Printed Electronics

Introduction and Current Research

Isak Engquist

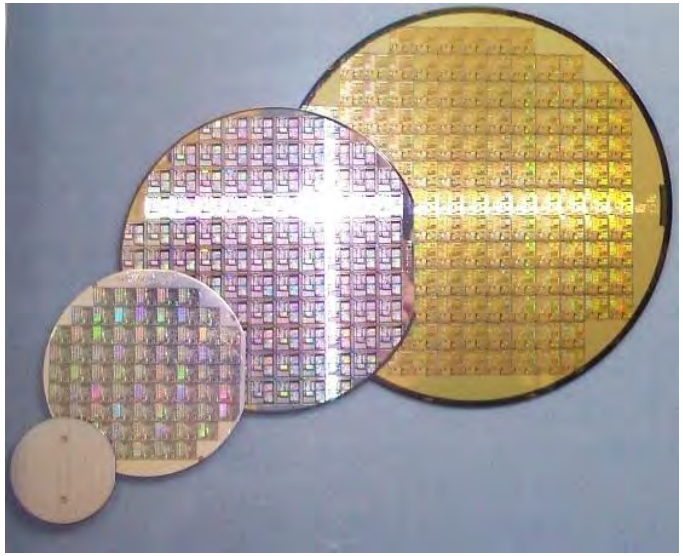
Organic Electronics, ITN

Organic Electronics group at LiU

- Founded in 2001
- 6 faculty, 2 postdocs, 14 PhD students
- Electrical engineering,
  organic chemistry, materials science
- Research
  - Printed Electronics
  - Organic Bioelectronics
  - Device Physics
- www.orgel.itn.liu.se

Organic Electronics

Electronics



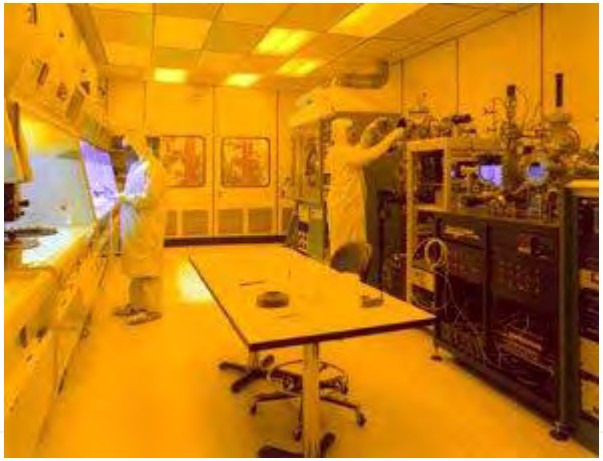
Electronics begins with the materials

Conductors

Insulators

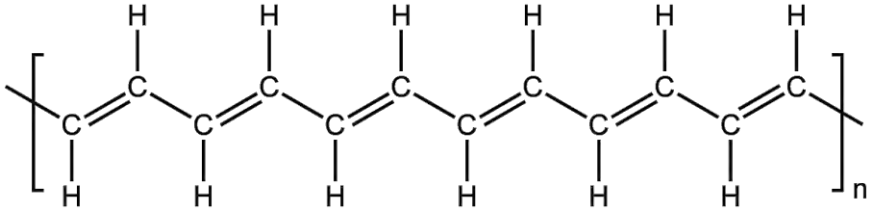
Semiconductors

Manufacturing equipment needed



€ 1,000,000,000

It all changed in 1977



Doped polyacetylene
conducts electricity!



Heeger, MacDiarmid, Shirakawa

Electronics
made with
Organic materials

Organic electronics!

Nobel Prize
2000

Organic electronic materials

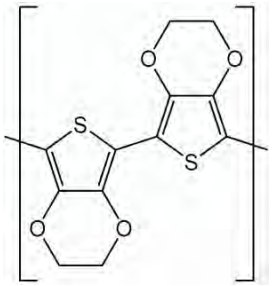
Ordinary electronic functionality is available:

- Conductors
- Semiconductors
- Insulators
- Dielectric materials
- Resistive materials
- Light emitting materials

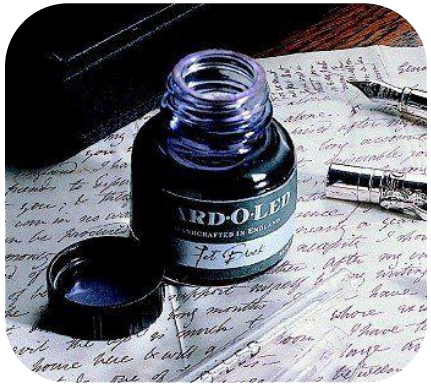
Organic materials also offer:

- Bending
- Stretching
- Solubility
- Color switching
- Specific chemical sensitivity
- Biocompatibility
- Ion transport
- Chemical doping/undoping
- Environmental compatibility

Electronic ink

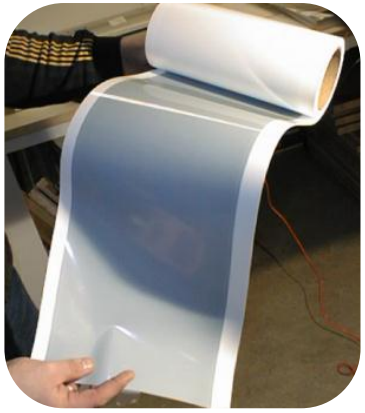


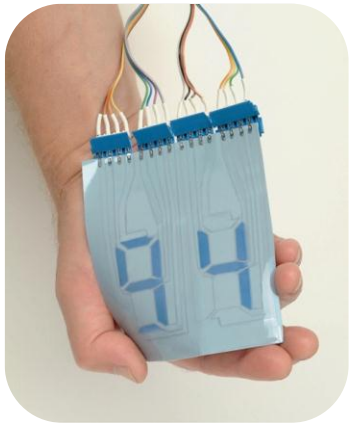
Conductive polymers....



