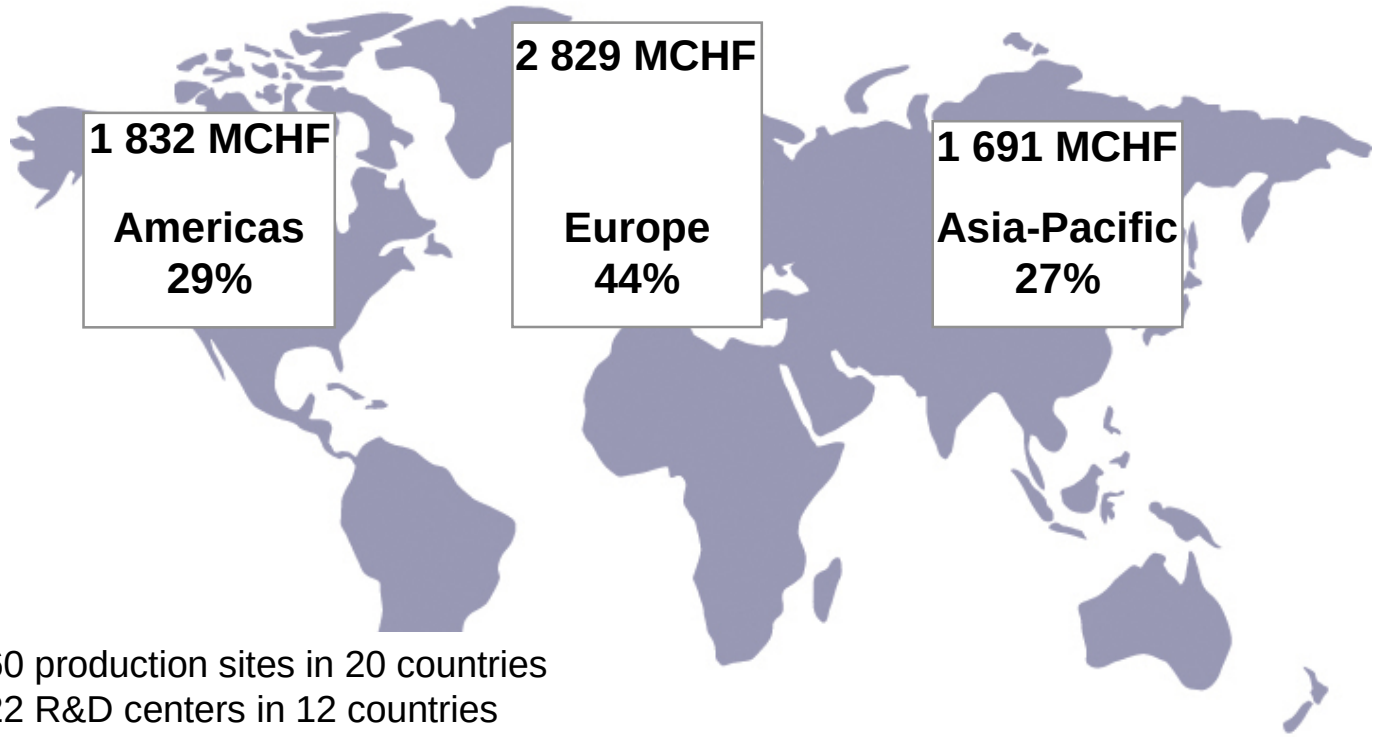
Organic Photonics: Displays, Lighting and Photovoltaics

June 25, 2008

Dr. Frank Bienewald, CIBA

CIBA - Broad global presence

Sales 2006



- 60 production sites in 20 countries
- 22 R&D centers in 12 countries
- Over 14'000 employees around the world

Segments focused on customer industries

Plastic Additives
Industries:
- Plastics
- Lubricants
- Home & Fabric Care
- Personal Care

Coating Effects
Industries:
- Coatings
- Printing
- Imaging
- Plastics
- Synthetic Fibers
- Electronics
- Information Technology

Water & Paper Treatment
Industries:
- Paper and Board
- Oil and Mining
- Water Treatment
- Detergents and Hygiene
- Agriculture

