

Functional Organic Films

Joint Bonn-Cologne Seminar

in Solid States

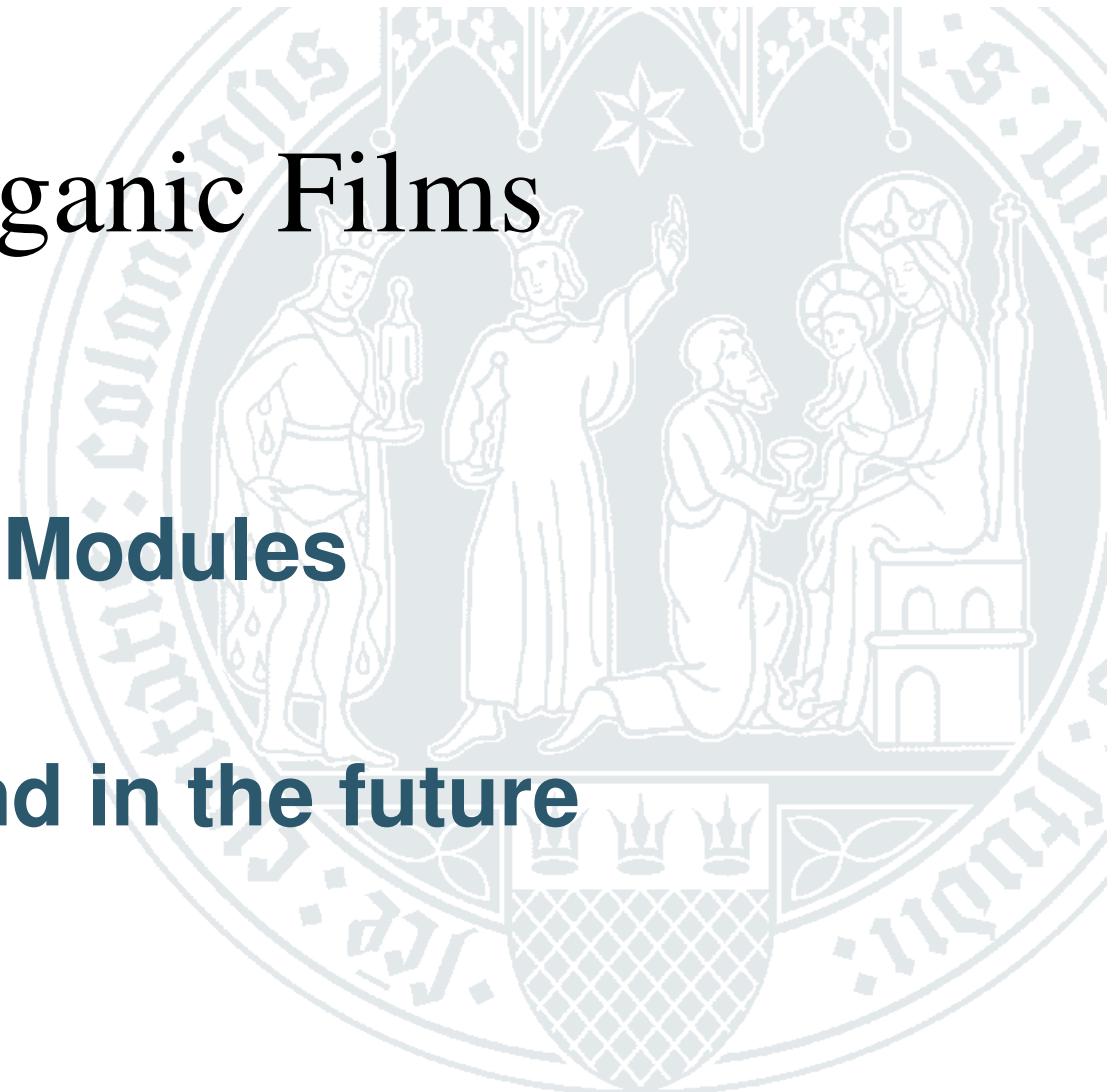
by Anna Silex

Tutor: Carsten Busse



Functional organic Films

- **Introduction**
- **Materials and Modules**
- **Conductivity**
- **Uses today and in the future**
- **Construction**



Introduction

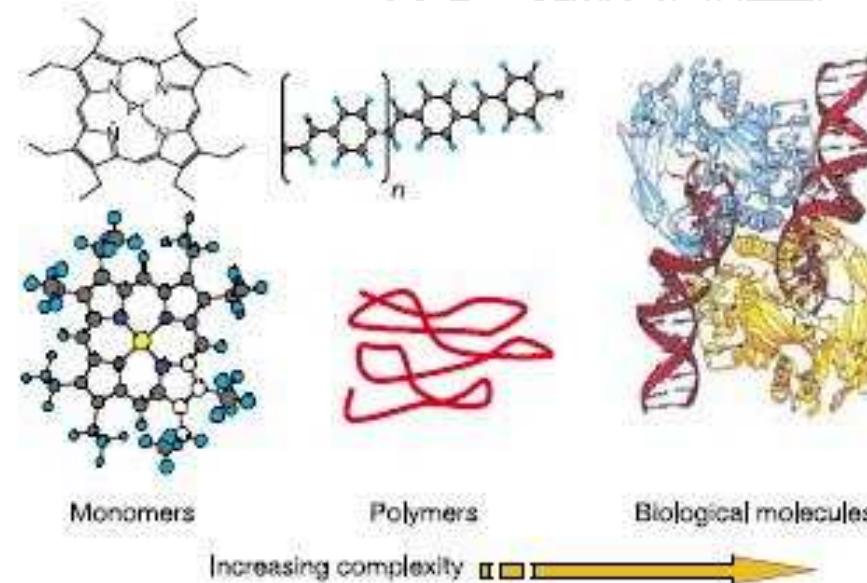
Why are organic films so interesting?

