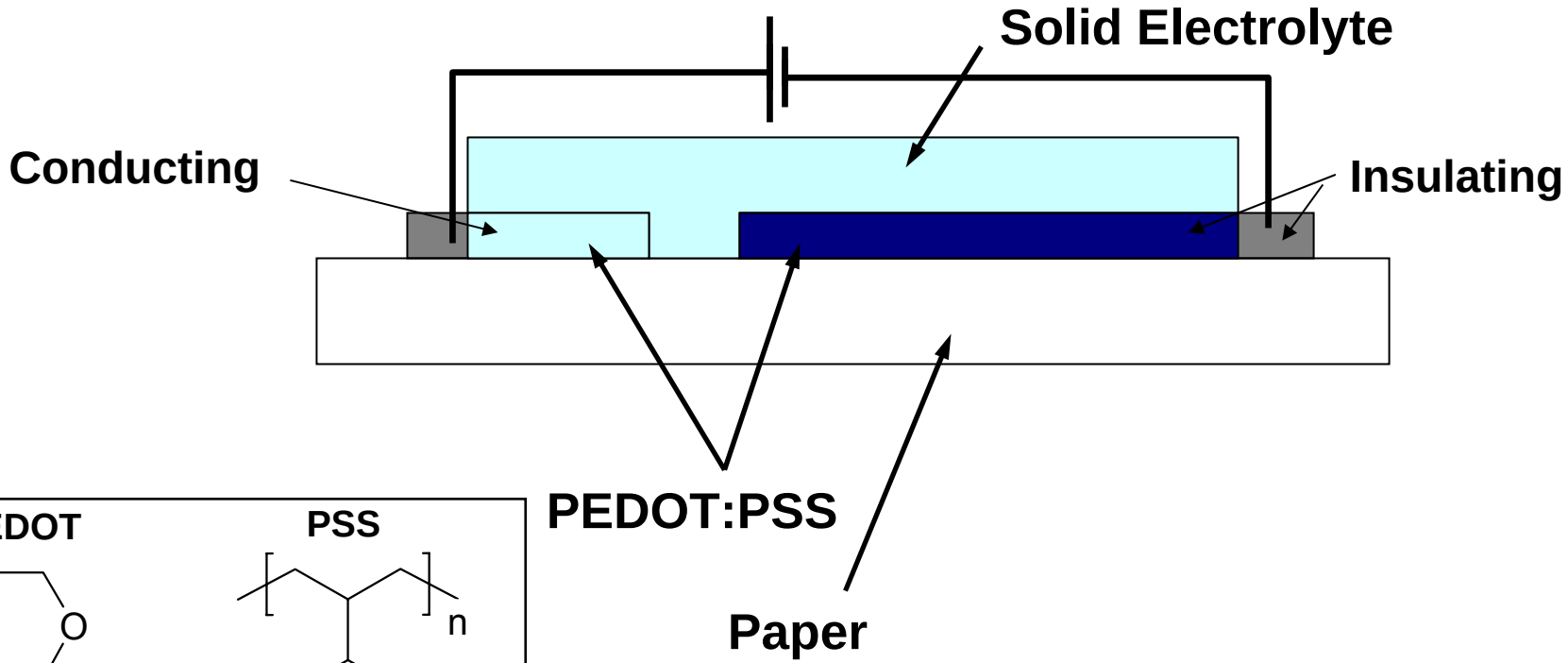


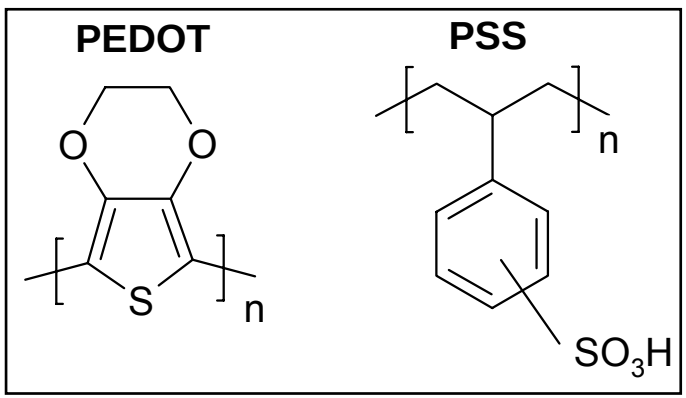
Printed displays - status

Prototype phase (Acreo):

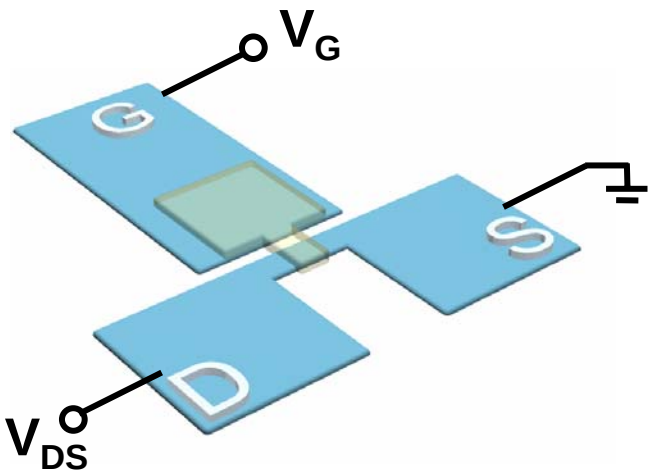
- Monochrome (Dark blue - light grey)
- Lateral structure: Counter electrode in the same plane as active electrode - simple processing
- Switch time: seconds
- Lifetime: > 9 months
- No of cycles: 1000 -10 000
- Retention: 15 min (typical)
- Generic high volume printing process (screen + lamination)
- Several potential customers/products