...can be used in electronic ink...

...that is printable on paper!

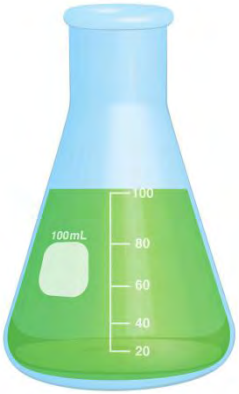




Printed electronics!

Organic electronic materials

Conductors



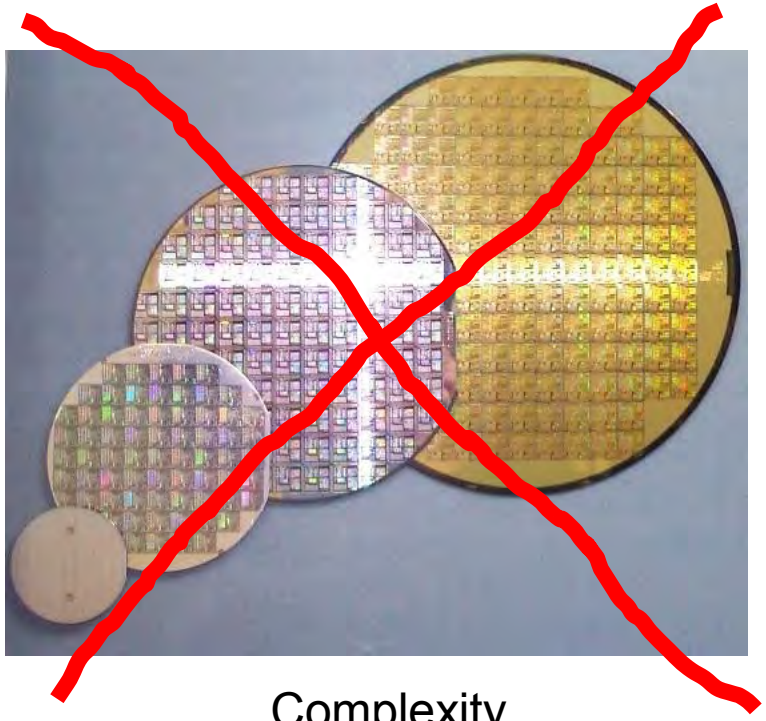
Insulators

Semiconductors

Manufacturing equipment needed

€ 1,000,000

Drawbacks?



Complexity

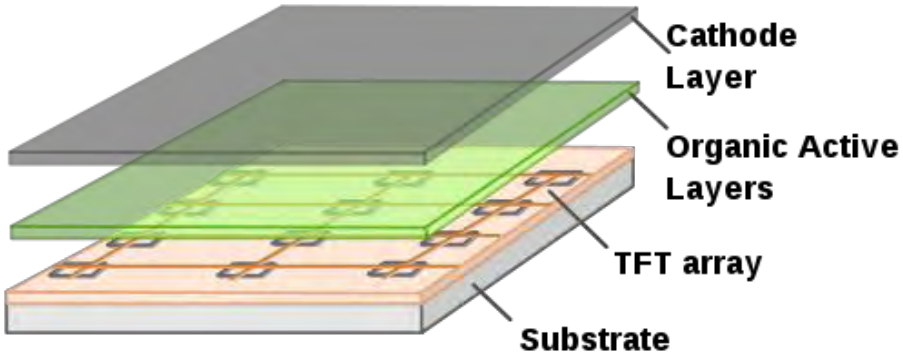
Size

Current issues

- Voltage
- Long-time stability

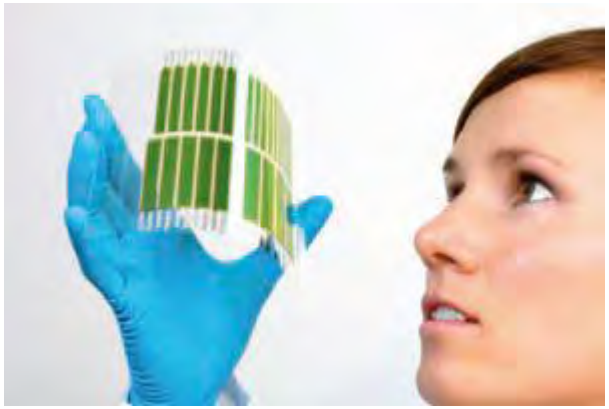
Where is printed electronics used today?