- Alternative to inorganic semiconductors with various advantages
 - Flexible (Van Der Waals)
 - Easily and cheaply made
 - Very thin films
 - Able to deposit on low-cost substrates



Materials and Components

- Small Molecules
- Polymers
- Biological Materials



Materials and Components

Small molecules

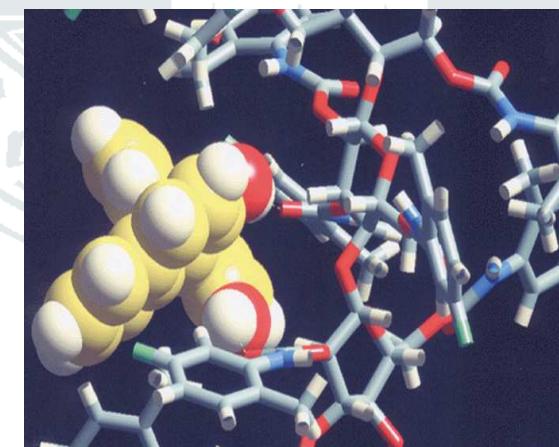
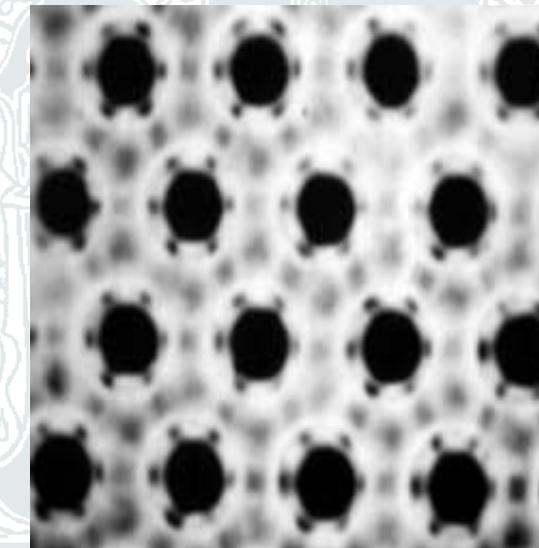
- Compounds with a well-defined molecular weight
- Based on Benzene-Rings for ex.:
 - Pentacene
 - Anthracene
- Deposited in vacuum



Materials and components

Polymers

- **Chains of repeating units**
- **No well-defined length thus molecular weight varies**
- **Deposited from liquid solution**

