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ADVANCED LAB

Organic Electronics: Overview and Applications

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OUTLINE

- Organic materials for flexible electronics
- Printing techniques
- Organic devices and applications

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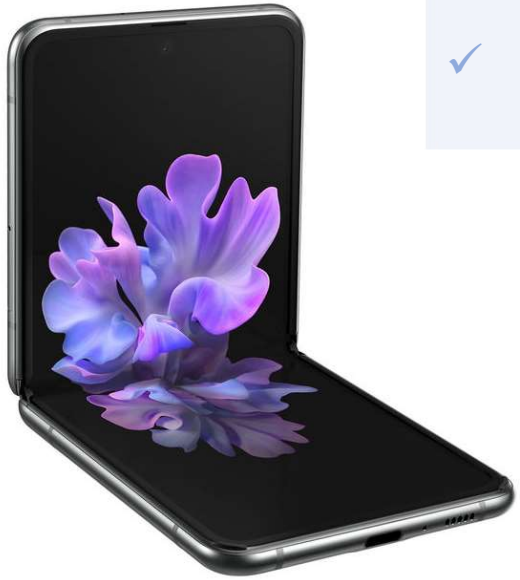
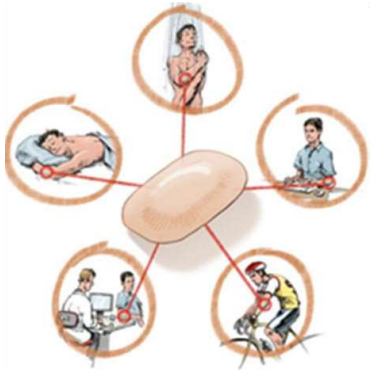
Introduction

Organic materials for flexible electronics

- ✓ Flexibility
- ✓ Low process temperature (~ 100°C)
- ✓ Solubility
- ✓ Biocompatibility
- ✓ Biodegradability

- ➢ Flexible, bendable plastic substrates
- ➢ Non-conventional substrates (paper, fabrics, ..)
- ➢ Printing techniques
  - Low-cost processes
- ➢ Environmental fiendly
- ➢ Implantable devices





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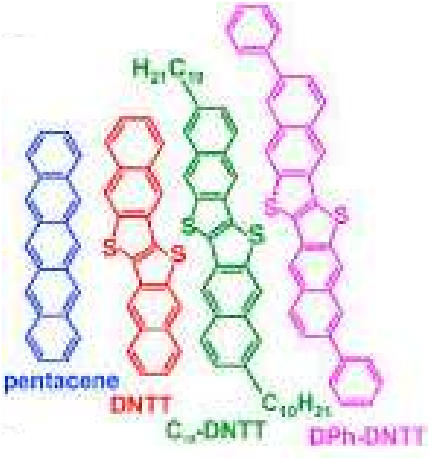
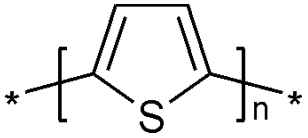
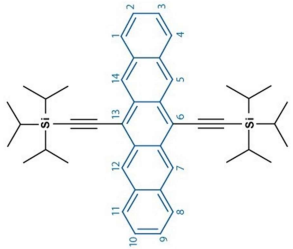
Organic Materials for electronics: semiconductors



- P-type organic semiconductors
- Based on benzene and/or thiophenes rings
  - Small molecules (functionalized to be soluble), blend with polymers
  - Polimers (P3HT,…)

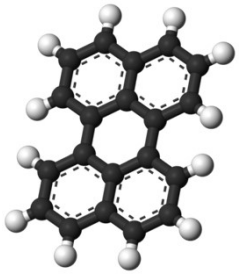


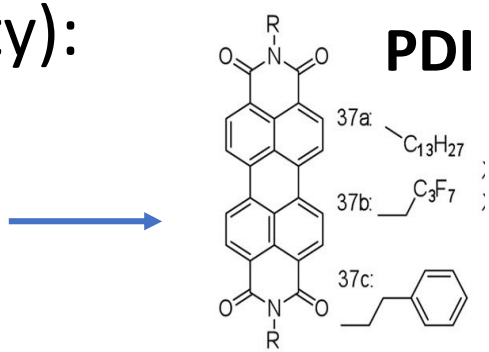


- N-type (less stable and lower mobility):