Displays



www.paperdisplay.se

Solar cells



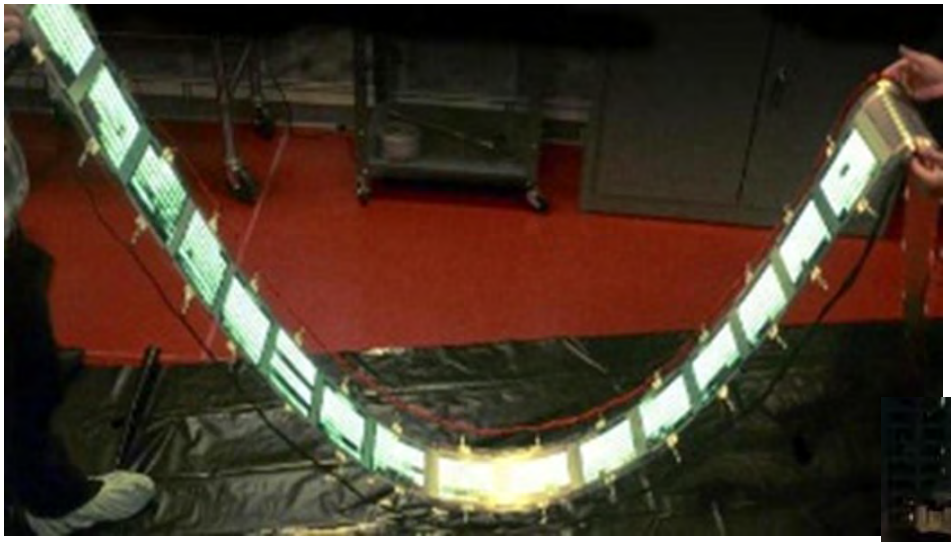
Heliatek GmbH

Power conversion efficiency

8,3%

(Konarka)

Lighting

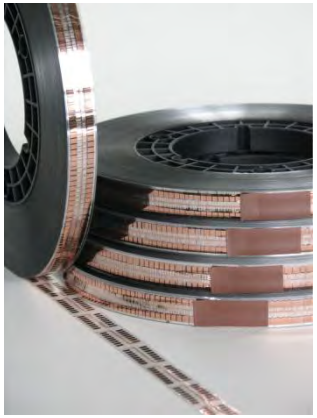


Osram opens pilot plant in Germany during 2011

www.osram.de

Electronic components and circuits

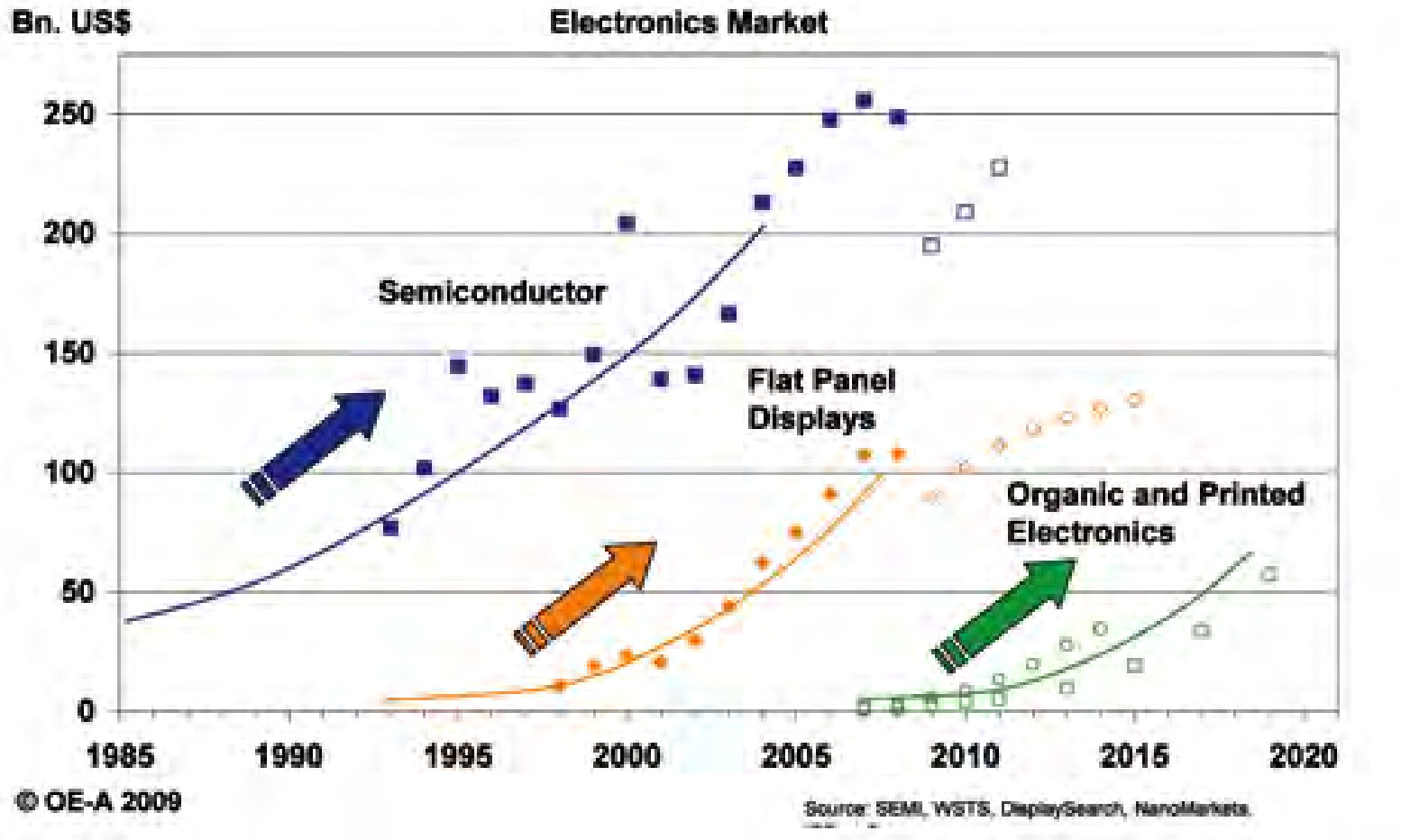
Zielke et al, Appl Phys Lett 87, 123508 (2005)



PolyIC, Thin Film Electronics

Hagen Klauk et. al.