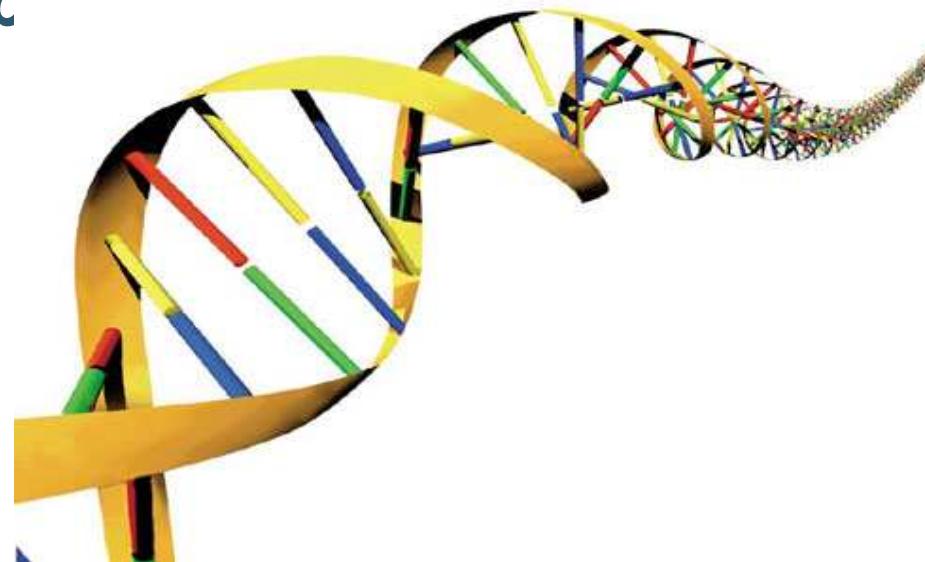


Materials and Components

Biological molecules

– Proteins and strands of DNA

– No explicit discussion of biological processes

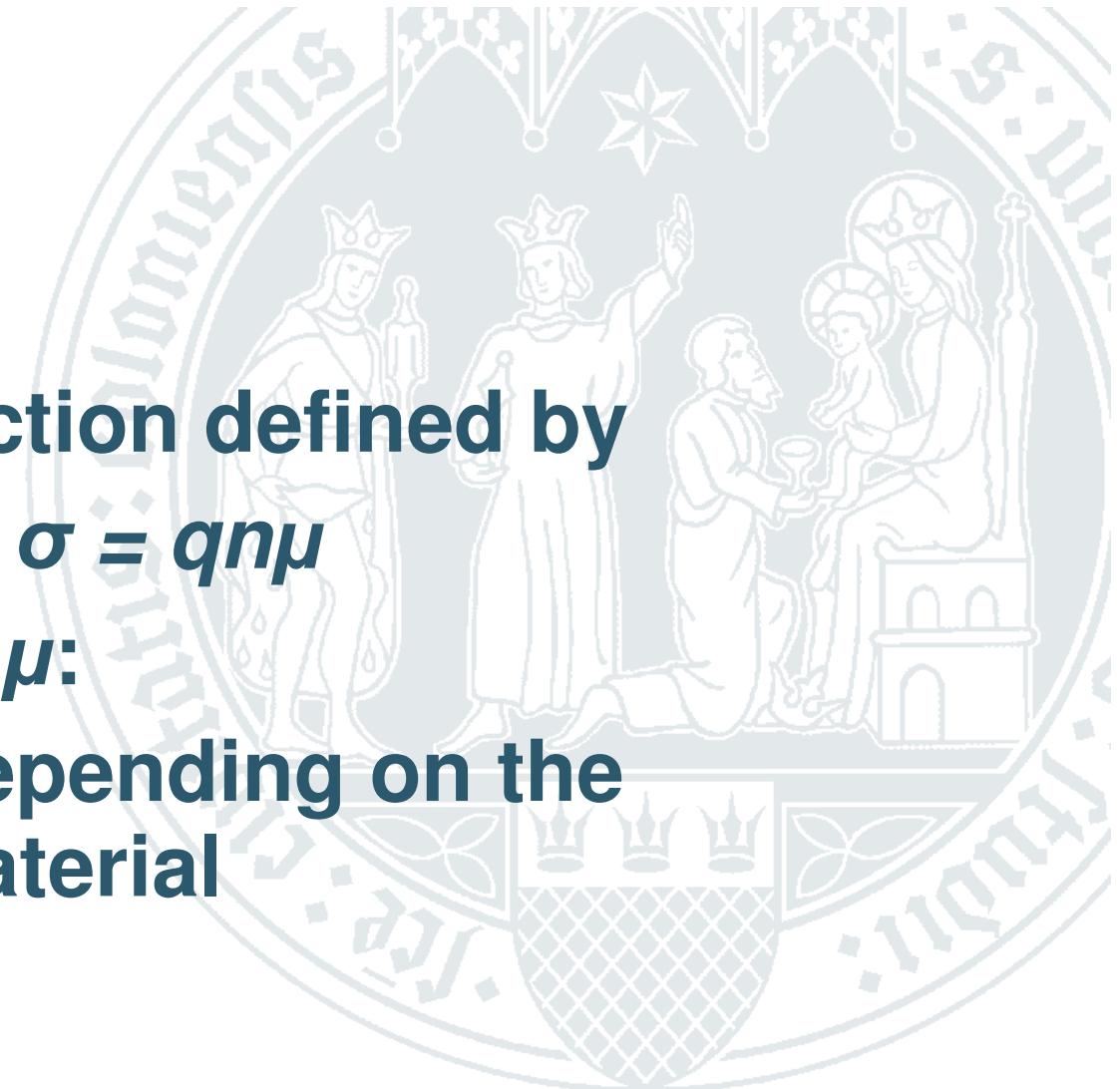


Conductivity

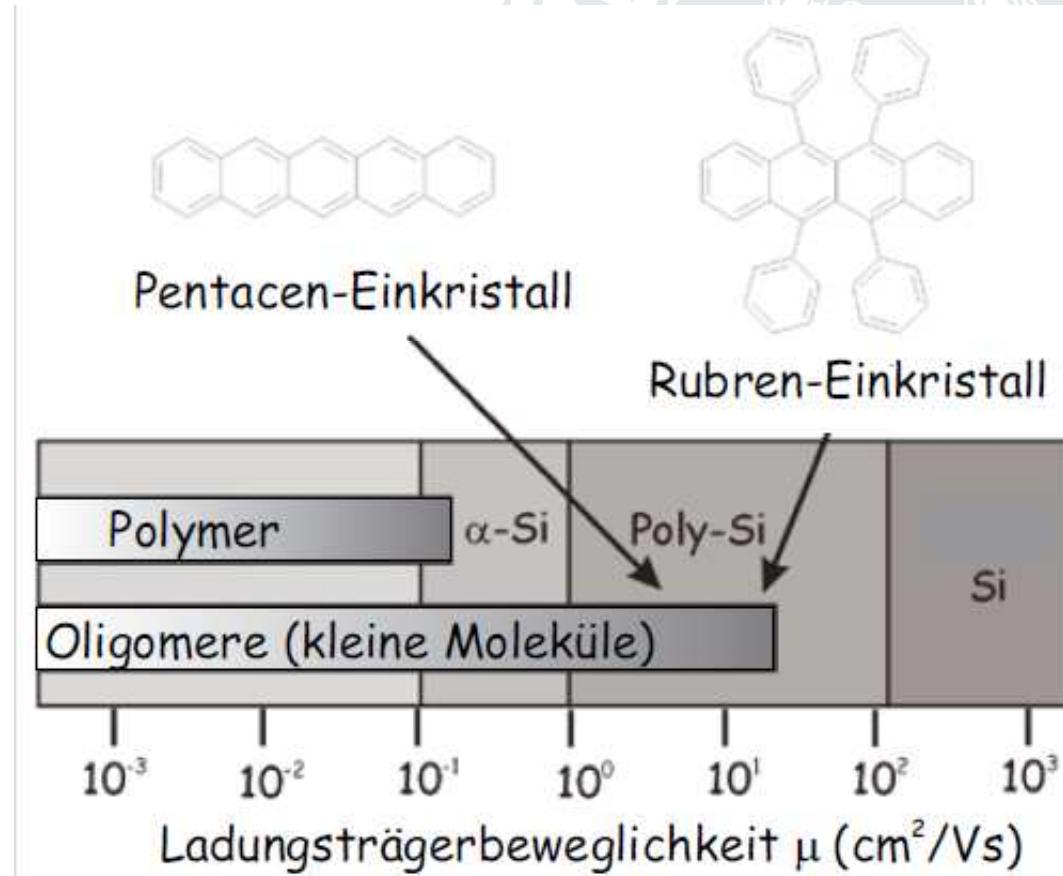
Conduction defined by

$$\sigma = qn\mu$$

look at mobility μ :
very different depending on the ordering of material



Conductivity