Group Research / New Growth Platform

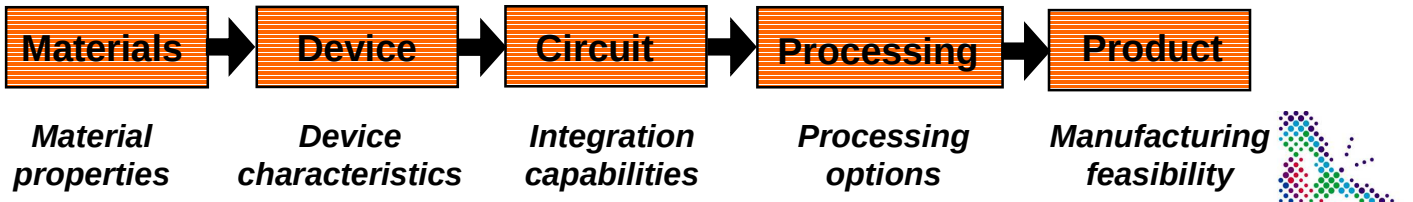
- **Organic Photonics:**
  - **Organic Photovoltaics**
  - **Organic Transistor Materials**
  - **Organic Lighting Materials**

- **Key to success:**
  - **Strategic research collaborations with selected external partners**
  - **Participation in National and International research programs**

Strategic Collaborations - Some Examples

- **University Partners :**
  - Prof. B. Batlogg, ETH-Zürich (Material development and testing)
  - Prof. Luisa de Cola, Münster (Nanomaterials)
  - Dr. Beat Ruhstaller, Winterthur (optical and electrical modeling of devices)
  - MPI-Mainz (Conductive nanomaterials)
  - Prof. René Janssen, Eindhoven (Photophysical measurements and Solar cell evaluation)

- **Technology partners**
  - CSEM (Material testing, Development of screening tools, Evaluation of printing options…)
  - VTT (Biomaterials, Printing technologies e.g. Roll-to-Roll printing)



Swiss Research Network

- Focus on the development of OLED materials for printing applications, mainly triplet emitters and host materials
- Strategic collaboration with CSEM for high throughput material testing and device engineering, and ZHW for computational performance simulations

csem

Zürcher Hochschule Winterthur

- Several projects funded by Swiss CTI

Why organic semiconductive materials ?

- **Numerous potential new applications in the area of Displays, Power Generation, Sensors, Memories and Data Processing**

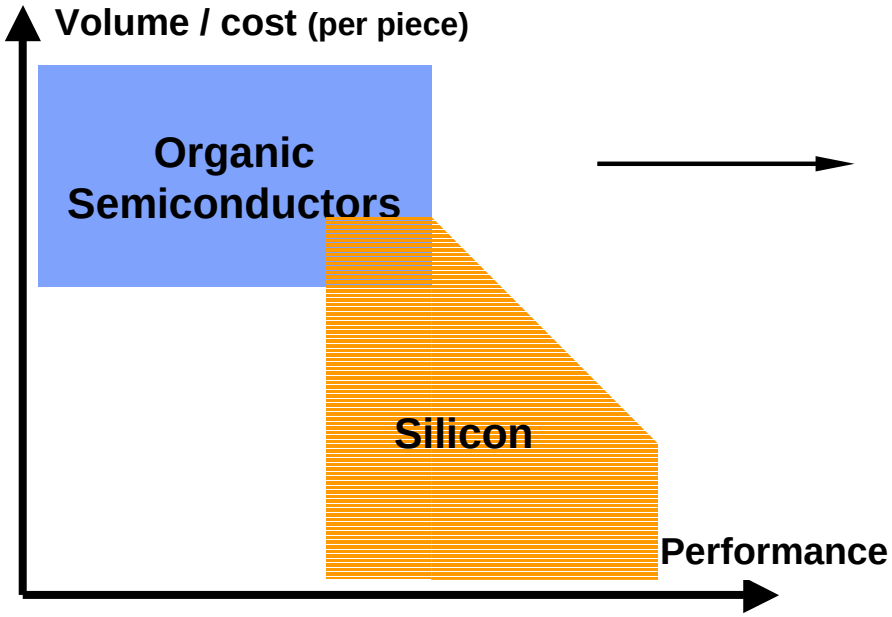
- **Flexible, large area and light weight devices possible**

Challenges:

- Good semiconductive properties
- Stability
- Processability
- Versatility

Need to understand the material in order to select and focus on the most promising application

Why printing ?