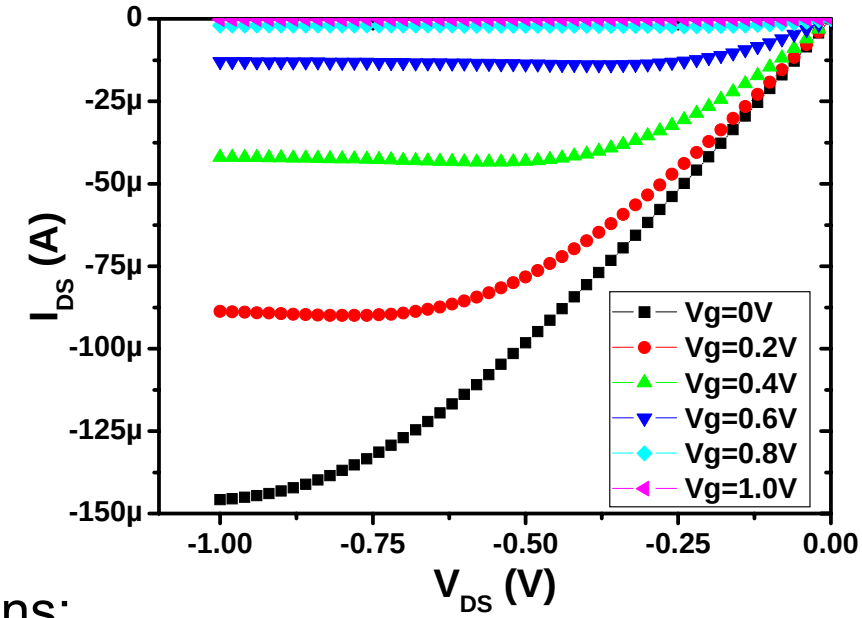
Electrochemical components: Electrical effects





Electrochemical Transistors





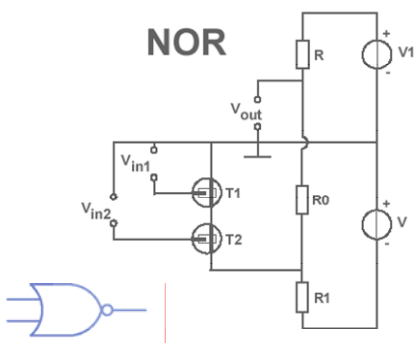
Features:

- Similar behavior as p-MOSFET depletion mode transistor
- 0.5 – 1.5 V
- Switch time: seconds
- Large current densities

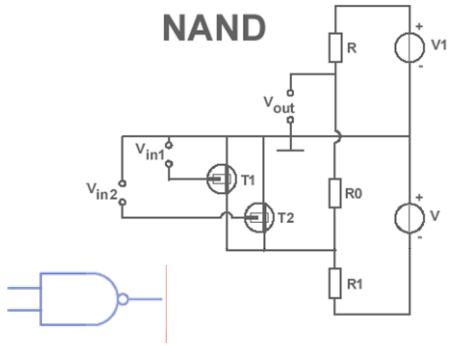
Applications:

- Counters
- Timer circuits
- Memory circuits
- Sensors
- Indicators

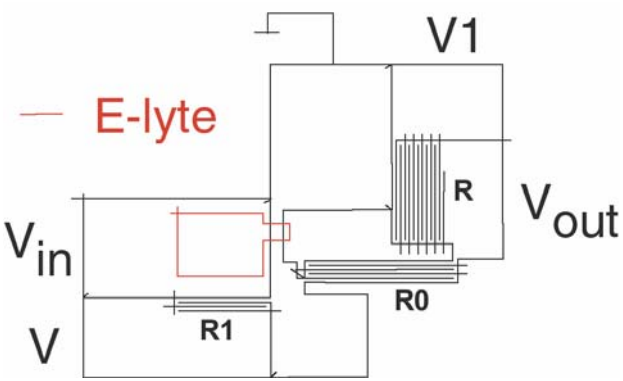
Building blocks for advanced electronic circuitry