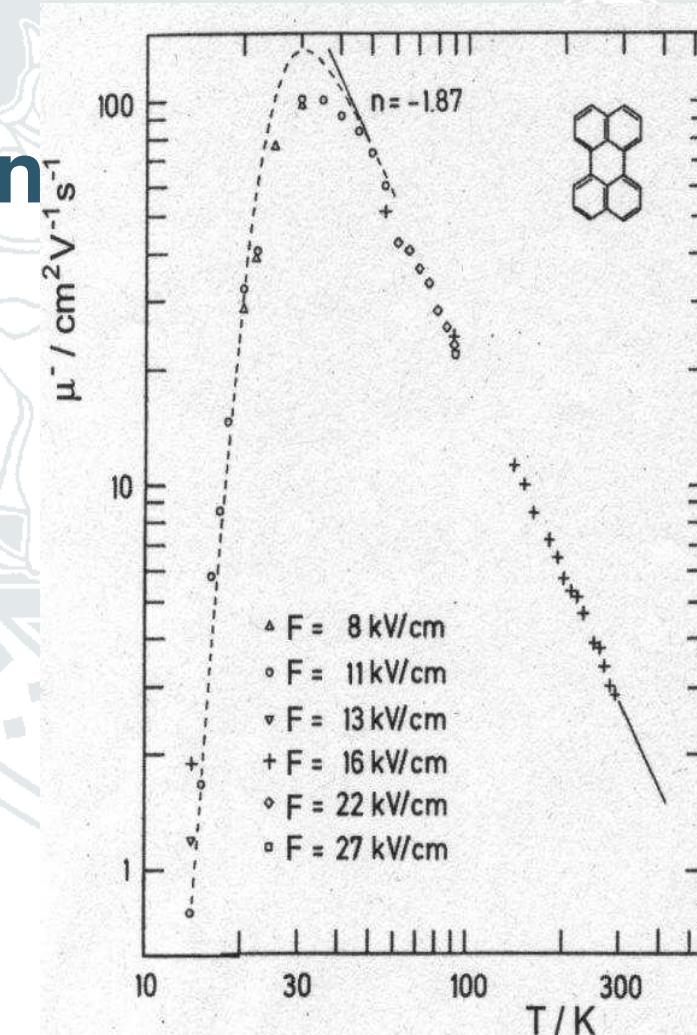
Conductivity

1.fully ordered and clean Crystals

Mobility μ increases when the temperature falls

from $1\text{cm}^2/\text{Vs}$ at room temp.

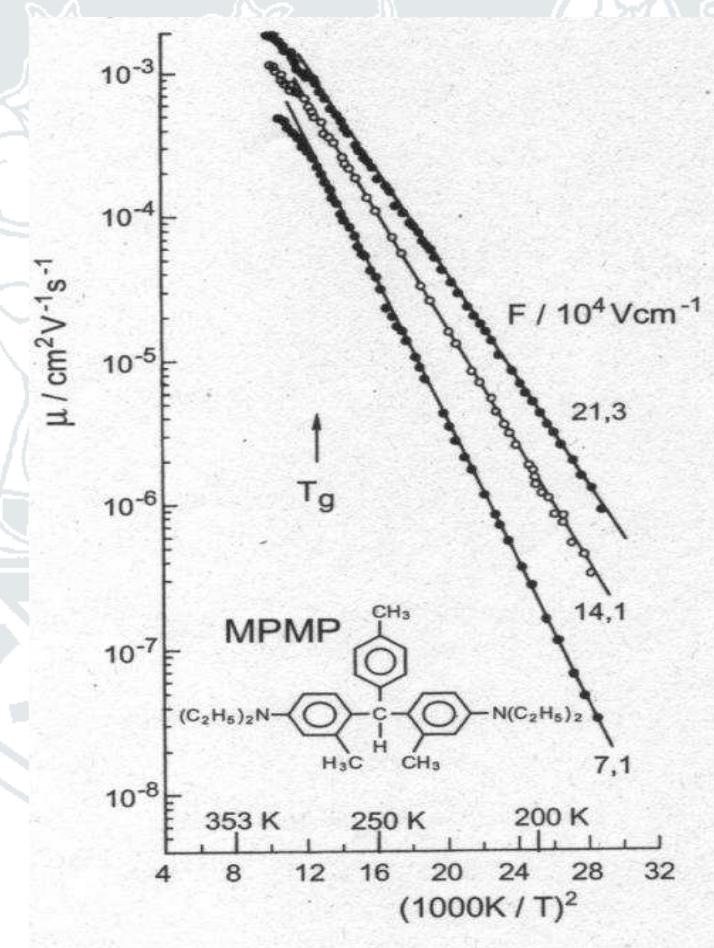
To $100\text{cm}^2/\text{Vs}$ at 30K



Conductivity

2. If Crystal doped, less ordered or polymer layers

→ $\mu: 10^{-3} \text{ cm}^2/\text{Vs}$ at 350K to $10^{-6} \text{ cm}^2/\text{Vs}$ at 200K