OE-A Market forecast



Printed electronics activities in Norrköping

Printed Electronics in Norrköping

Linköping University

acreo

NORRKÖPING SCIENCE PARK

PEA Printed Electronics Arena

supported by:

VINNOVA
En investering för framtiden

EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden

NORRKÖPING

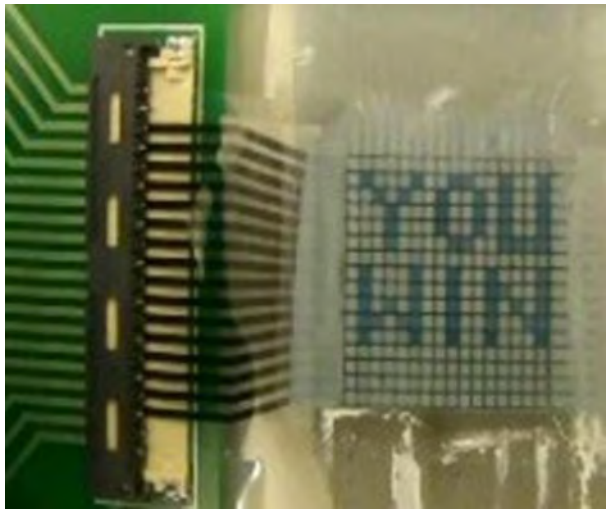
East Sweden Region

PEA Manufacturing

PEA
Printed
Electronics
Arena

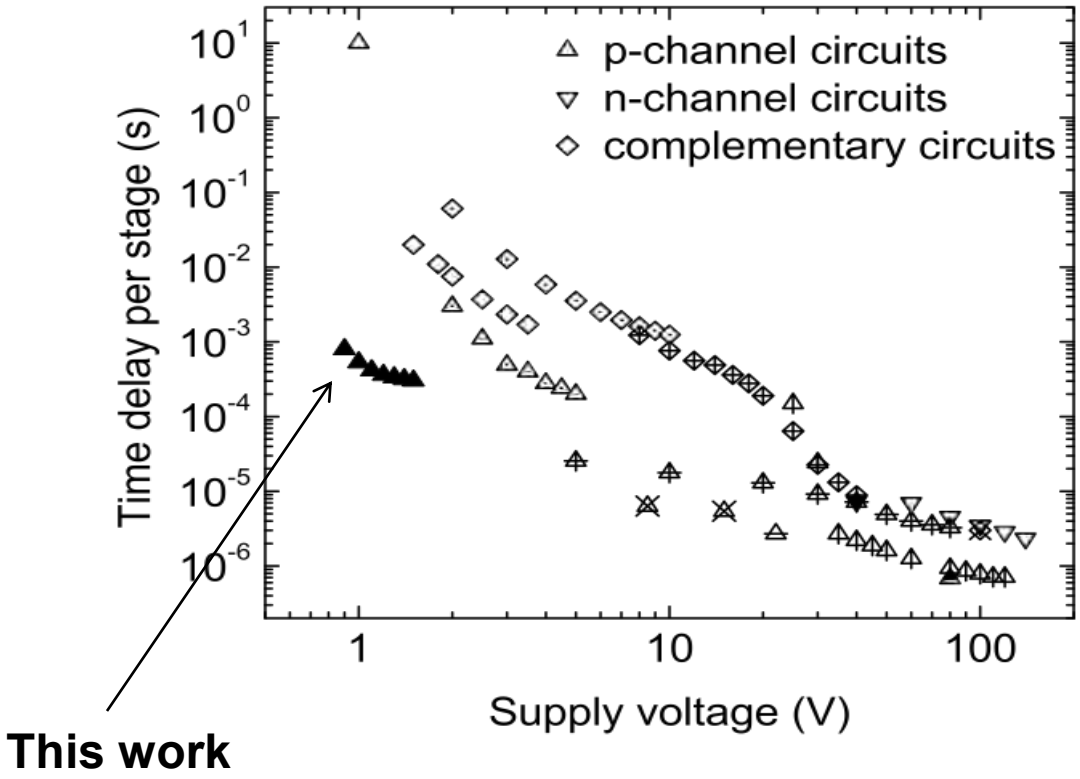
- Test environment for development of small scale production of Printed Electronics
- Equipment includes flat screen printing, UV, IR and hot air dryers, dry phase patterning equipment, inkjet printers, label printing press reel to reel for screen and flexo, lamination and a fully equipped analytical laboratory.