Fullerene

Perylene





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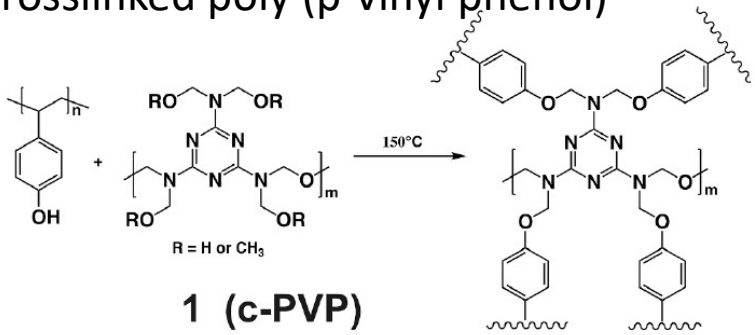
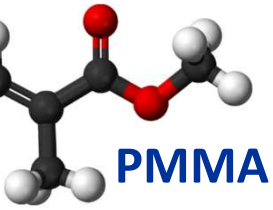
Organic Materials for electronics

Insulatrors: Polymers

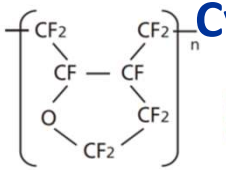
Crosslinked poly (p-vinyl phenol)



1 (c-PVP)



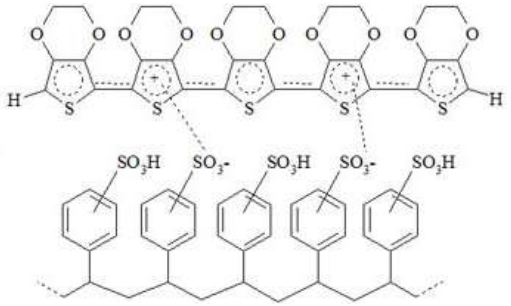
PMMA - plexiglass



Cytop – (Teflon-like)

Conductors: organic polymers and nanoparticle dispersions

PEDOT-PSS
CNT
Grafene
Metal nanoparticles (Ag, Au) + low temperature sintering



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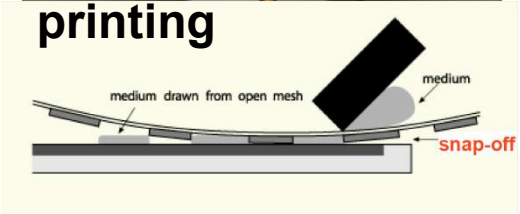
Printing techniques

Ink Jet

Screen printing



- These printing techniques are available in the NanoMicroFab lab
- Low-cost, large area (up to A4), low temperature
- Require inks or paste with different viscosity
- Scalable for roll to roll process
- Relatively low resolution (down to 10-20 µm)

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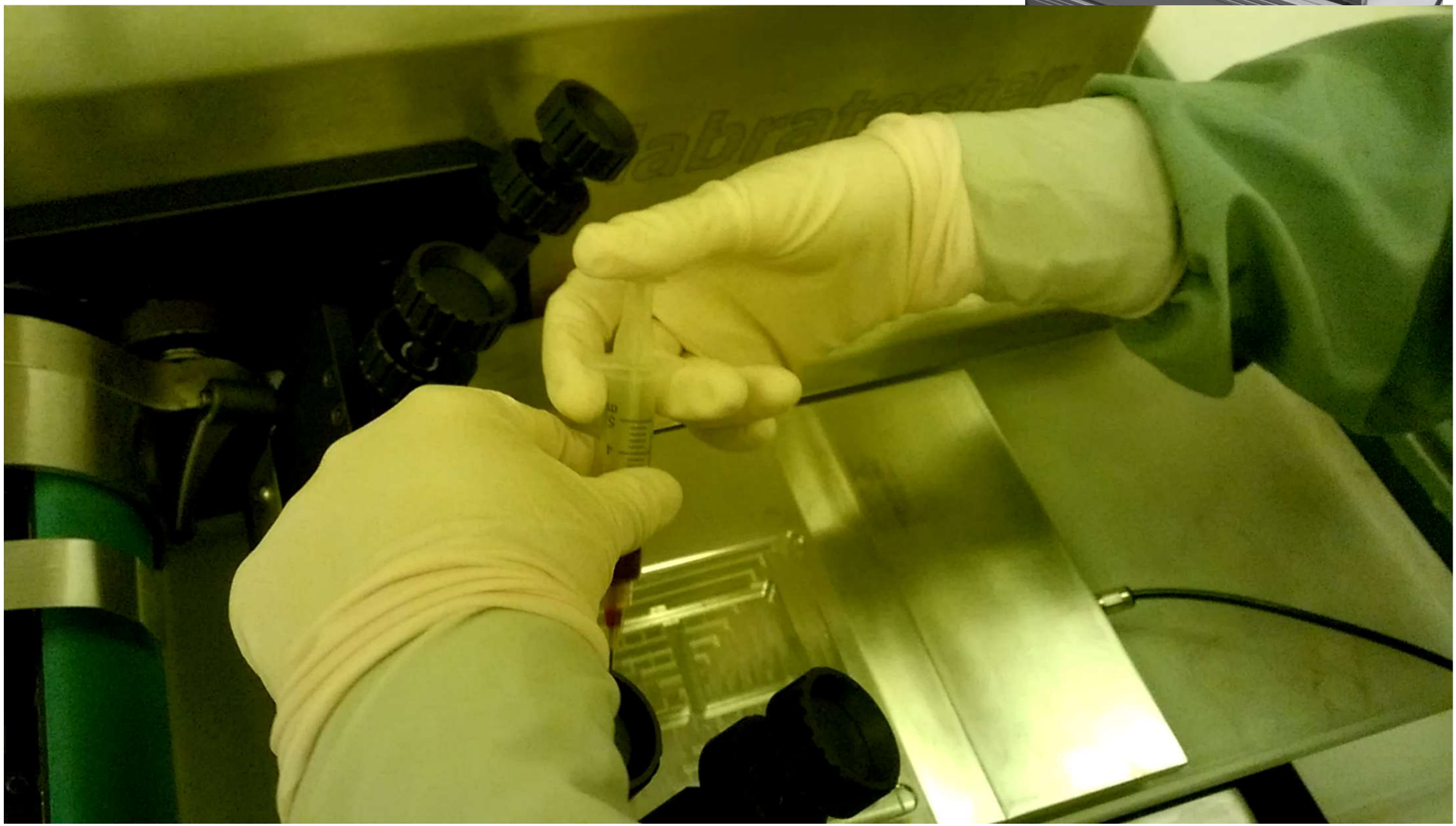