Vin1	Vin2	Vout
0	0	1
1	0	0
0	1	0
1	1	0

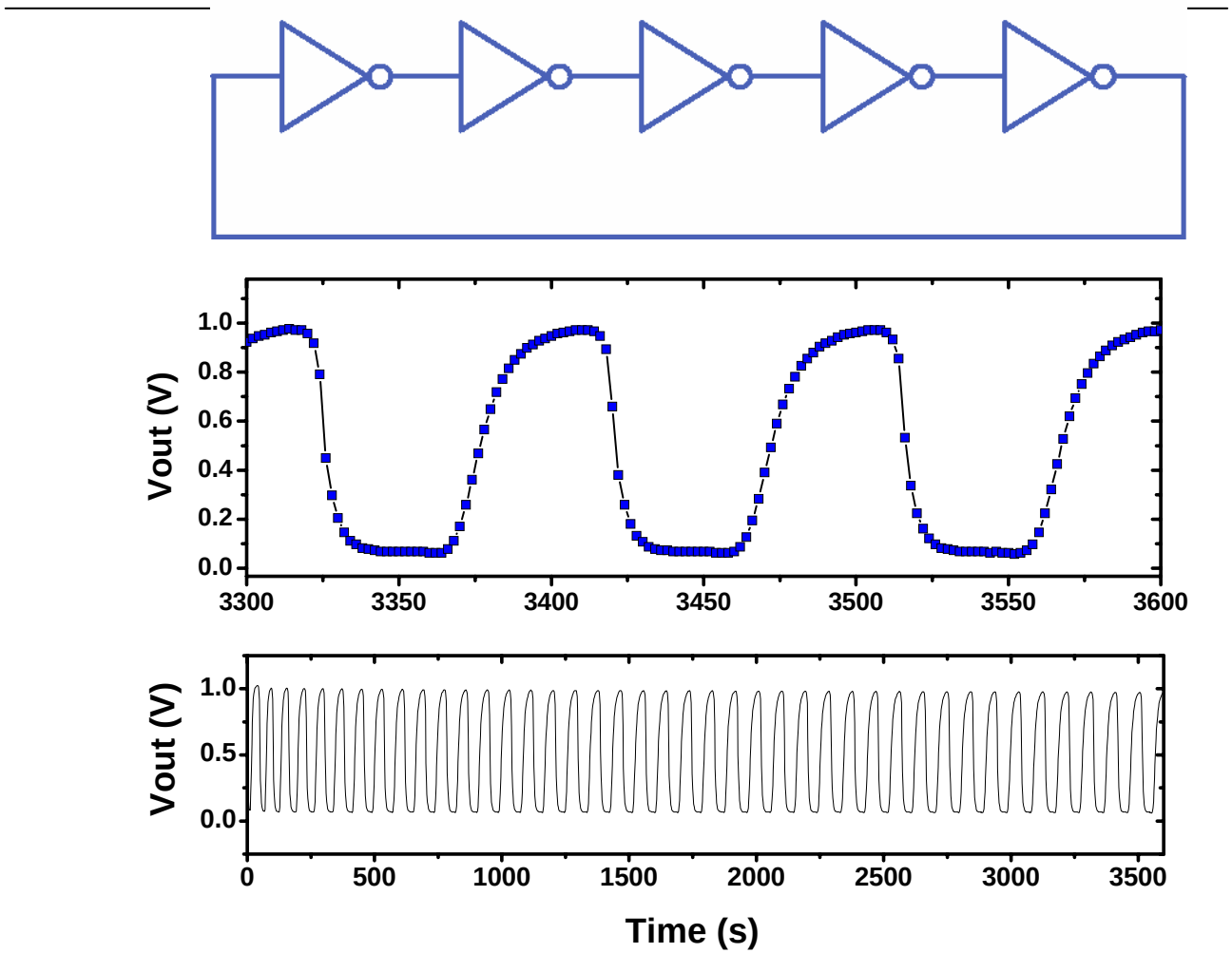


Vin1	Vin2	Vout
0	0	1
1	0	1
0	1	1
1	1	0

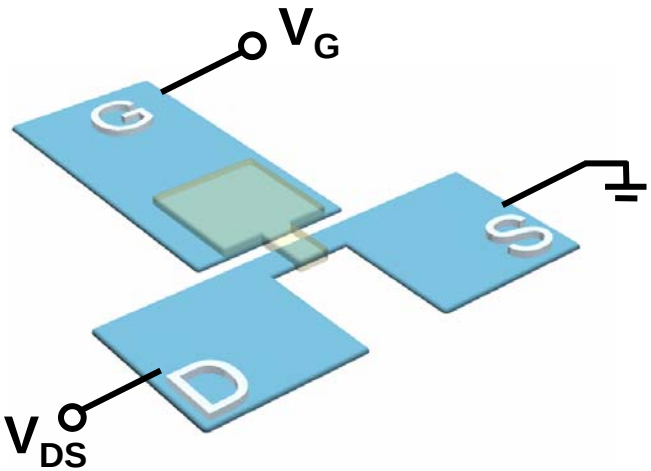


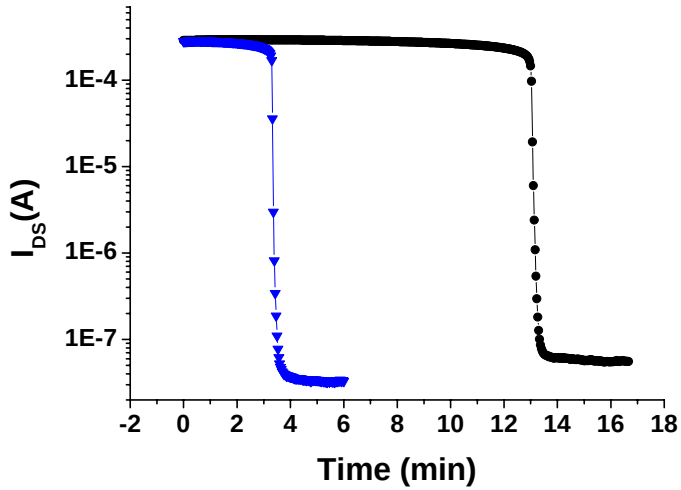
Our goal with this generation of components is to make simle logic systems (drivers, registers, timers, sensors,…) on packages, labelslarge etc.

A simple subsystem – the Ring Oscillator

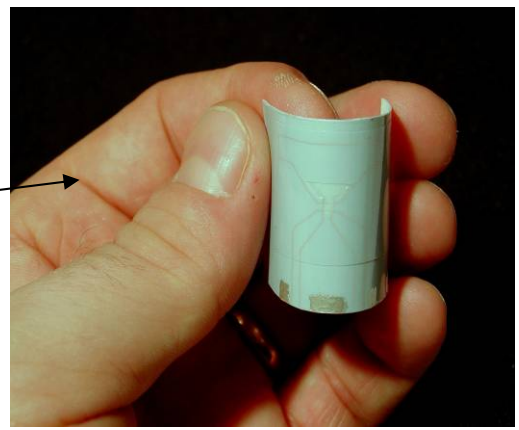


Timer transistor





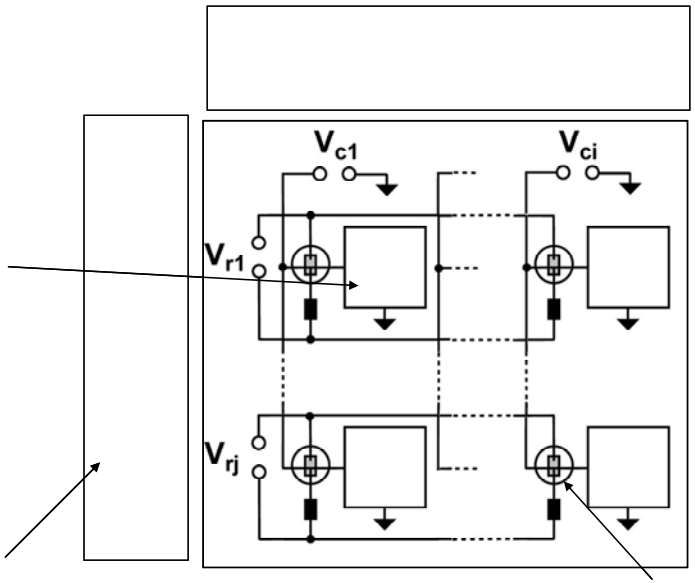
- **Timer-”time” specified in the printing process**
- **Irreversible switch of trans-conductance yields a single use timer function**
- **Can be modified to humidity and temperature logging**