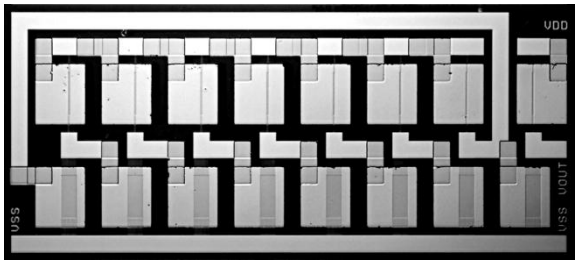
Displays



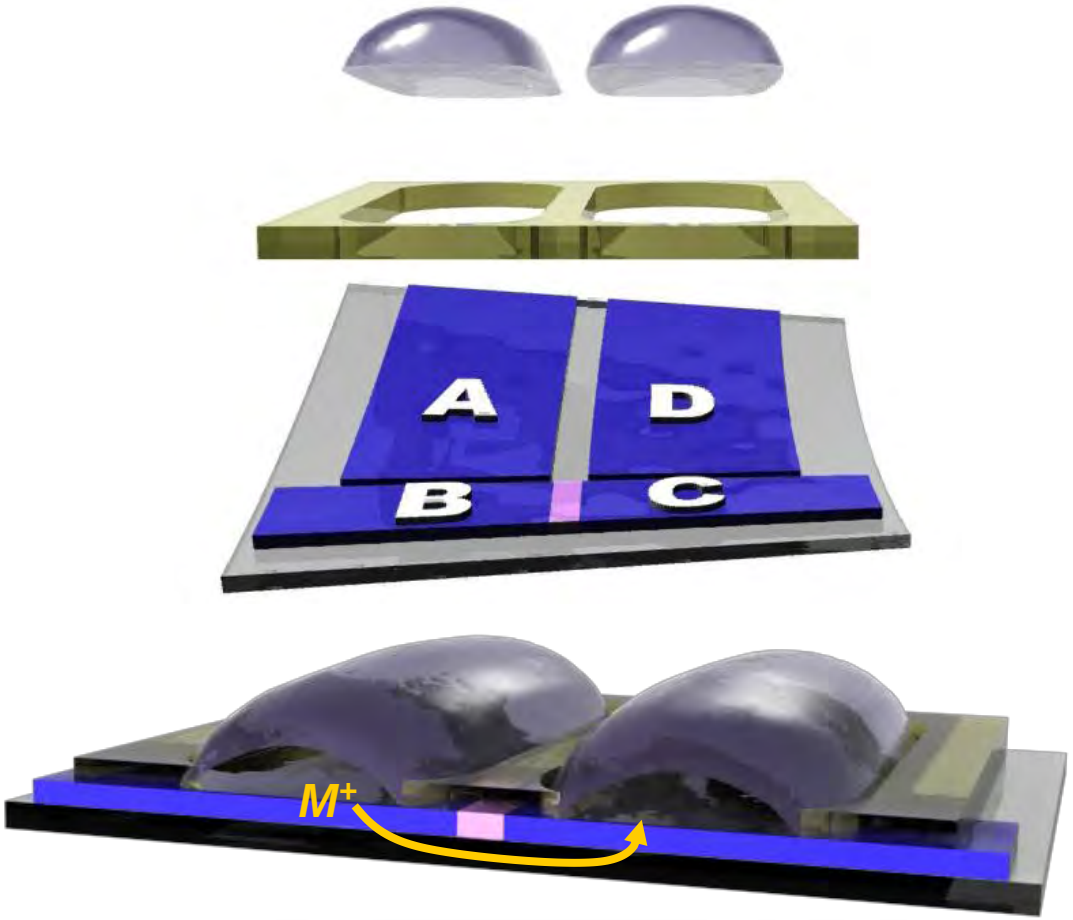
The 1 V transistor

The time delay per stage of OFET ring oscillators vs. the supply voltage





The ion pump

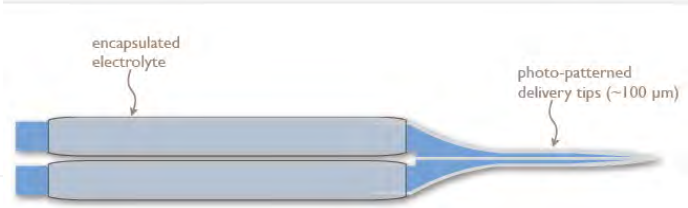


Electrolyte

Su-8 Barrier

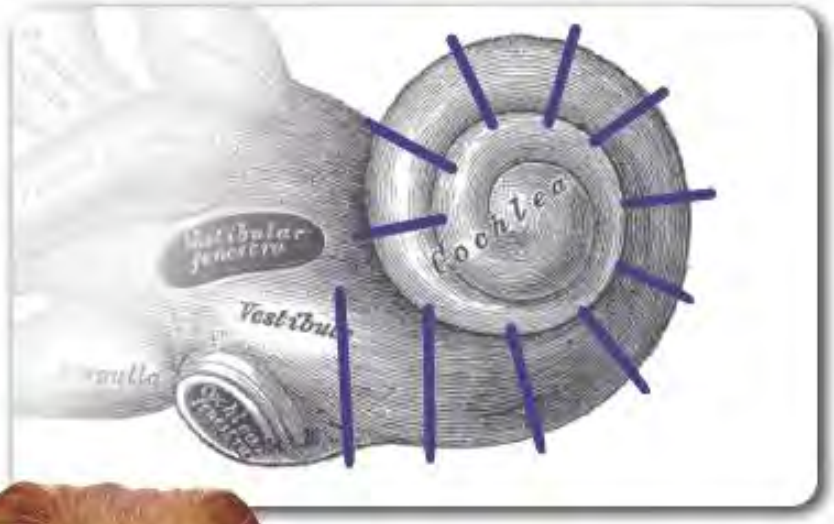