Printing techniques

- Different levels of performance
- Different applications (limited overlap)

- Large area possible
- Flexible devices achievable

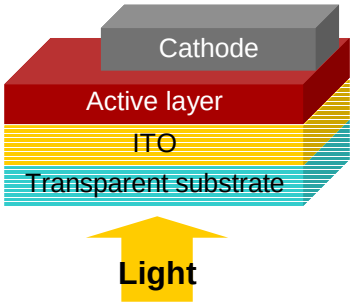
Challenges for Printing

- **Alignment of several layers**
- **Layer thickness**
- **Micro & Nano patterning**
- **New materials for more variations of ink formulations**

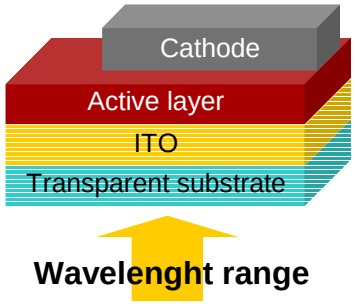
Innovative Printing Technology Emerging

Potential application

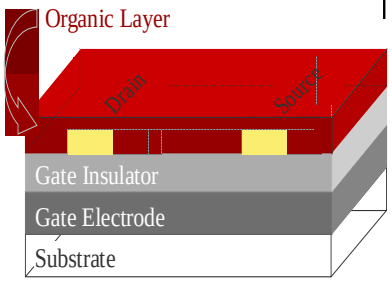
Solar cell

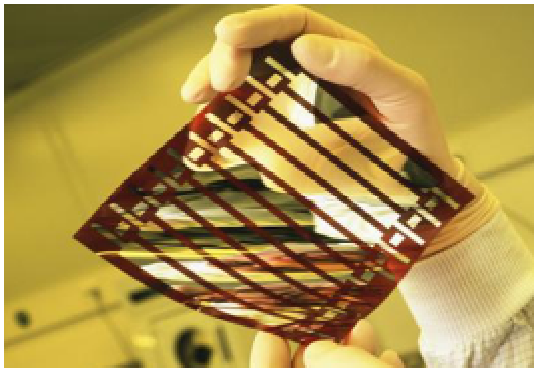


