Transistor Organik – OTFT

Elektronika Organik

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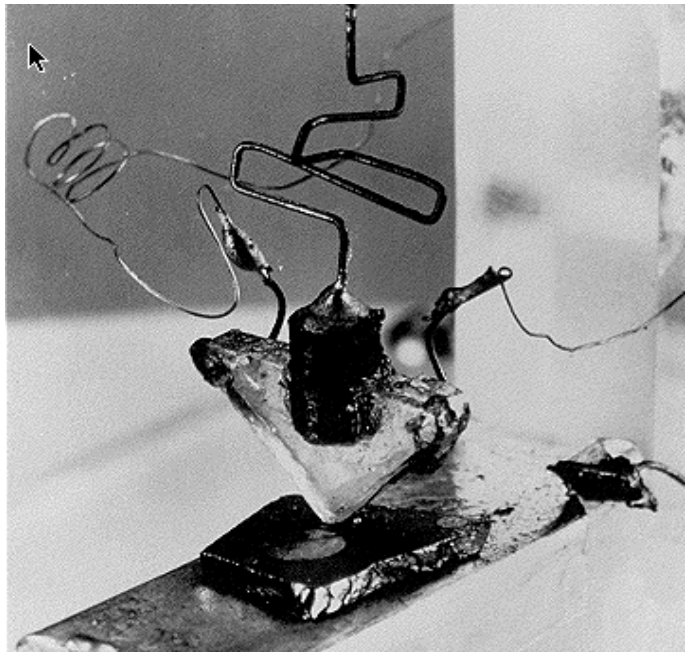
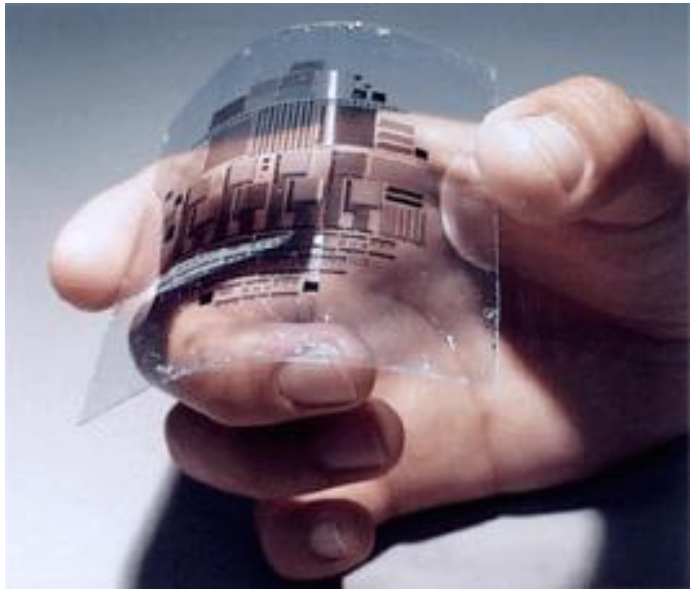
Outlines

- Introduction to Organic Electronics
- Applications
- Organic Thin-Film-Transistors (OTFTs)
- Organic Materials
- Recent Advances
- Summary

The first transistor (1947)
Size: 2.5cm



Today OTFT

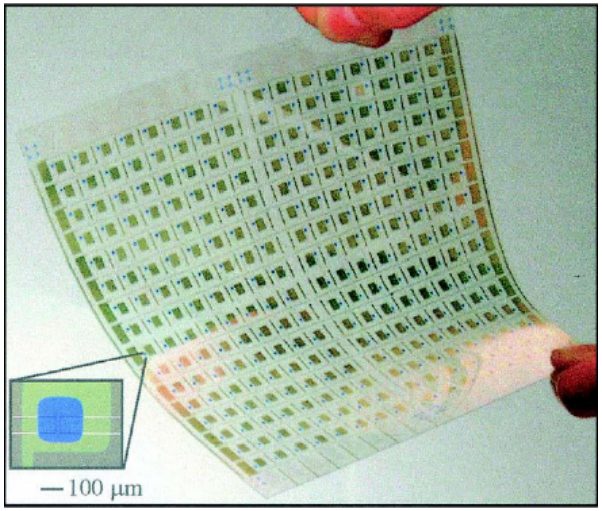


What and why an organic transistor?