PEDOT:PSS

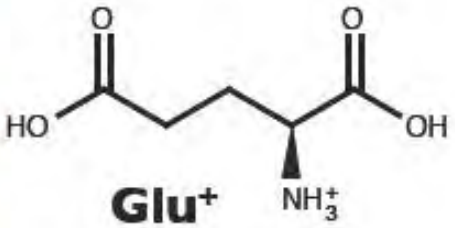
Substrate



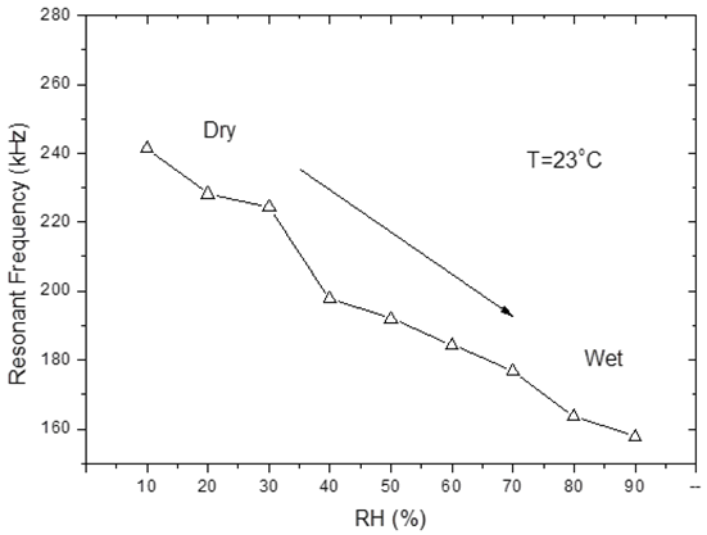
The ion pump in vivo: Delivery to the Guinea Pig Cochlea

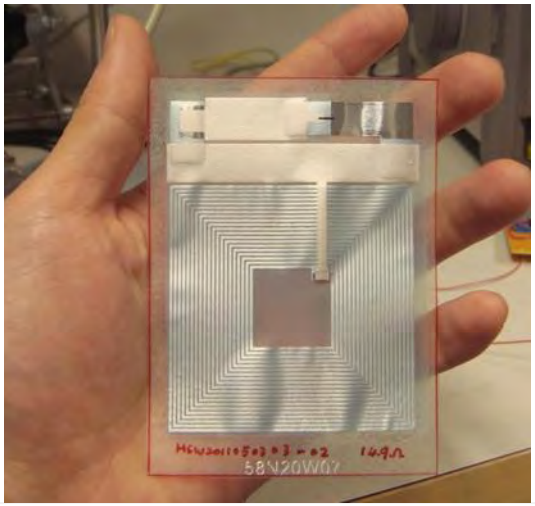
- hair cells damaged by Glu
- diffuse through RWM
- histological and "live" readout