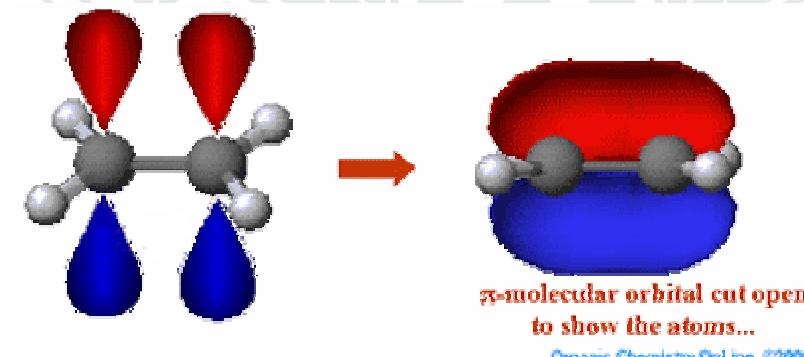


Conductivity

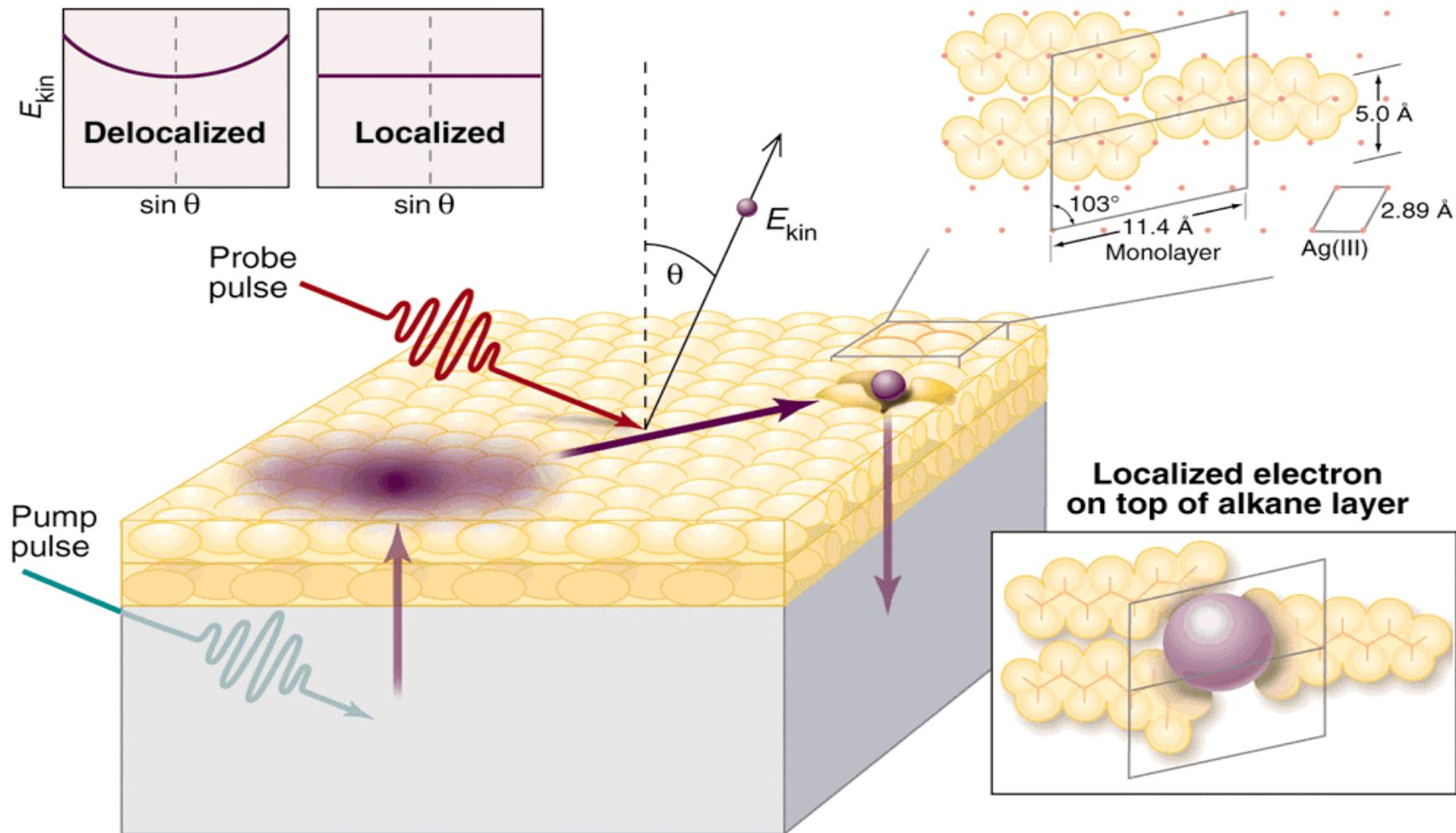
Why these differences?