Matrix addressed paper display

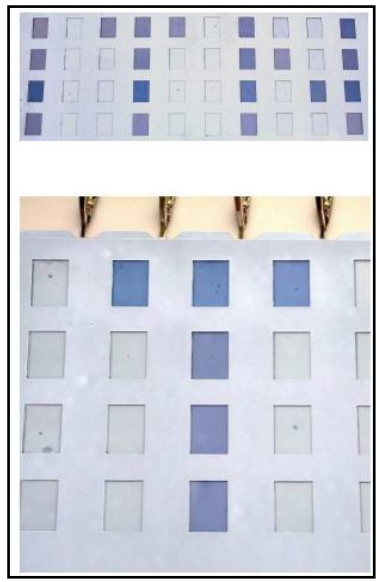
- **Transistors and display pixels made from the same base technology**

1 st demo:



Multiplexer/Decoder /Drivers

Enhancement transistors

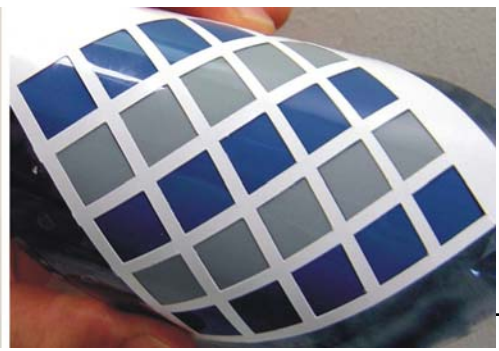


P. Andersson et al, Active Matrix Displays Based on All-Organic Electrochemical Smart Pixels Printed on Paper, Advanced Materials, vol. 14, no 20, 1460-1464, (2002).

Summary active matrix displays

- Smart pixels arranged into cross-point matrix
- Paper or plastic substrates
- Flexible displays
- All-organic materials
- Standard printing techniques
- Low operation voltage
- Low currents → Low power consumption
- Fill factor ≥ 65 %
- No additional resistors or electrical vias:
  Promising for reel-to-reel manufacturing



Powering

Battery

- Printable
- Simple construction
- 1,5 Volt, 1.0 mA max load, 300µA continuous
- Collaboration with battery company

Photo voltaics

- University cooperation (IFM)
- R2R focus

RF power

- Diodes + metal antennas
- Diodes: Printable, DC from 100kHz-15 MHz
- Antennas (DPP – see next slides)

Dry Phase Patterning of metal/polymer laminates

High Speed production

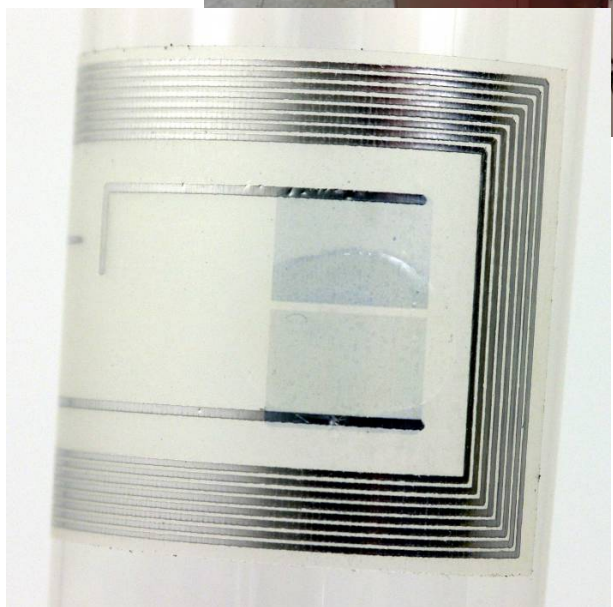
- High volume R2R production (150 m/min)
- Low cost

Environmental friendly

- Recyclable residual products
- No chemicals

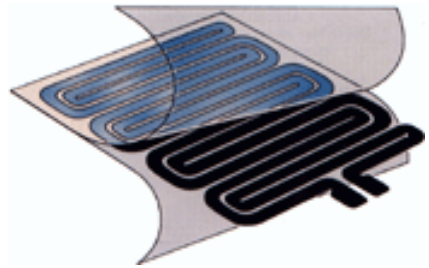
New Products

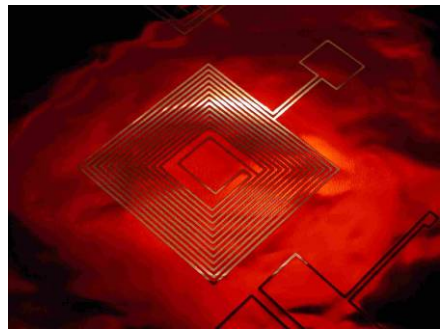
- Paper substrates
- Heat sensitive materials

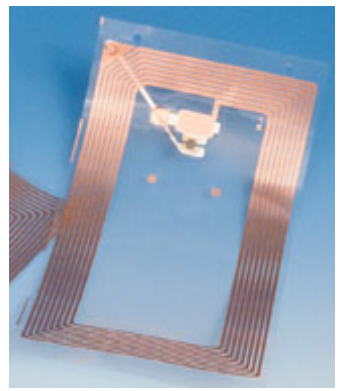


Application areas

- Antennas
- EAS tags
- Heating foils
- Printed circuit interconnect
- Replace wires in cars
- Pattren of laminated materials
- Create texture in materials