- First Organic Transistor - 1986
  - Using organic molecules (Polymers) rather than silicon for their active material.
  - Semiconductor
- Advantages
  - Less Complex & Lower-cost Fabrication
    - Solution Processing ←→ Photolithographic patterning
    - lower temperature manufacturing (60-120° C)
    - Print-able Organic Transistors
  - Mechanical flexibility
    - compatibility with plastic substances: foldable & light weight
  - Strong Optical Absorption and Efficient Emission

Applications

- Flexible low-weight large-Area Displays
  - OLED + OTFT
- Optical recording (optical absorption)
- Electronic circuits printed on paper
- Electronic Papers
- Ultra Low-Cost Low-Performance Applications
  - Smart cards
- Low-heat dissipation circuits



Organic Thin Film Transistors (OTFT)

- Similar to MOSFETs
- 3-Terminal Device
  - Voltage Controled Switch
- Differences
  - Carrier Transport
    - Discrete Energy Levels
    - Hopping
  - Organic Active Layer
  - Depletion Devices

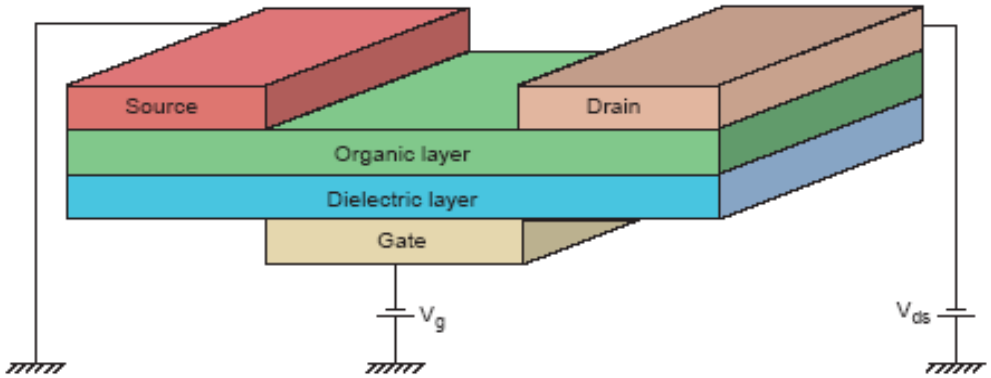
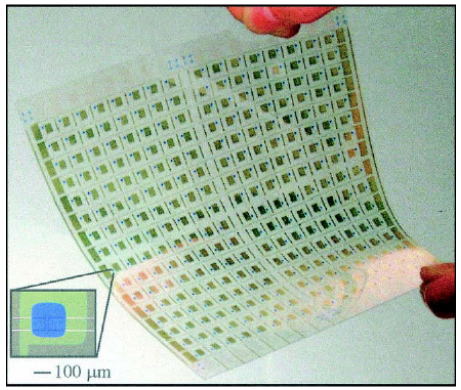


Figure1 [1]



Organic Thin Film Transistors (OTFT)

- Current Flow Mode
  - V_{th} is not Constant
  - Smaller die-electric Constant
  - Velocity Saturation
    - Due to hopping
    - Is more likely to occur

$$I_D = \mu \frac{w}{L} C_{OX} \left[(U_{GS} - U_{th}) U_{DS} - \frac{U_{DS}^2}{2} \right]$$