Photodiode

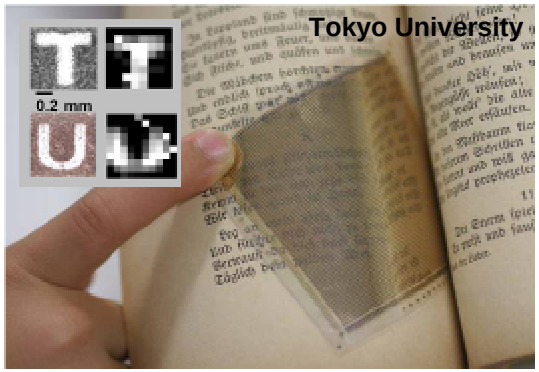


Transistor





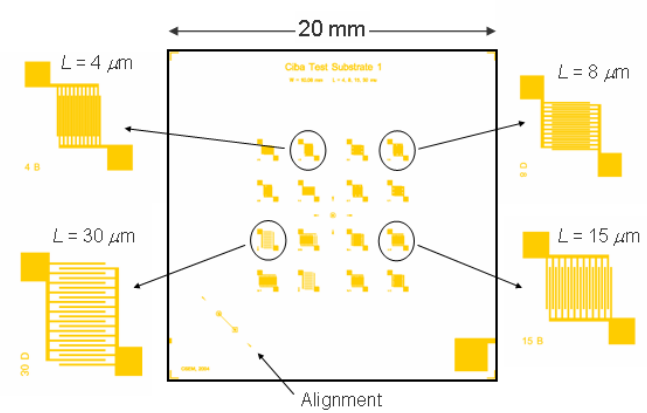
Pilot line

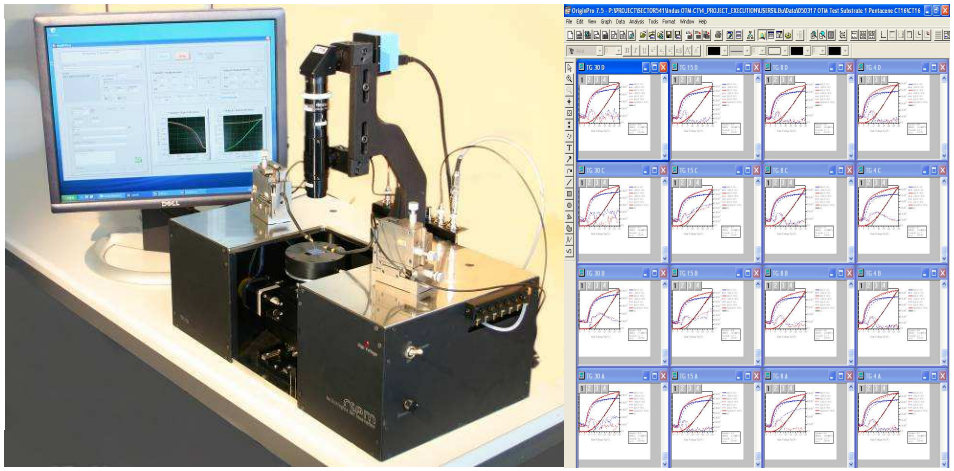


Demonstrator

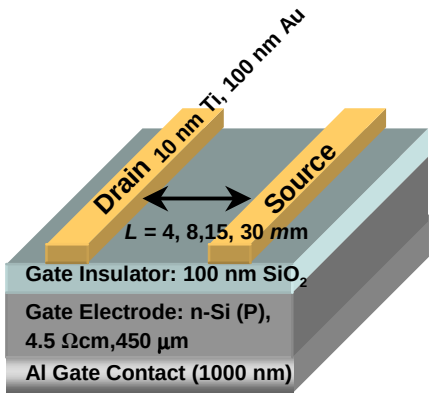
Prototype

Automated Prober – TP10



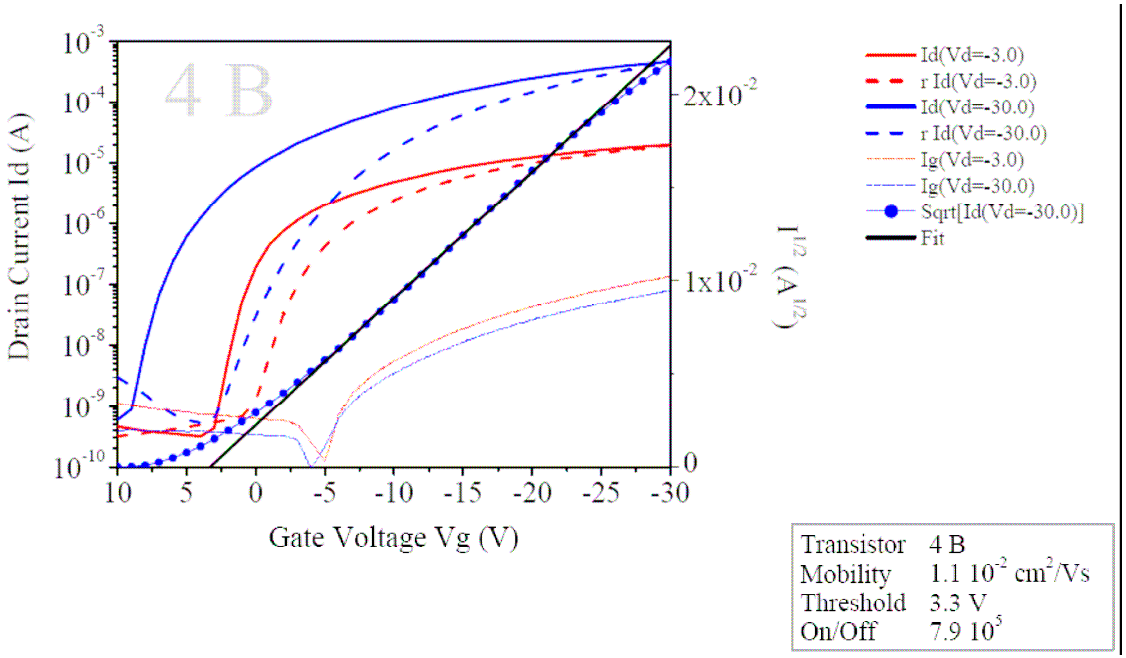


- Developped at csem



Data and graphs are generated and analyzed automatically and summarized in a report

Organic Field Effect Transistors (OFET)



- Mobility of 0.1-0.3 cm^2/Vs
- On/Off ratio up to 10^7
- Threshold voltage close to 0