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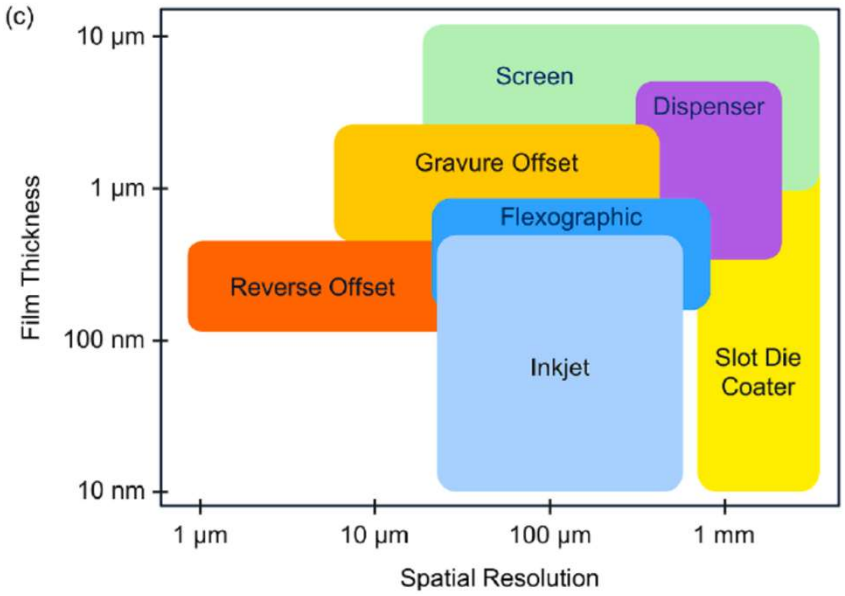
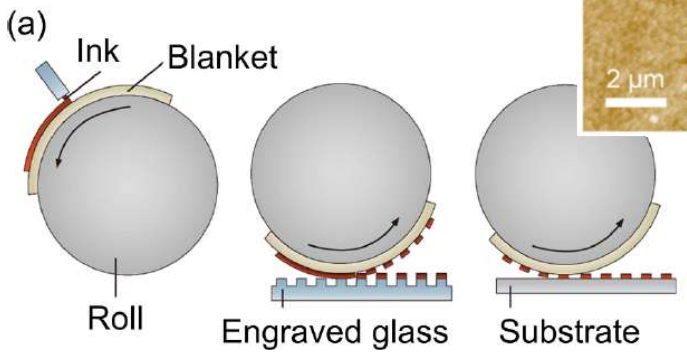
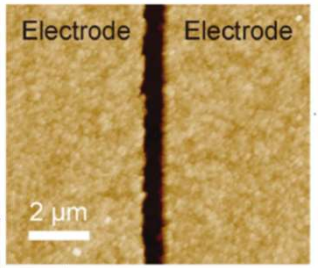
New high resolution Printing techniques