- In Crystals: band conductivity due to ordering and temperature
- In Polymers (etc.): Hopping due to small mean free path

charge carrier localised on molecule
doping very important



Conductivity



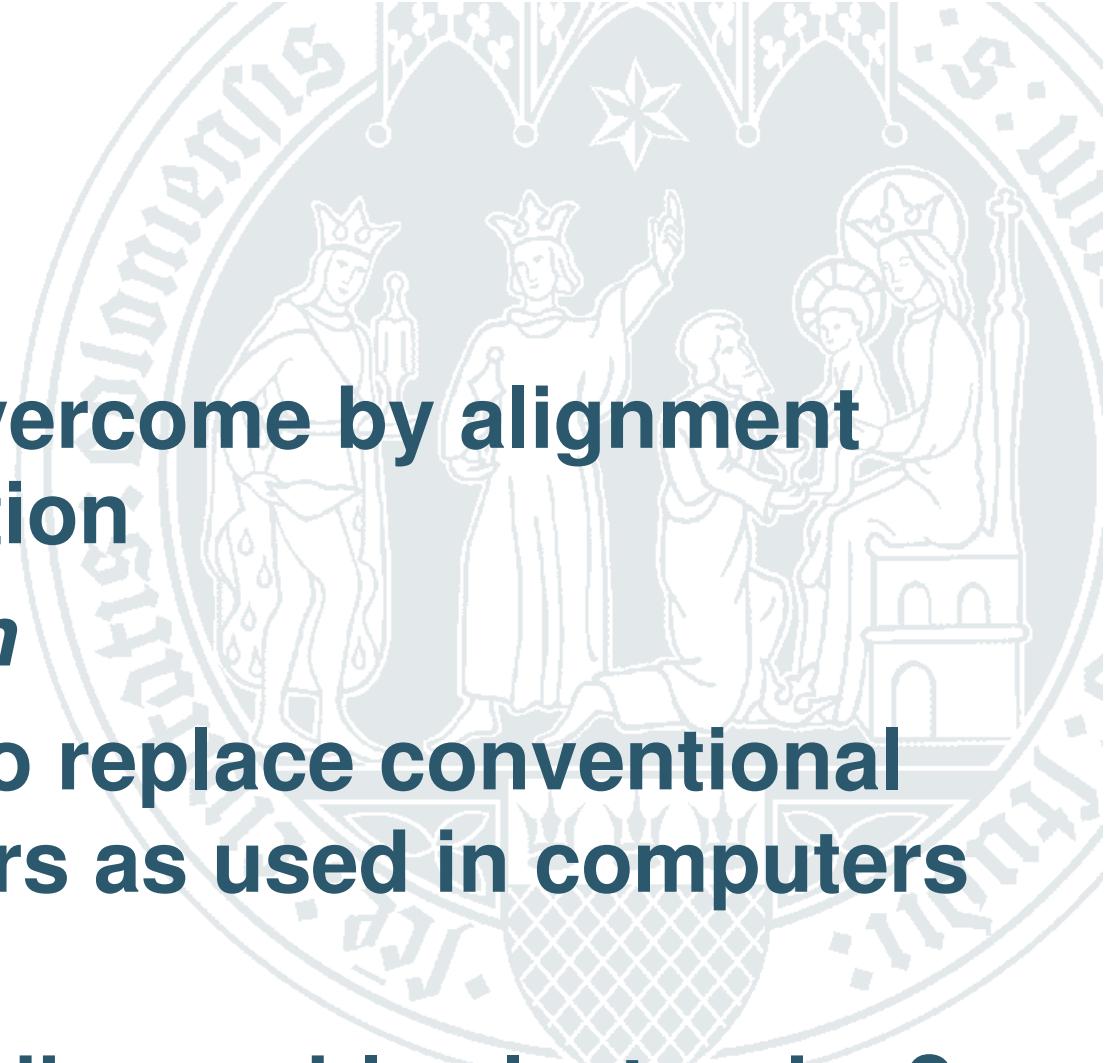
Conductivity

**Low σ can be overcome by alignment
during deposition**

=> $\sigma = 10^6 \text{ S/cm}$

**=> not enough to replace conventional
semiconductors as used in computers
for example,**

but as low-cost disposable electronics?



Uses Today and in the Future



Uses Today and in Future

Low Conductivity due to small μ

**=> no uses comparable to those with
inorganic semiconductors**

but either very cheap and chearful!

**Or through layering gets higher
frequency**

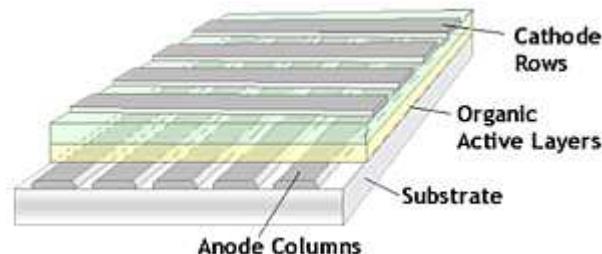
Uses Today and in Future

- **OLED (Organic Light Emitting Diodes)**
 - Already in mobile phones
 - Big displays
- **OTFT/OFET (Organic Thin Film/Field Effect Transistor)**
- **Organic solar cells**
- **Organic Lasers**