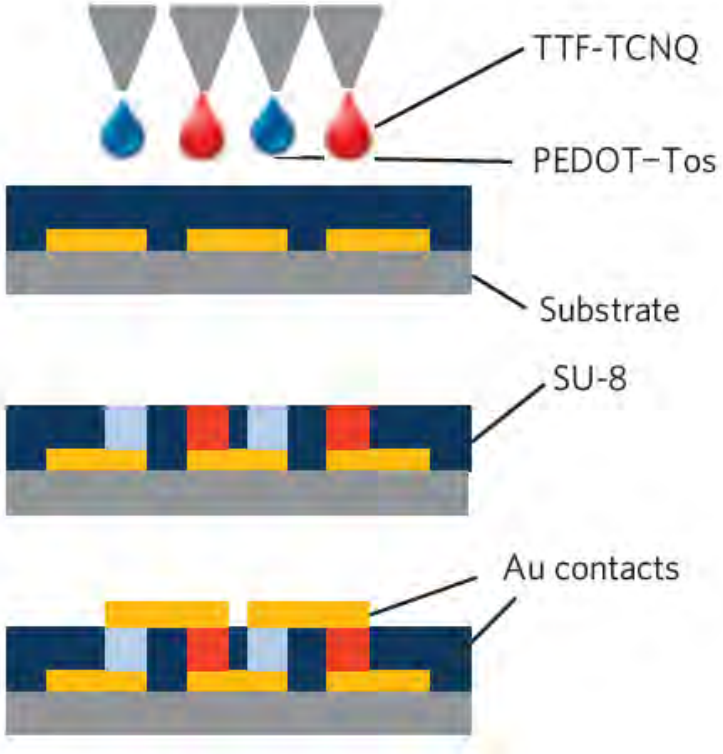
The moisture sensor label

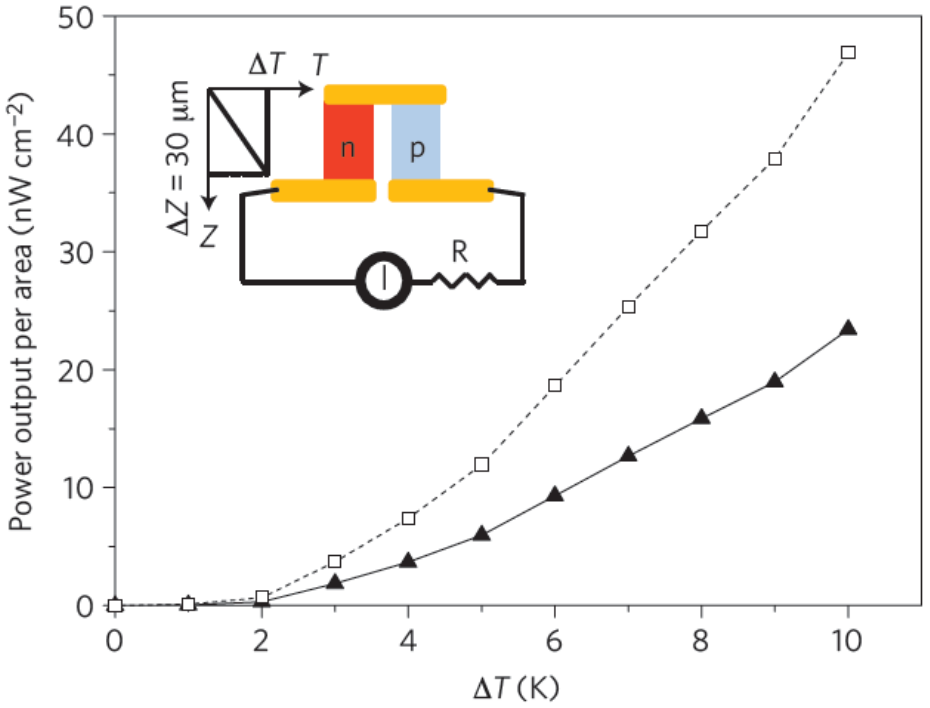




Thermoelectricity

Thermoelectric Generators – first organic thermoelectric material



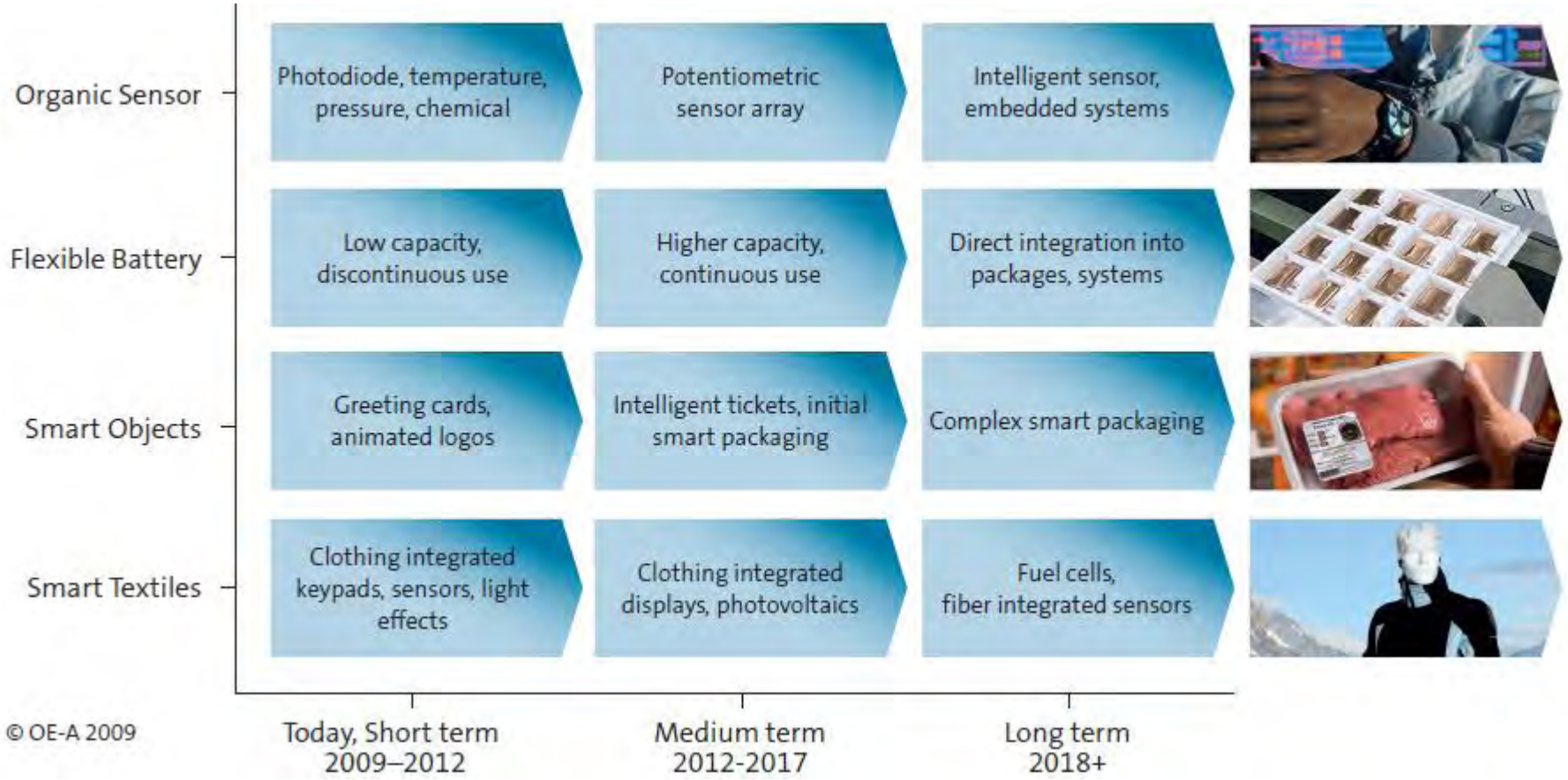


Nature Materials 10, 429-433 (2011).