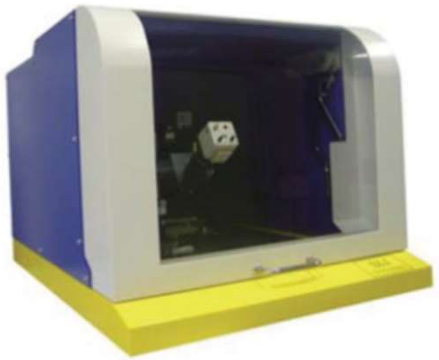


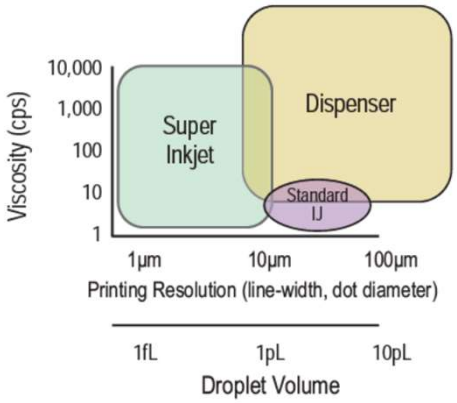
Reverse off-set printing

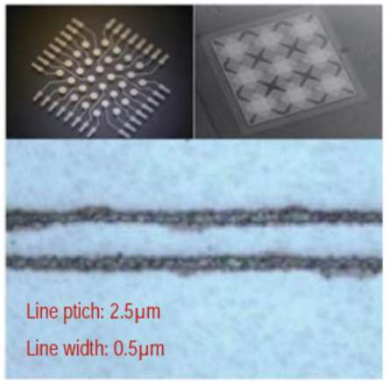




Femtoliter ink-jet







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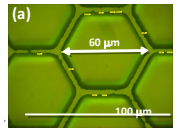
Fully printed OTFTs: manufacturing process

PEN - Teonex Q65FA 100 µm thick

S/D plate typical cell

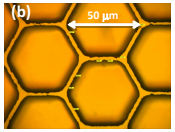
Source/Drain
Ag (InkJet+SAM) or PEDOT (gravure)
Thickness ≈ 35-70 nm
Annealing 120° oven

OSC plate cell



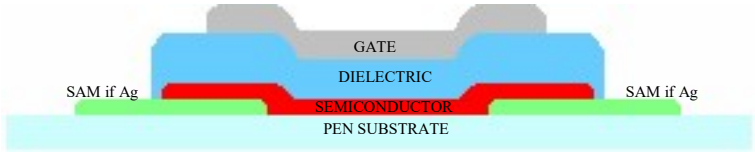
OSC
GRAVURE printing
Merck SP400 (polymer, p-type)
Thickness ≈ 25 nm
Annealing 100° hot plate

OGI plate cell



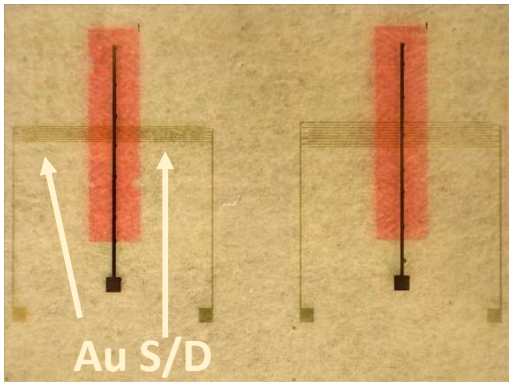
OGI
GRAVURE printing Cytop CTL809M
Thickness ≈ 400 nm
Annealing 100° oven