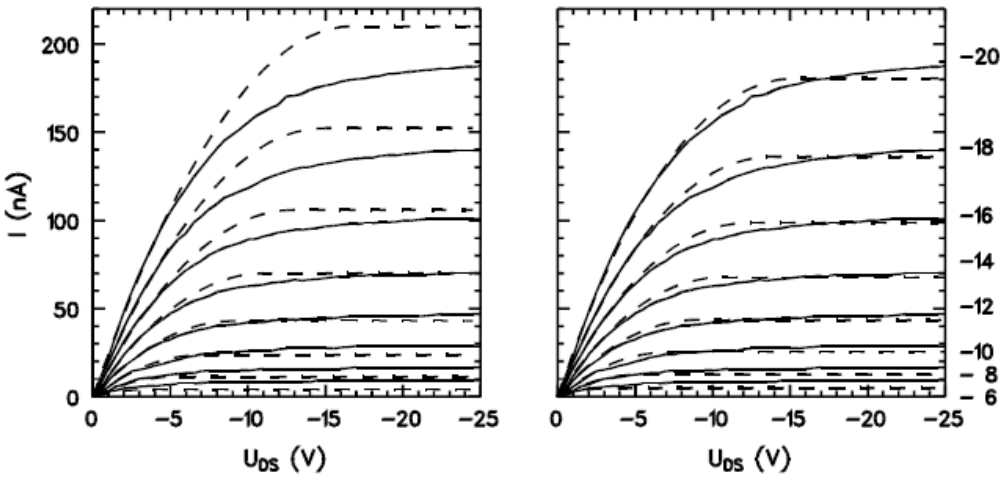


Figure2 [2]

Organic Thin Film Transistors (OTFT)

- Key Parameters
  - Mobility (μ ≈ 1-10 cm^2/vs)
    - Much Lower than Si
  - On-Off Ratio
    - Suitable (10^6)

Material	Mobility
a-Si	0.1 cm^2/Vs
Organics	1-10 cm^2/Vs
Si	200 cm^2/Vs

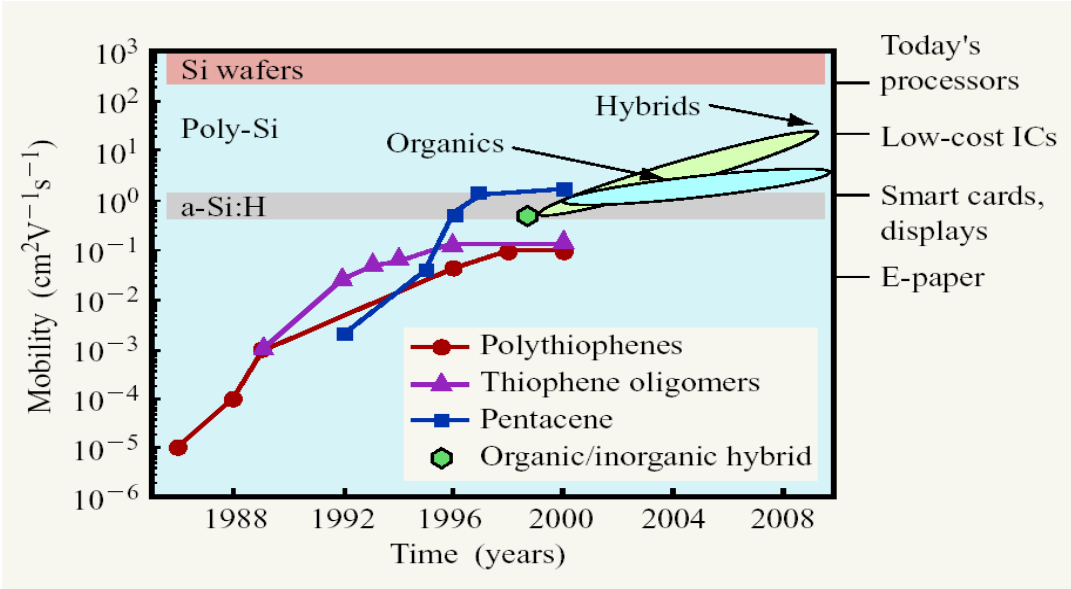


Figure3 [4]

New Organic Materials

- Challenging factors
  - Performance
  - Electrical Parameters
  - Process-ability
    - Solubility
  - Long-Term Stability
  - Regular Structure
    - Facilitate Hopping Process
  - Purify-ability
    - Impurity → charge traps