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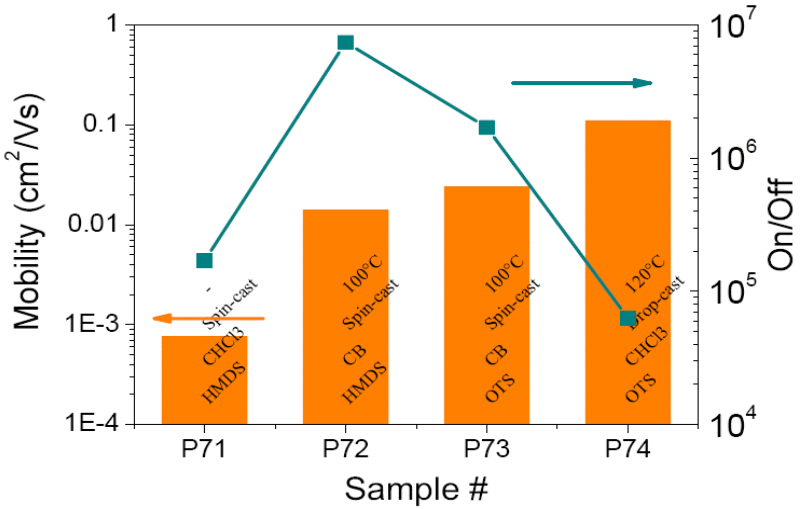
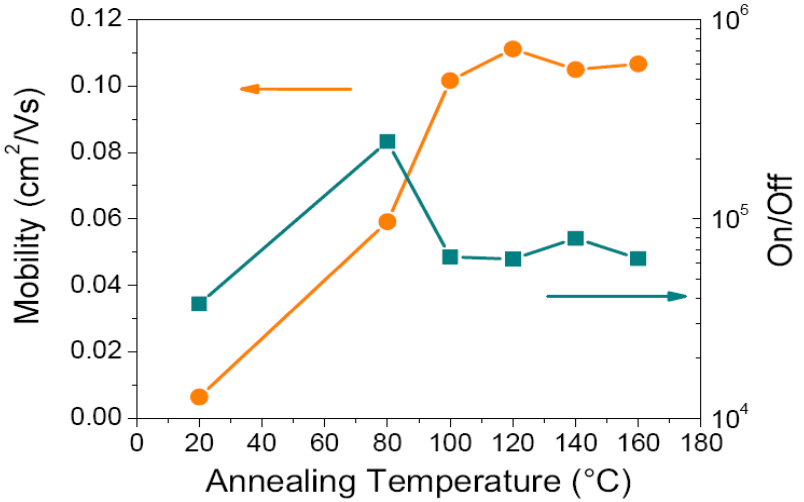
OFET properties of an interesting candidate

OFET Properties



Annealing characteristics



Issues:

- Processability
- On/Off ratio drops for good mobility

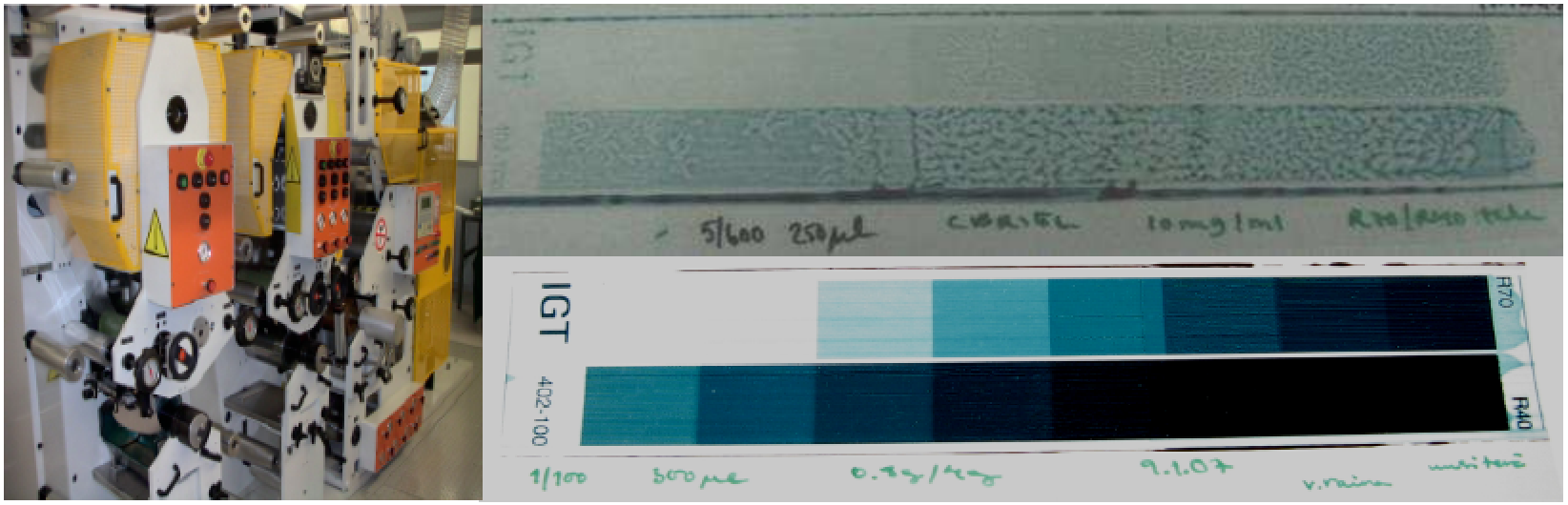
In collaboration with the Swiss Center for Electronics and Microtechnology