Gate
INKJET printing ANP DGP40 LT-15C
Thickness ≈ 200 nm
Annealing 80° oven

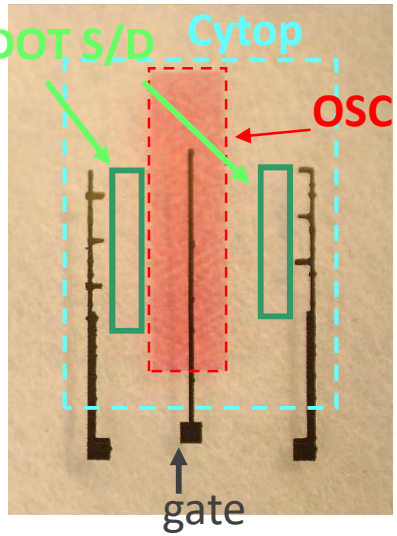


Inkjet printer: Dimatix DMP 2831
Gravure printer: Labratester NSM

Au/ printed Ag electrodes



Printed Ag/PEDOT electrodes



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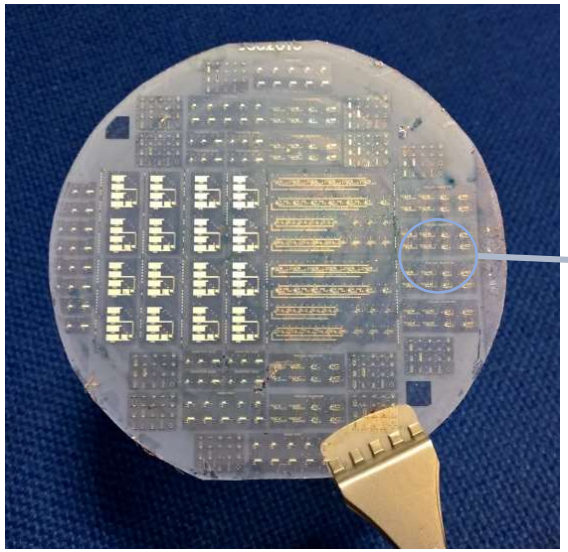
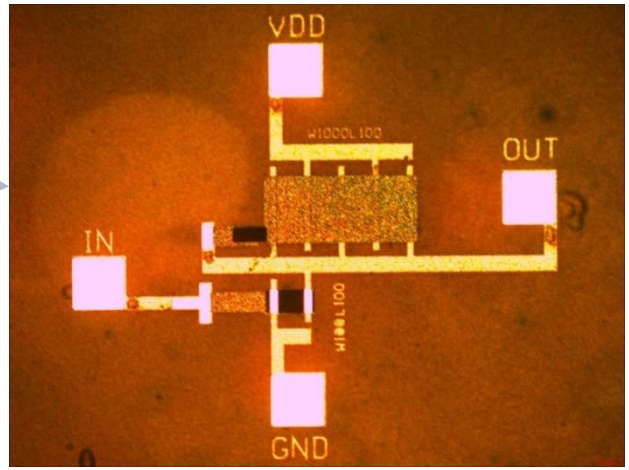
OTFT applications

OTFT circuits

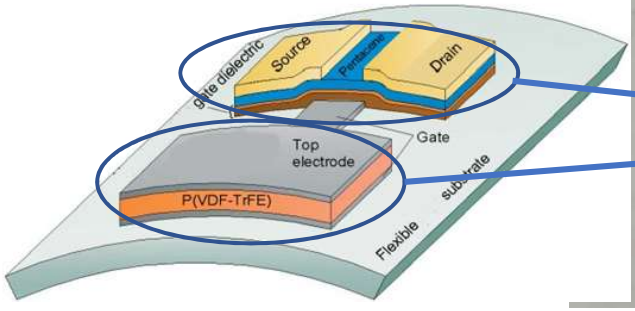


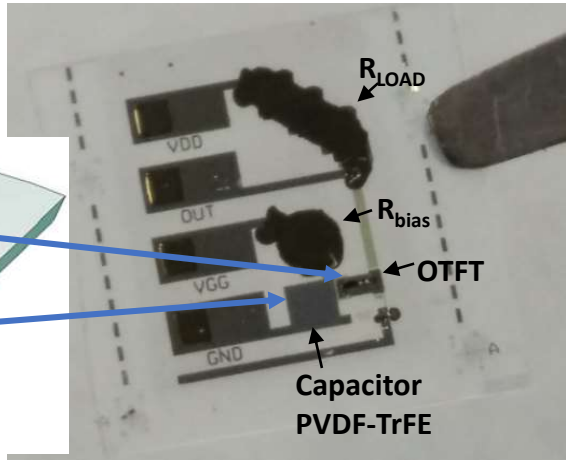
Inverter

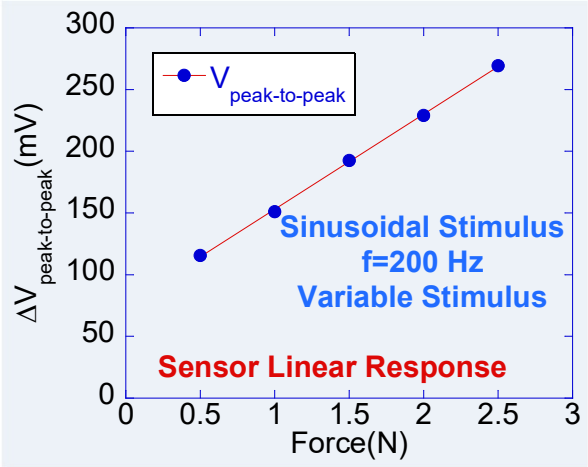


Circuits have been designed by using the OTFTs compact model that we have developed