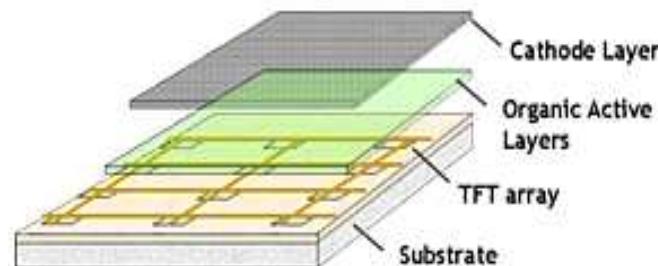


OLED

Passive Matrix OLED



Active Matrix OLED



**Electron and hole recombine
and send out a photon**

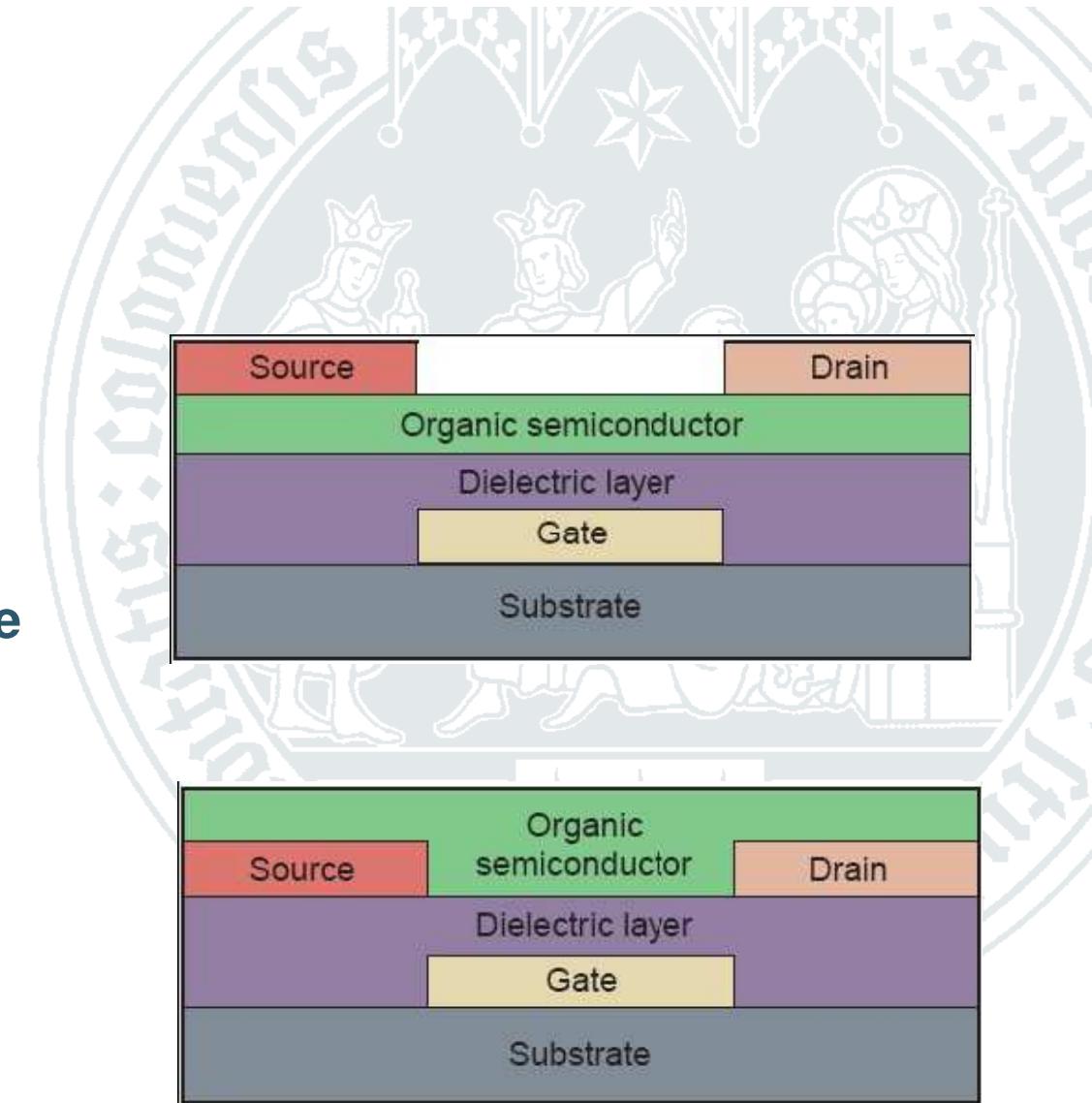
OTFT/OFET

Top contact:

- + organic material grows on homogeneous layer
- difficulties in placing the source and drain