csem

Ciba

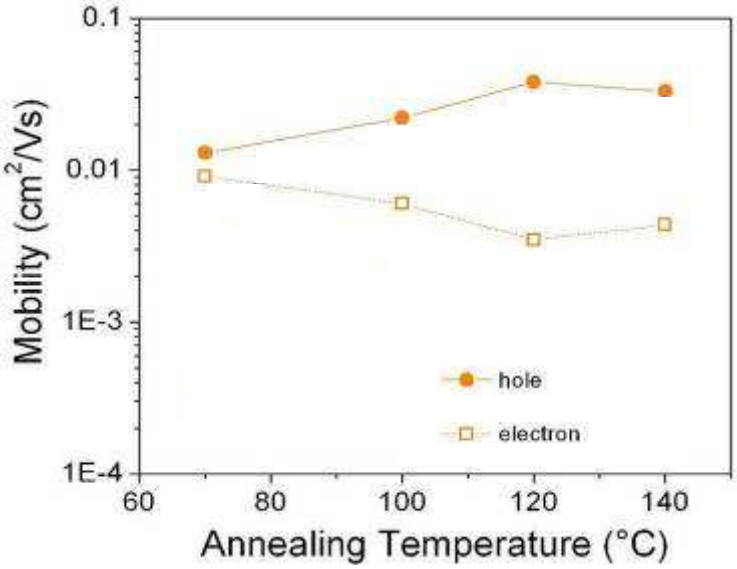
Printable semiconducting polymer

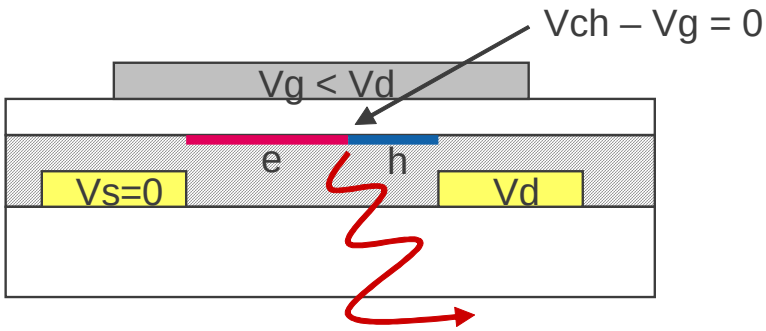
- Mobility up to 10^{-1} cm^2/Vs
- On/Off ratio of 10^6
- Threshold voltage close to 0



In Collaboration with the technical research center of Finland

Organic Light Emitting Transistor (OLET)