Tactile sensors







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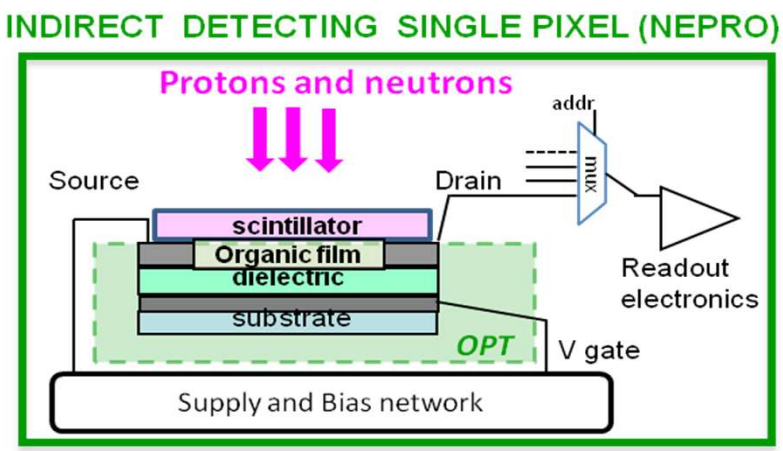
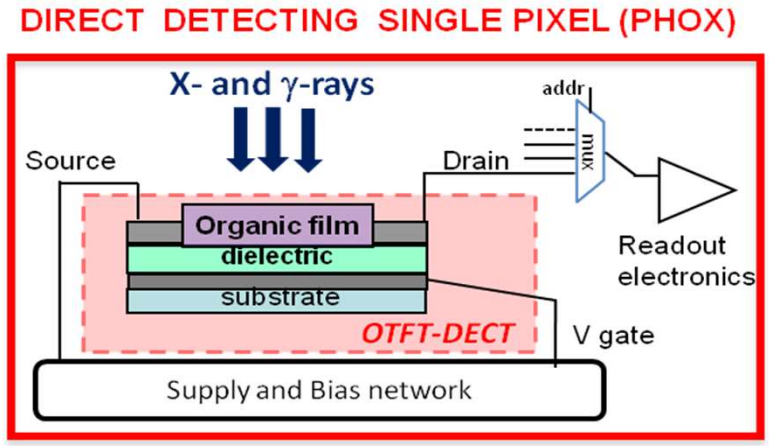
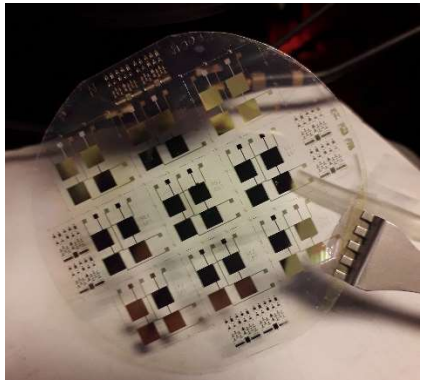
OTFT-applications

Ionizing radiation detectors

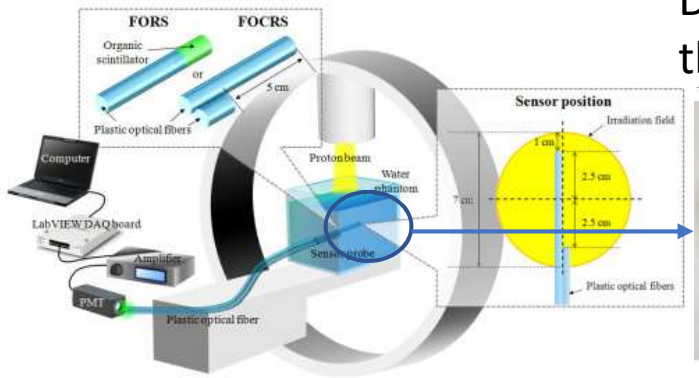






Flexible **I**onizing **R**adiation d**E**tectors – **FIRE** project (INFN – CSN5 Call 2019)