Printed electronics in the future

OE-A Roadmap for Organic and Printed Electronics Applications

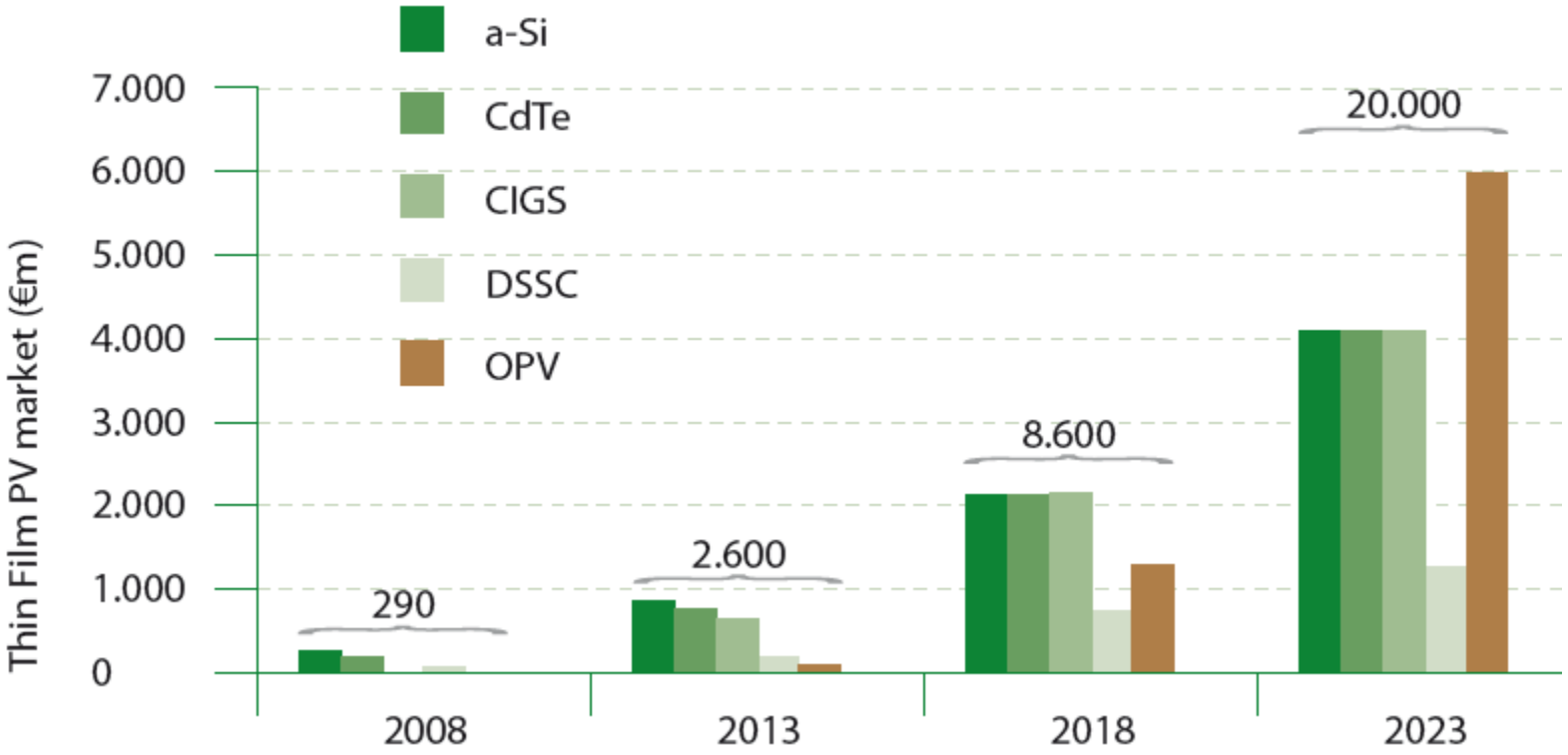
	Today, Short term 2009–2012	Medium term 2012-2017	Long term 2018+	
Organic Photovoltaic	Consumer and first off-grid applications	Off-grid power, building integration	Grid-connected power generation	
Flexible Display	Price labels, e-readers	High resolution colour e-readers, e-posters	Electronic wallpaper, rollable OLED TVs	
OLED / EL Lighting	Small lamps, design and decorative applications	Light tiles, technical and architectural lighting	Flexible lighting elements	
Printed RFID	Brand protection, e-ticketing	Logistics and automation	Item level tagging, EPC, identification	
Printed Memory	Brand protection, identification, games	High end brand protection, advanced games	Electronics, multimedia	


Organic Sensor
Photodiode, temperature, pressure, chemical
Potentiometric sensor array
Intelligent sensor, embedded systems
Flexible Battery
Low capacity, discontinuous use
Higher capacity, continuous use
Direct integration into packages, systems
Smart Objects
Greeting cards, animated logos
Intelligent tickets, initial smart packaging
Complex smart packaging
Smart Textiles
Clothing integrated keypads, sensors, light effects
Clothing integrated displays, photovoltaics
Fuel cells, fiber integrated sensors
© OE-A 2009
Today, Short term 2009–2012
Medium term 2012-2017
Long term 2018+

Printed lighting

- Forecast: OLED lighting 5% of European market by 2014
- Osram, Philips

Solar cells and power harvesting



Strategic reserach agenda, Organic and Large Area Electronics (2009)

Printed displays

- Flexible color displays with video capability
- Thin, flexible e-readers (the Harry Potter newspaper)

Plastic Logic

Self diagnostics

- Inexpensive diagnostic kits for home use
- Improved tests for e.g. glucose

The Internet of things

- Sensor labels
- Item-level tagging
- Connection to Internet directly or via reader

Linköping University

expanding reality

Organic Electronics

www.liu.se