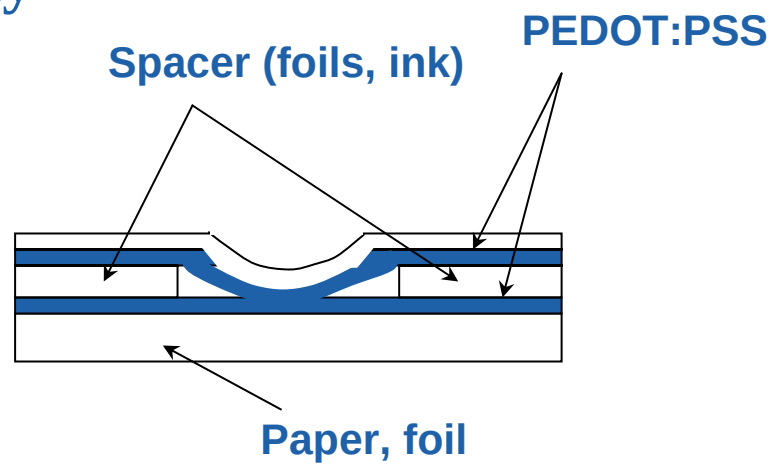


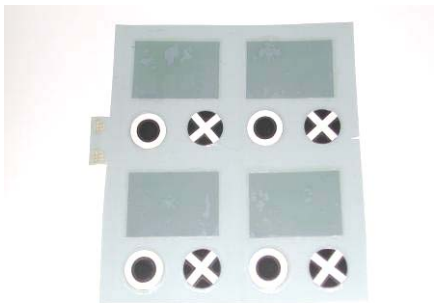


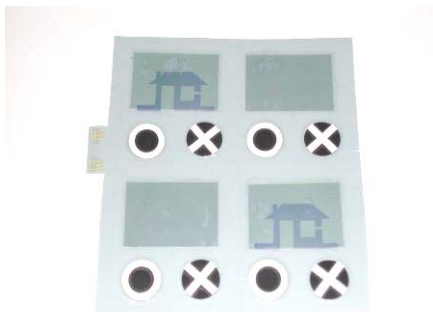


Interactivity with the paper

Push buttons – interactivity







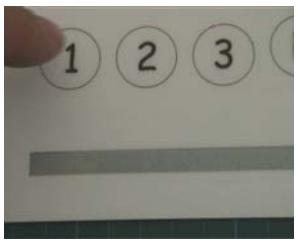
Electronic memory game printed on paper

Concept Demonstrator

”Smart Label”

Includes:

- **Display**
- **Push-buttons**
- **Logics (transistors)**
- **Battery**



Elektronic- id

Properties

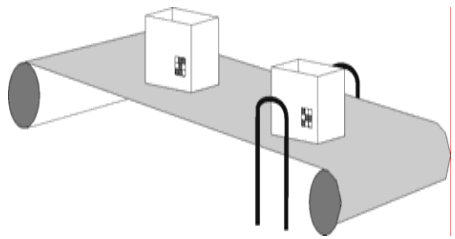
- Electrically readable printed id code
- Only organic materials (environmentally friendly)
- Can be printed by standard printing equipment. Easy to integrate into printing line
- Can be read through all "non-conducting" materials
- Can be over printed or laminated (hidden)
- Simple, low cost reader

Produkt demonstrators

Demo: Medical packaging

Others:

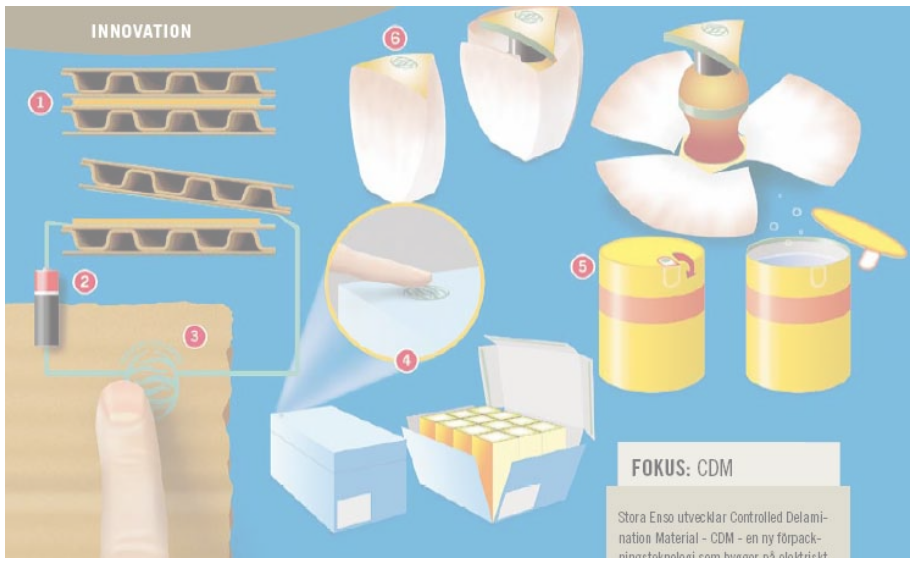
- Security
- Authentification
- Brand protection
- Logistics
- Etc.