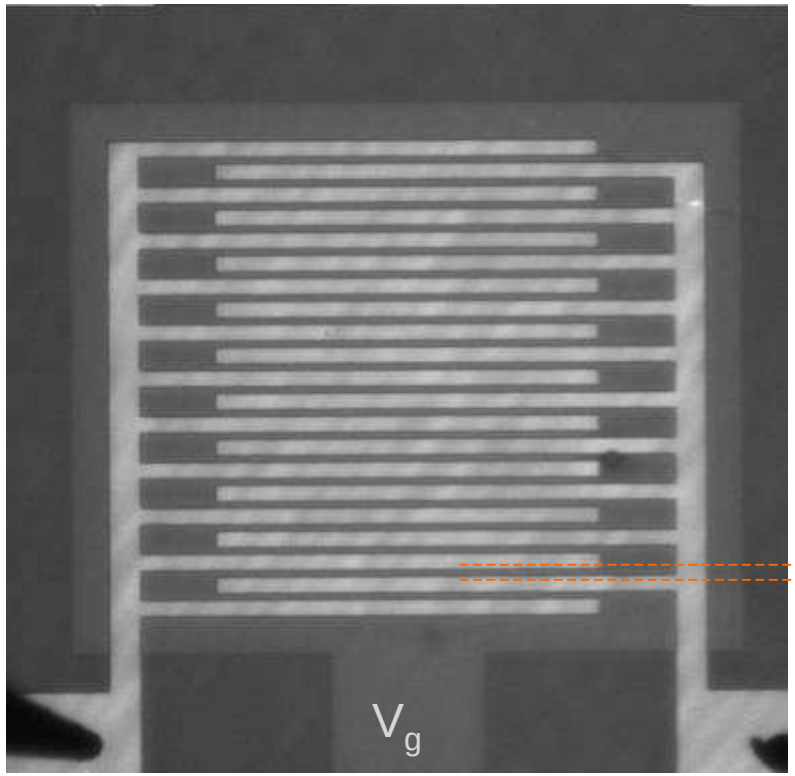


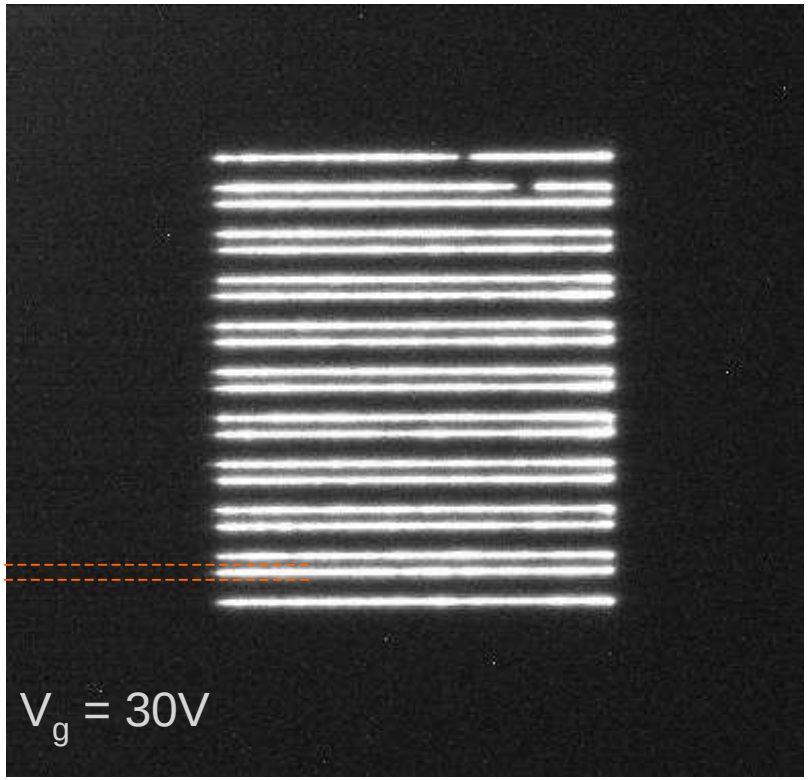


- Balanced Charge carrier mobility
  → Ambipolarity
  → drop of the On/Off ratio

- Holes and electrons can be injected at the same time, meet and recombine radiatively in the channel

Organic Light Emitting Transistor (OLET)