PROTON THERAPY DOSIMETRY



Detectors for Proton therapy for prostate cancer

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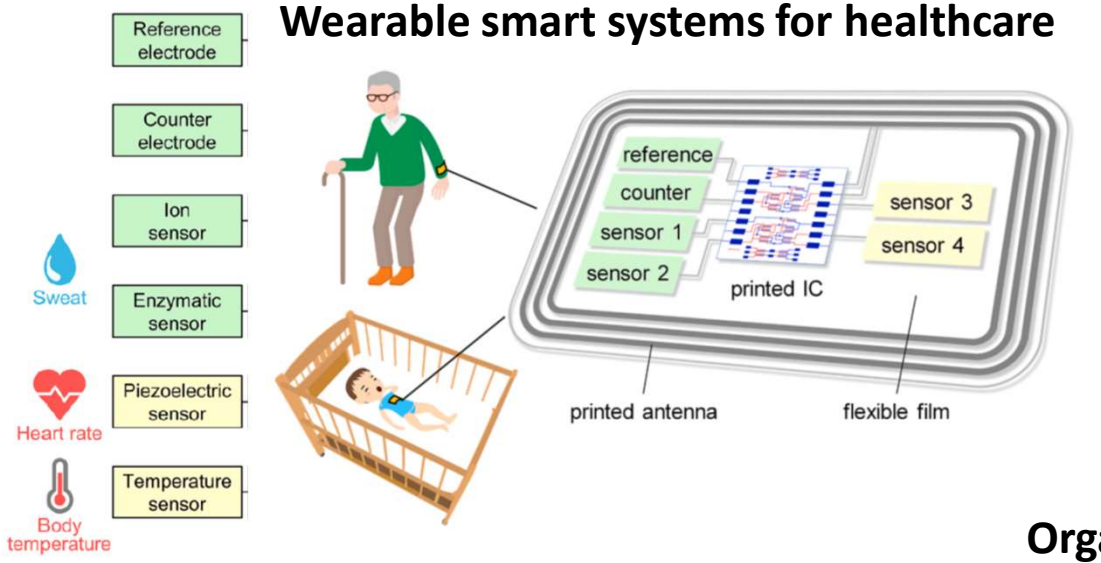
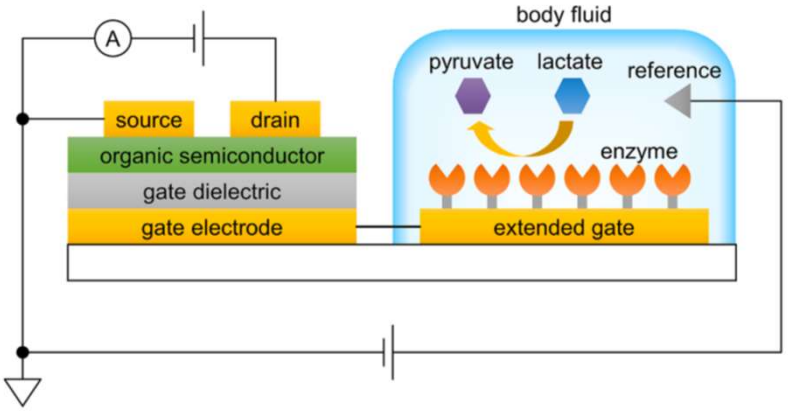
OE applications

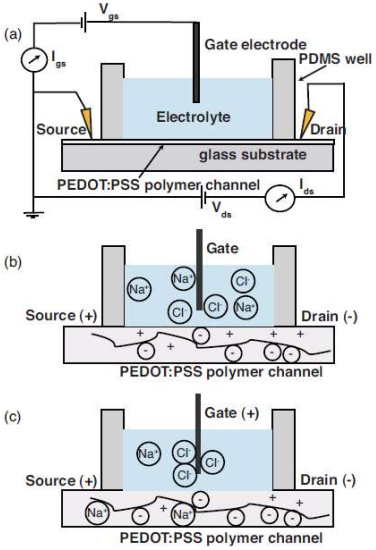
Wearable smart systems for healthcare

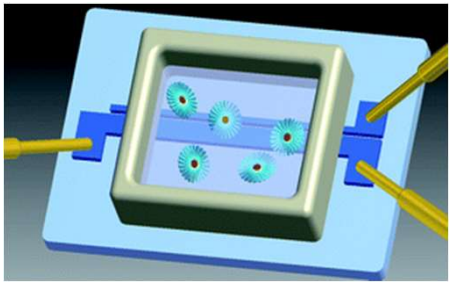


Extended gate OTFT – EG-OTFT



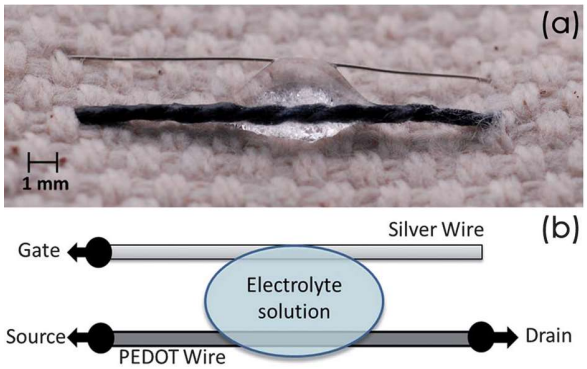
Organic Electrochemical Transistors OECT