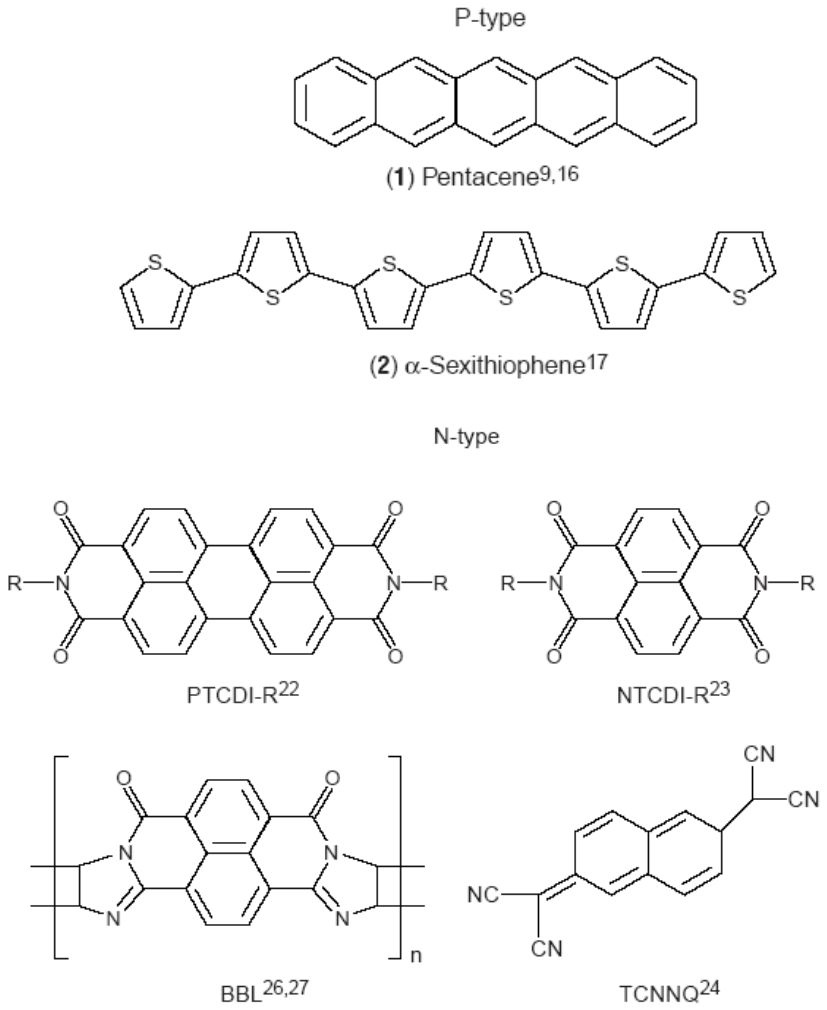


Figure4 [1]