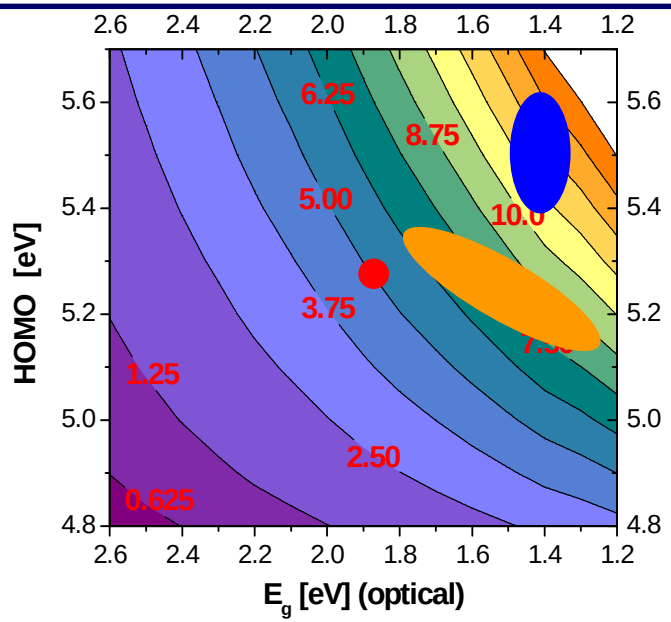


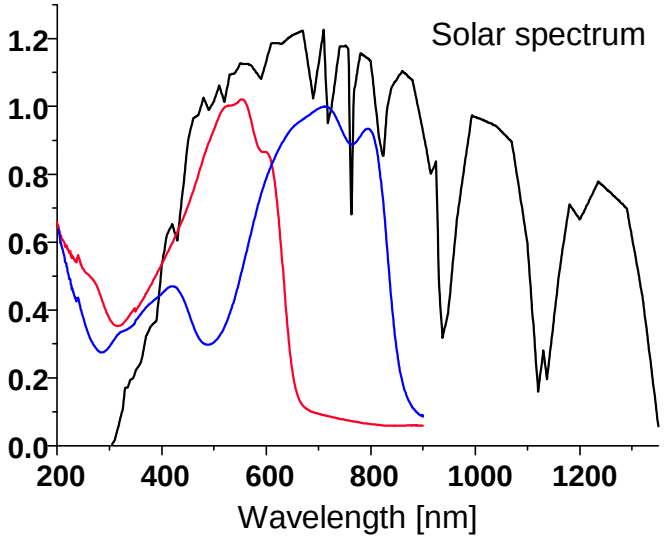


V_s = 0 V

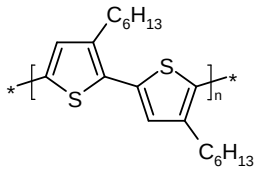
V_d = 140 V

Organic Bulk Heterojunction Solar Cells – Potential of Ciba polymers

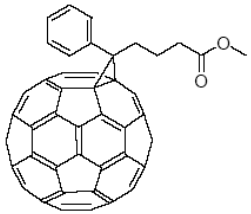




- P3HT / PCBM is the most studied system with reliable achieved efficiencies up to 4%
- State of the art low band gap material is reaching now around 5.5%
- Potential of the Ciba polymer in the range of **12-14%**



rr-P3HT



PCBM

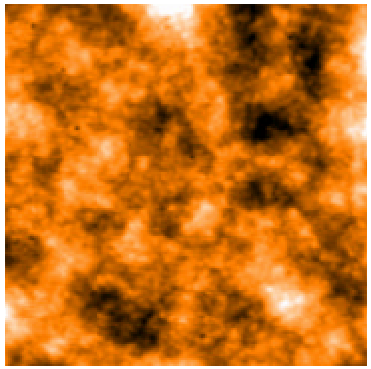
Collaboration with Prof. R. Janssen @ TU/e

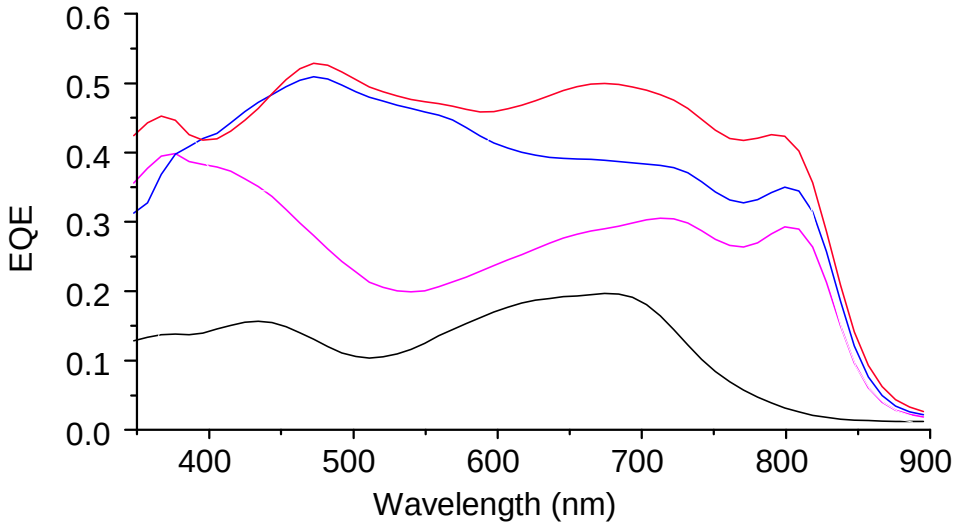
The importance of processing

CIBA low bandgap polymer **1**

/

[60]PCBM or [70]PCBM **2**





J_{SC} = 3.6 mA/cm^2 V_{OC} = 0.79 V *FF* = 0.39 η_{est} = 1.1%	***April 2006***
J_{SC} = 7.9 mA/cm^2 V_{OC} = 0.62 V *FF* = 0.51 η = 2.5 %	***Sept. 2006***
J_{SC} = 12.0 mA/cm^2 V_{OC} = 0.60 V *FF* = 0.49 η = 3.5 %	***June 2007***
J_{SC} = 12.8 mA/cm^2 V_{OC} = 0.60 V *FF* = 0.56 **η_{est} = 4.3 %**	***August 2007***

Ciba

Summary

- Novel class of photoresponsive materials uncovered
- Extremely high potential of Ciba proprietary polymers for solar cells
- State-of-the-art transistor performance have been obtained
- Scale-up of polymeric semiconductor ongoing
- Very promising also for other applications