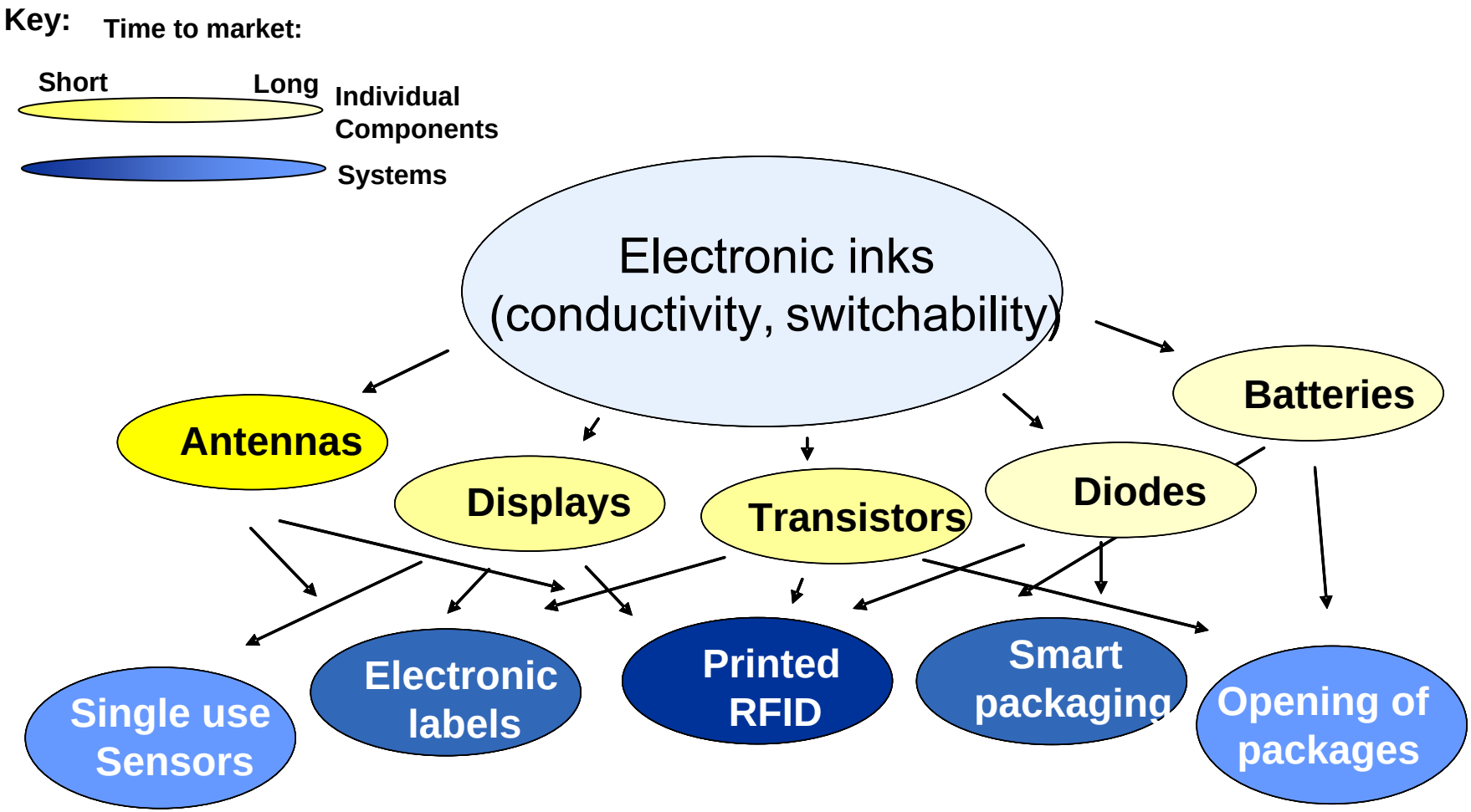
CDM, Controlled Delamination Materials with Stora Enso

Stora Enso is developing new electrical delamination technology for opening packages. With CDM, Controlled Delamination Materials, two attached packages or parts of packages can be easily separated using electricity. This enables easy opening of consumer packages and new distribution solutions, in which CDM is used to hold the items together and to release them smoothly.

The cooperating partners include leading research institutes such as the Royal Institute of Technology in Stockholm, Karlstad University, the Packaging Arena and the Acreo Institute in Sweden.



Overview - technology platform



Product ideas – product monitoring

- History monitors
- Freshness sensors
- Timers with display to show expired products
- Digital thermometers
- Humidity sensors
- Freezing indicators
- etc