Progress in performance of OTFTs from 1986 to the present

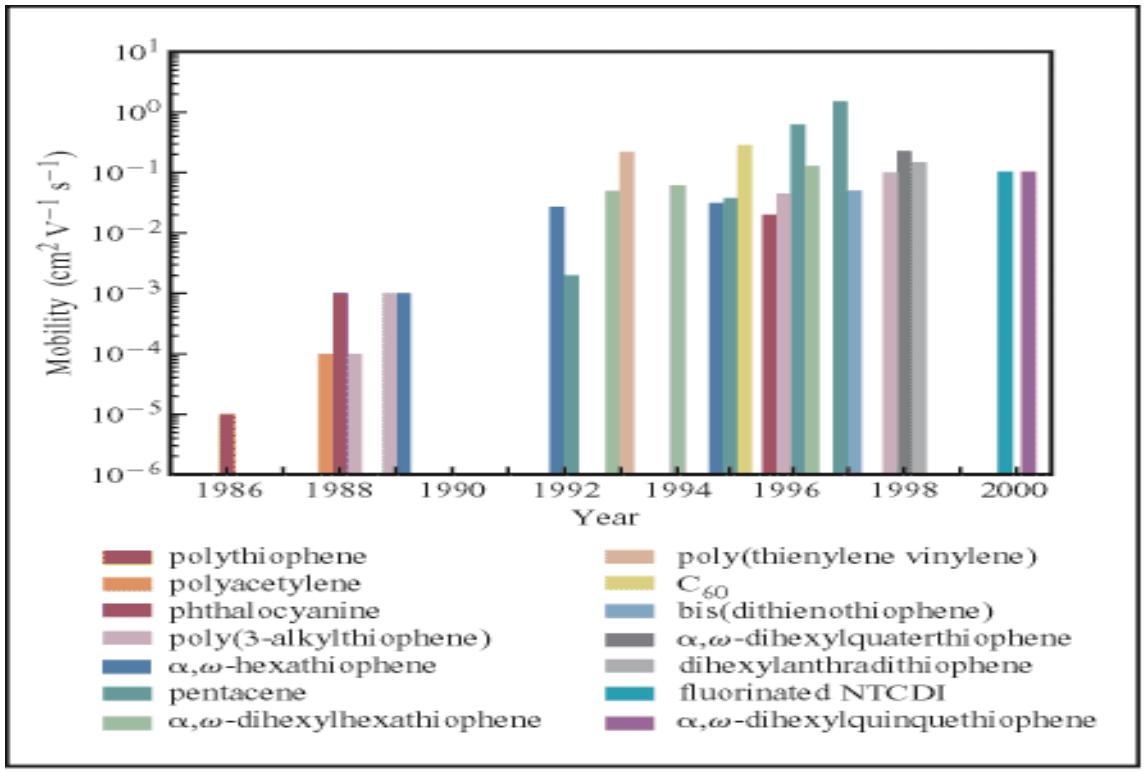


Figure 1

Semilogarithmic plot of the highest field-effect mobilities (μ) reported for OTFTs fabricated from the most promising polymeric and oligomeric semiconductors versus year from 1986 to 2000.

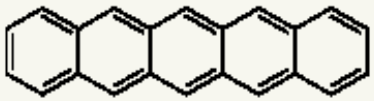
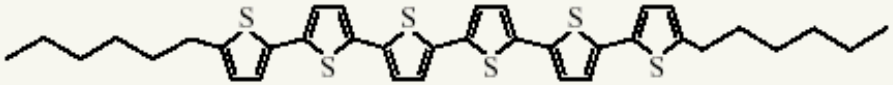
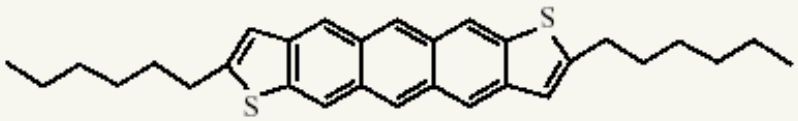
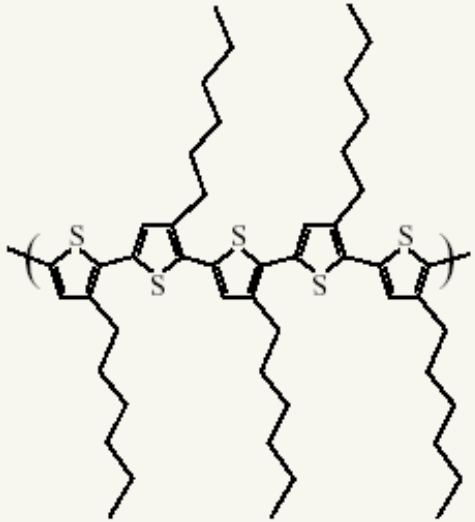
Figure5 [4]