Organic conductor + Electrolyte.
The analyte diffusion changes the organic conductivity

OECT on a cotton fiber.



saline sensing in sweat

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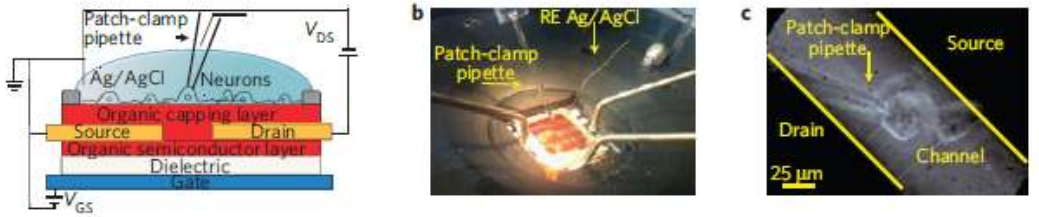
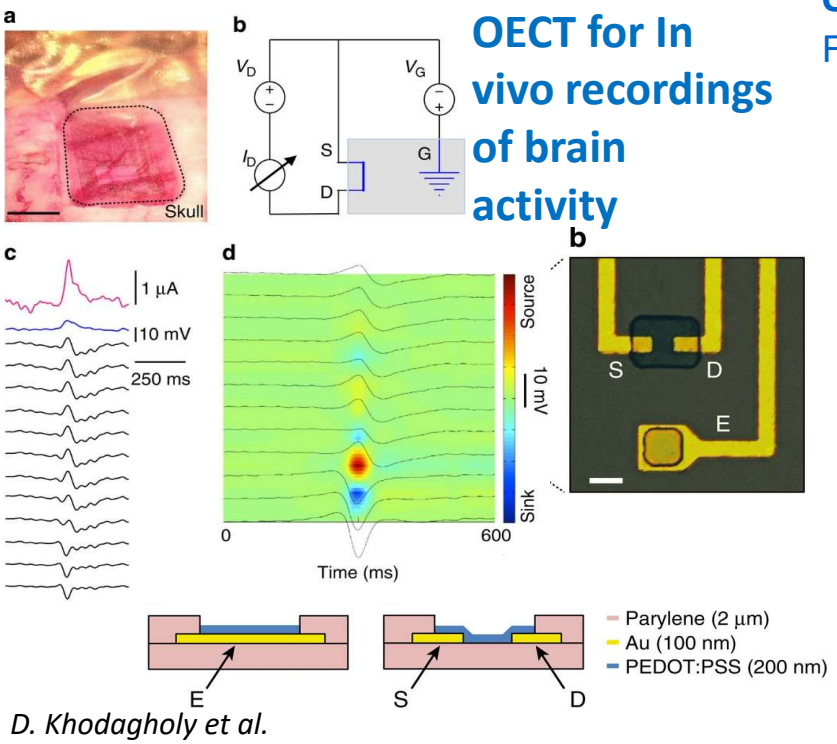
Implantable devices

- **Biocompatibility**
- **Flexibility and conformability**
- **Possible biodegradability**



Organic Cell Stimulating and Sensing Transistors (O-CSTs)

For neural activity monitoring (*V. Benfenati et al.*)

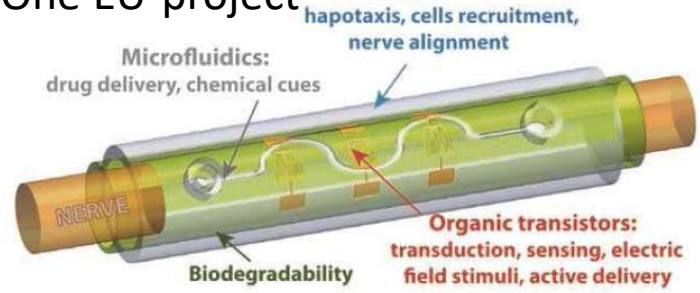


OECT for In vivo recordings of brain activity

D. Khodagholy et al.

Devices for treatment of spinal cord injury

iOne EU-project



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SUMMARY

- Organic materials and printing techniques allow to develop devices on flexible and non-conventional substrates, widening the fields of application of the flexible electronics
- Wearable, biocompatible, biodegradable electronic circuits and sensors are some of the main applications for organic flexible electronics