Product ideas – Interactive packages

Hidden special offers

To display interactive communication

Simple games

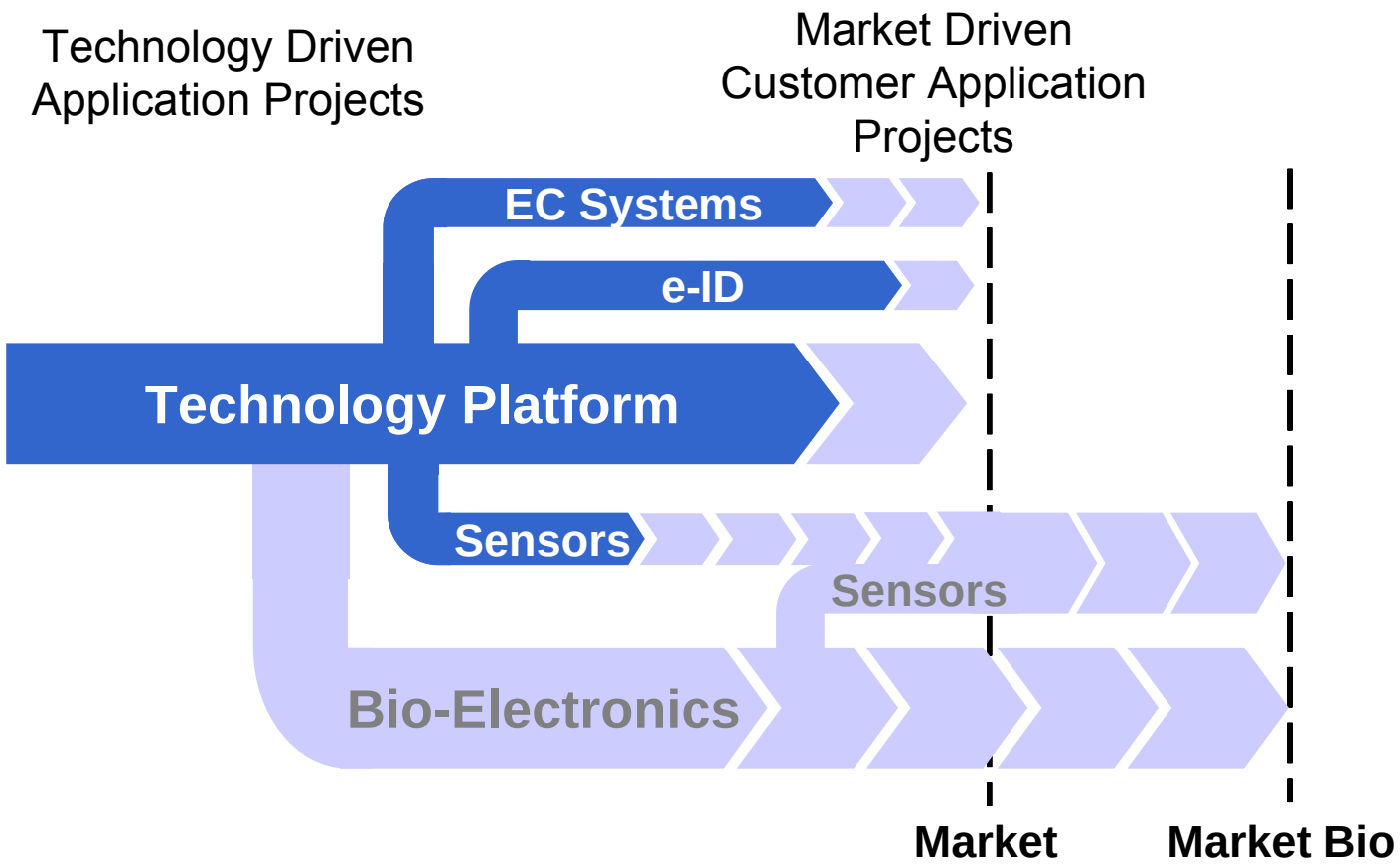
Product ideas - authentification

Tickets
Perfumes
Pharmaceuticals
Electronics
Computer games
etc

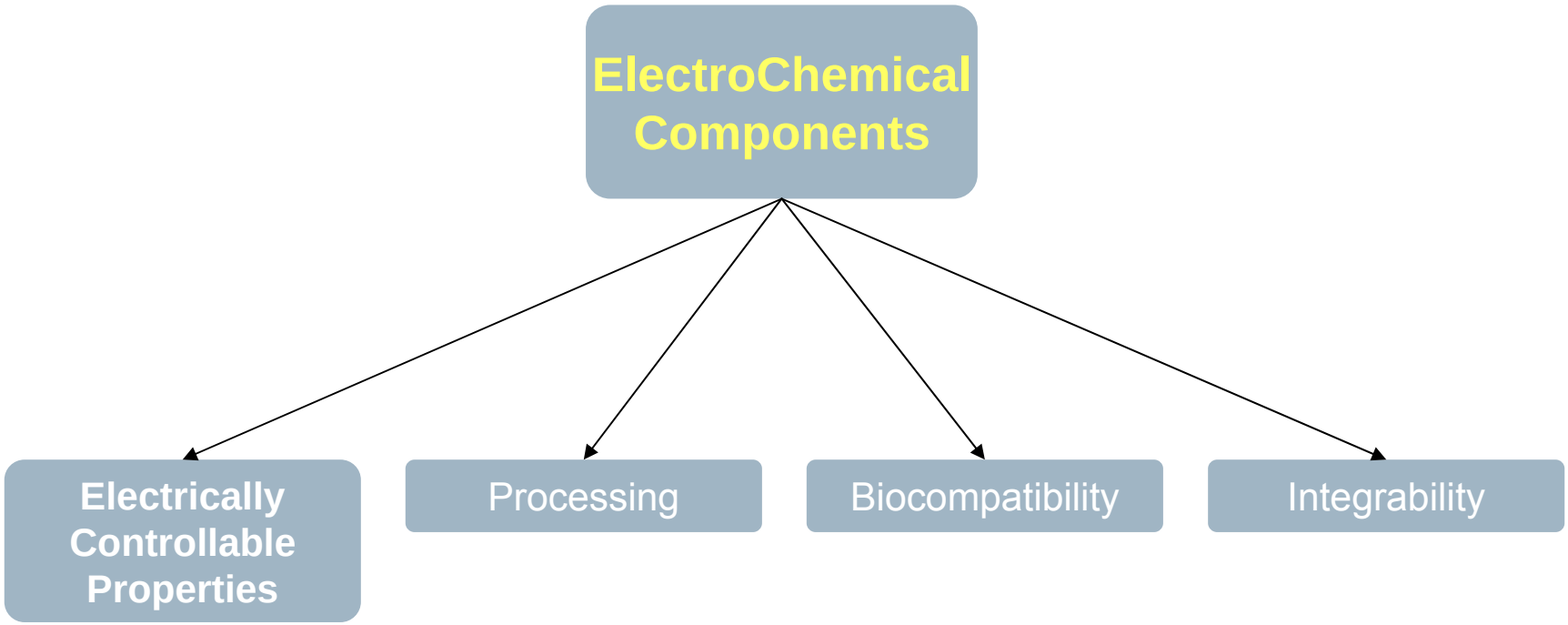
Authentification:

- Push a button and get verification on a display
- Verification can be either direct or via logic circuitry

Next step


Technology Driven
Application Projects
Market Driven
Customer Application
Projects
EC Systems
e-ID
Technology Platform
Sensors
Sensors
Bio-Electronics
Market
Market Bio

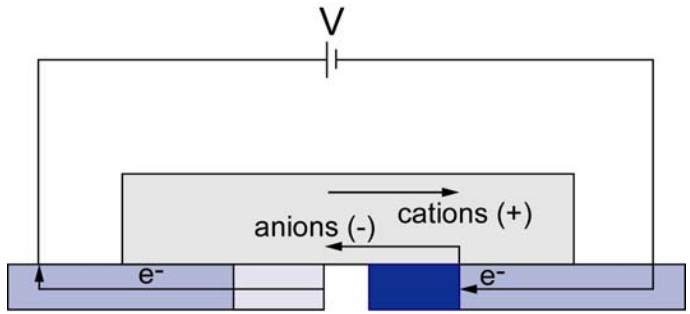
Electrochemical Components



Electrically Controllable Properties

Electrochemical devices can be used to transfer *electronic* currents into *ionic* currents and vice versa.

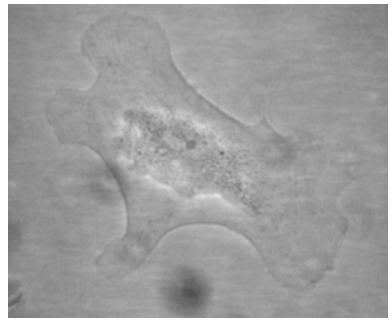
Oxidation/reduction of the polymer is accompanied not only by a ***change in color and conductivity but also surface energy*** (wettability).