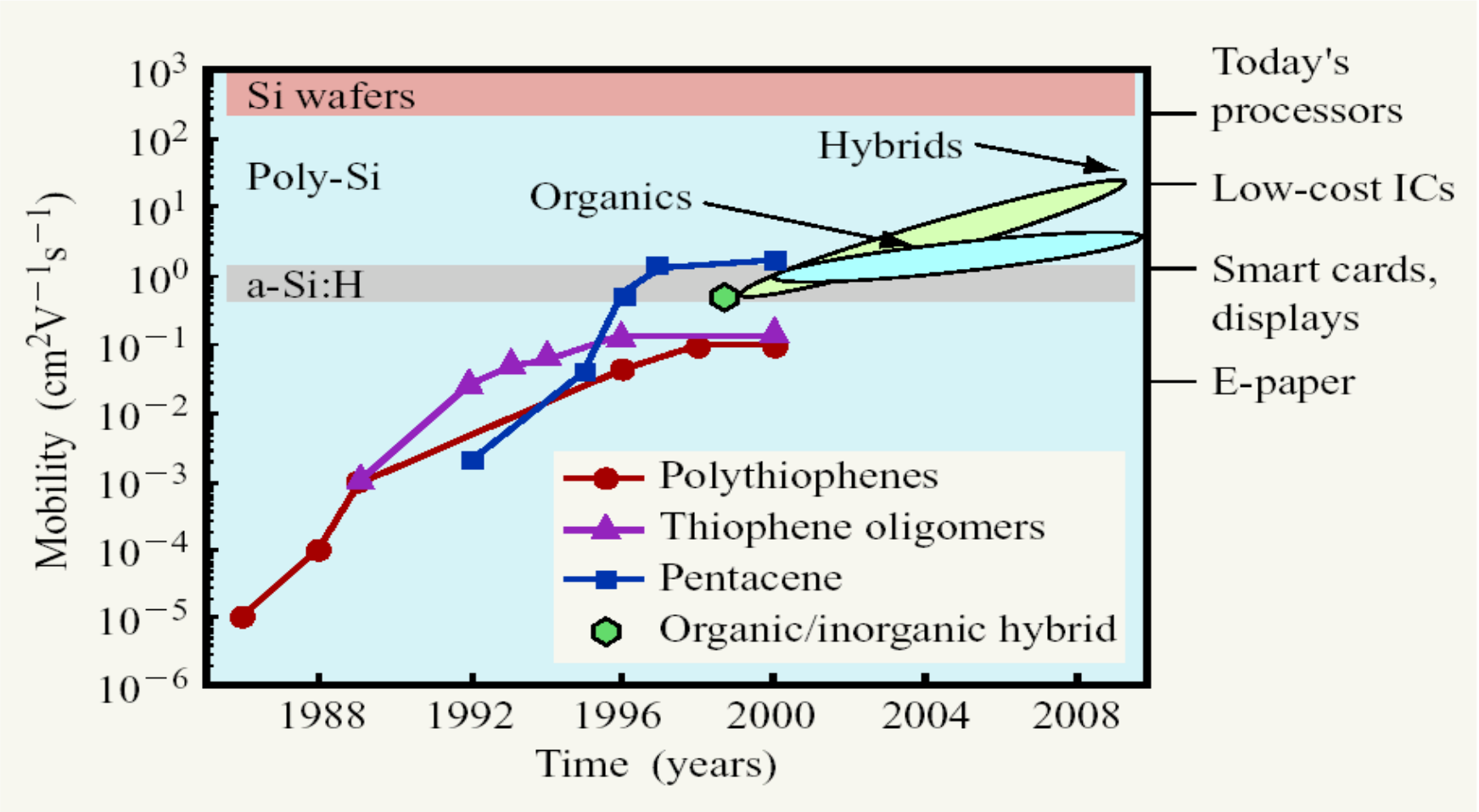
Summary

- organic electronics is ready to meet the requirements for product realization
  - Compatibility with a huge variety of substrates (web-coated polyester, paper).
  - Reliability readouts according to product requirements (shelf and operational lifetimes).
  - Yield enabling profitable manufacturing.
  - Proof of concept for simple and cheap manufacturing methods.
  - Realization of supply voltages down to 1 V

Future Outlook: Time to Start Reviewing those Chemistry Books

- OTFTs for active-matrix (LDC) displays
- Flexible view screens (or anything…)
- New generations of smart cards
- Organic smart pixels with OLEDs
- Large-area display electronics
- Organic semiconductor advances in mobility, switching time, and manufacturing may lead to many possibilities

Semiconductor	*Representative chemical structure*	*Mobility* ($cm^2V^{-1}s^{-1}$)
Silicon	Silicon crystal	300–900
	Polysilicon	50–100
	Amorphous silicon	~1
Pentacene		~1
α,ω-dihexyl-sexithiophene		10^{-1}
α,ω-dihexylanthra-dithiophene		10^{-1}
Regioregular poly(3-hexylthiophene)		10^{-1}
Organic–inorganic hybrid	Phenethylamine–tin iodide	~1



Mobilities of organic semiconductors have improved by five orders of magnitude over the past 15 years. Large research efforts using materials such as these led to some of this increase.

References

[1] Colin Reese, Mark Roberts, Mang-mang Ling, and Zhenan Bao. *"Organic Thin Film Transistors"*, Material Study, September 2004.

[2] S. Forrest, P. Burrows, M. Thompson. *"The dawn of organic electronics"* , IEEE Spectrum, Vol. 37 No. 8, 2000

[3] G. Paasch (1,2), S. Scheinert (1), R. Tecklenburg (2). *"Theory and modeling of organic field effect transistors"*

[4] C. D. Dimitrakopoulos, D. J. Mascaro. *"Organic thin-film transistors: A review of recent advances",* IBM Journal Of Research & Developmenmt, Volum 45, 2001

Credit: *Mehrdad Najibi*