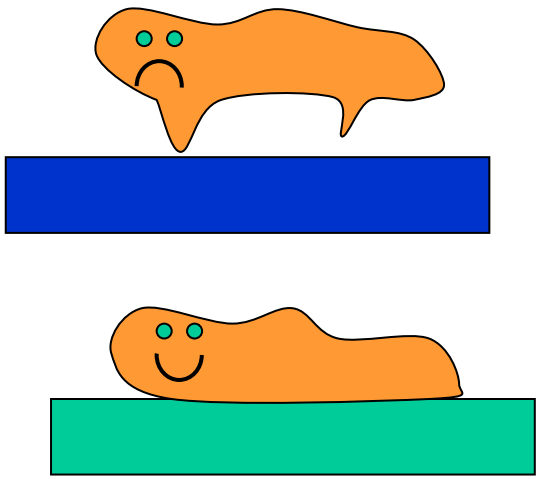


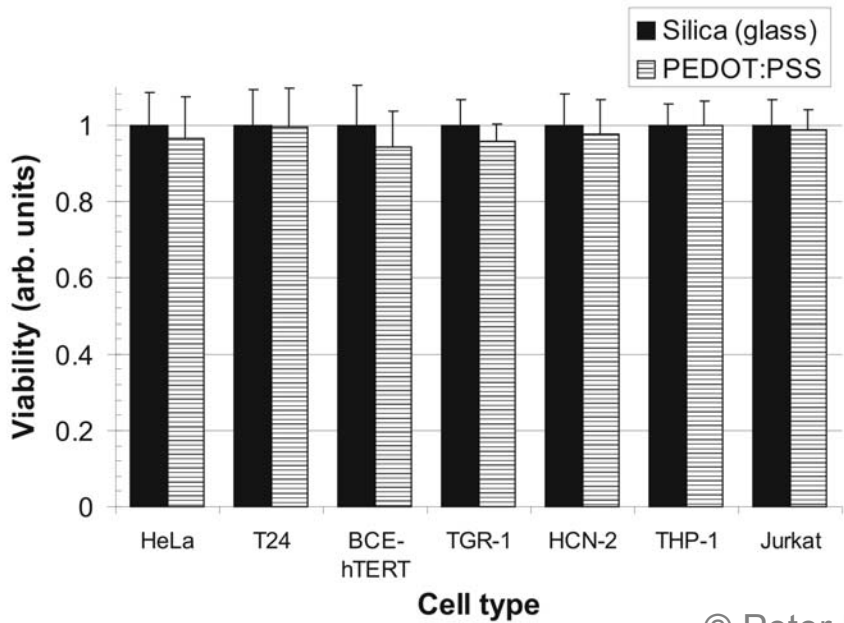
Bottom layer (blue):
Conducting polymer (PEDOT:PSS)
Top layer (grey):
Electrolyte

Biocompatibility

The PEDOT:PSS surface show great biocompatible properties. 7 different celltypes have been used when comparing the viability on PEDOT:PSS and silica, all show comparable viability.







OBOE

Goal:

The goal of the OBOE project is to record and regulate signals in individual cells to control stem cell differentiation, steer cell-to-cell signaling and to achieve neural interconnects using organic electronic ion-pumps; surface tension and texture switches; macromolecule dispensers; cell wall throughputs conjugated polyelectrolyte recorders.

Members:

Karolinska Institutet

Dept. of Microbiology and Tumorbiology Center: Agneta Richter-Dahlfors
Dept. of Medical Biochemistry and Biophysics: Ernest Arenas
Dept. of Cell and Molecular Biology: Jonas Frisén, Urban Lendahl
Dept. for Clinical Neuroscience: Hans von Holst
Dept. of Neuroscience: Ola Hermansson

Linköpings universitet INSTITUTE OF TECHNOLOGY

Organic Electronics: Magnus Berggren
Biomolecular and Organic Electronics: Olle Inganäs
Image Coding: Robert Forchheimer
Organic Chemistry: Peter Konradsson
Scientific Visualisation: Anders Ynnerman

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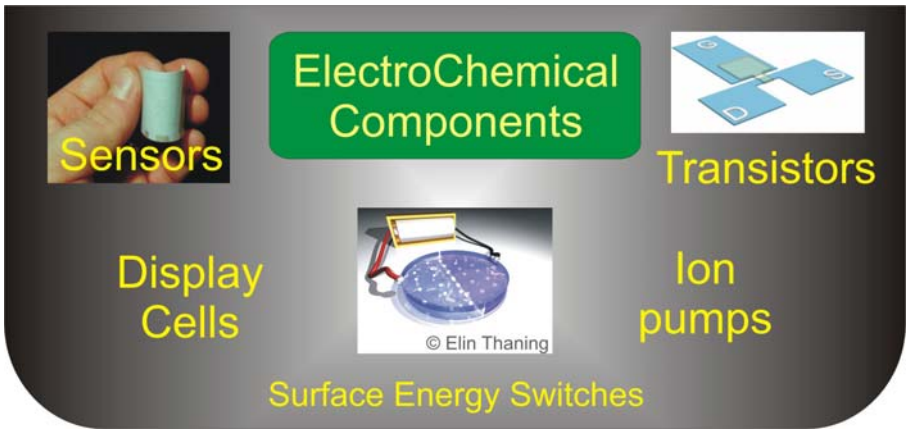
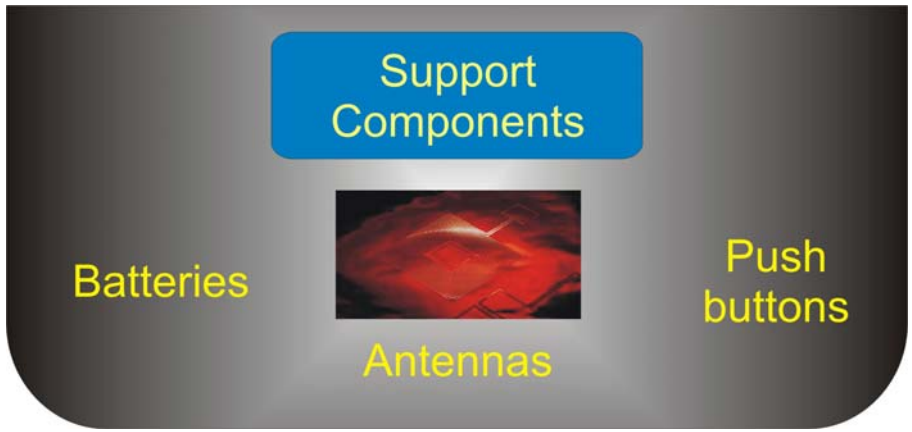
Printed Electronics: Göran Gustafsson

Toolbox and future visions





Future applications

By combining organic electronics and biology new simple self tests can be reality.