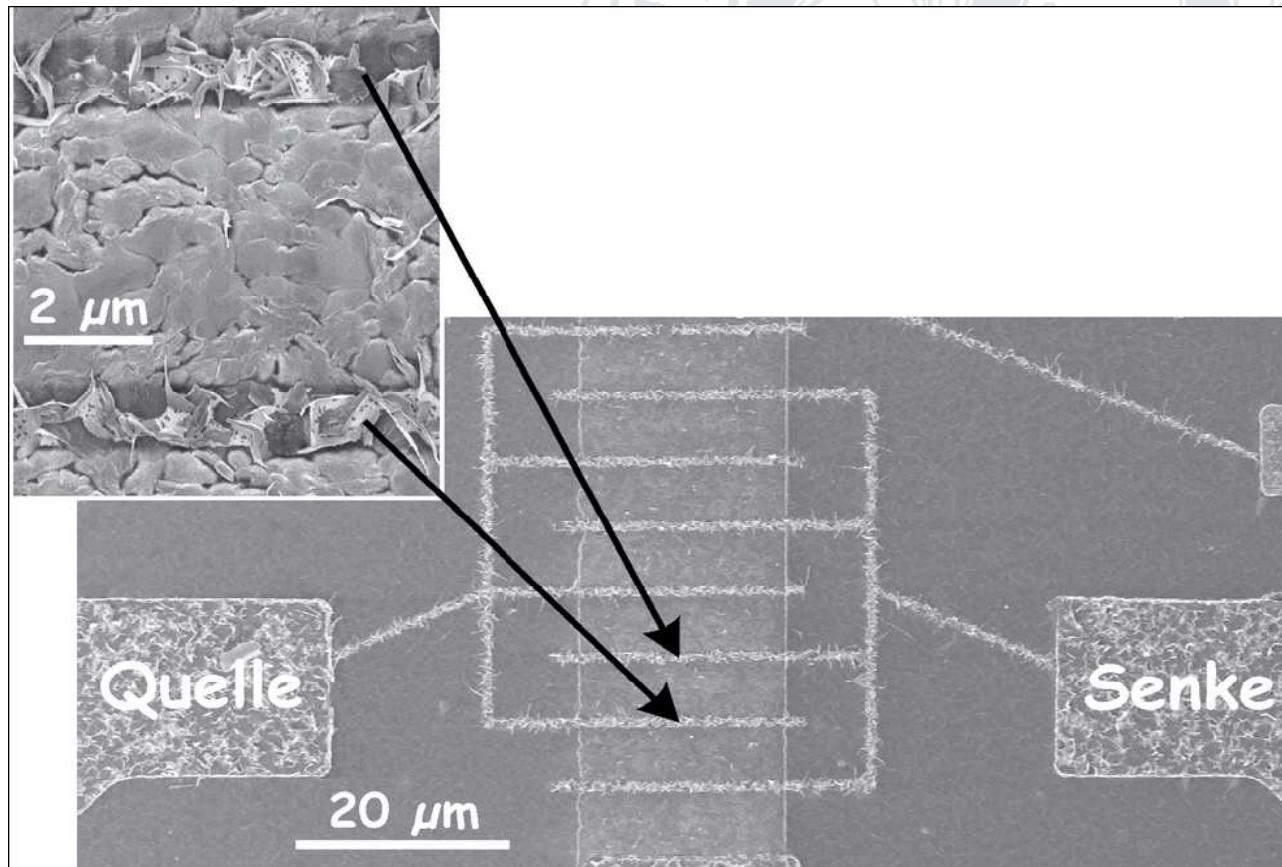
bottom contact:

- organic layer grows unevenly

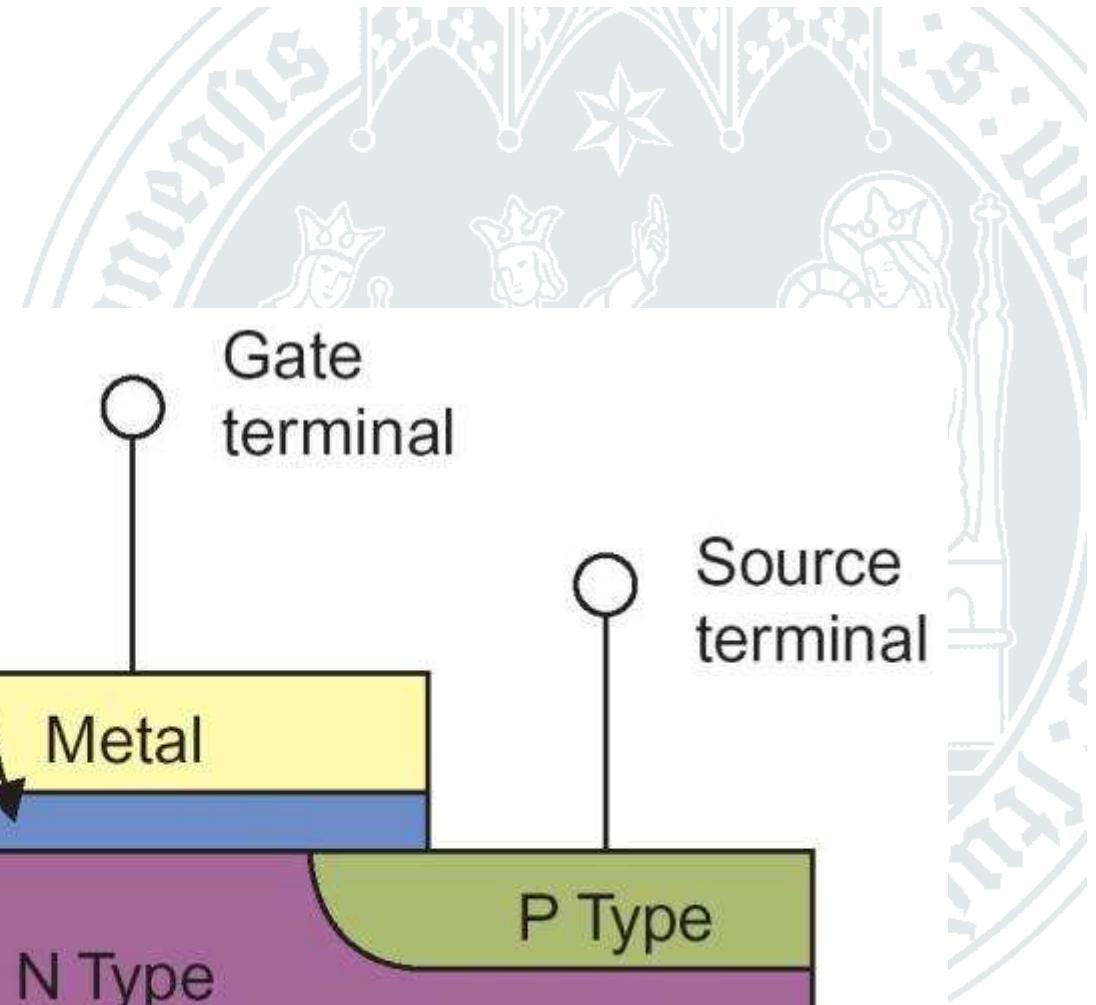


OTFT/OFET

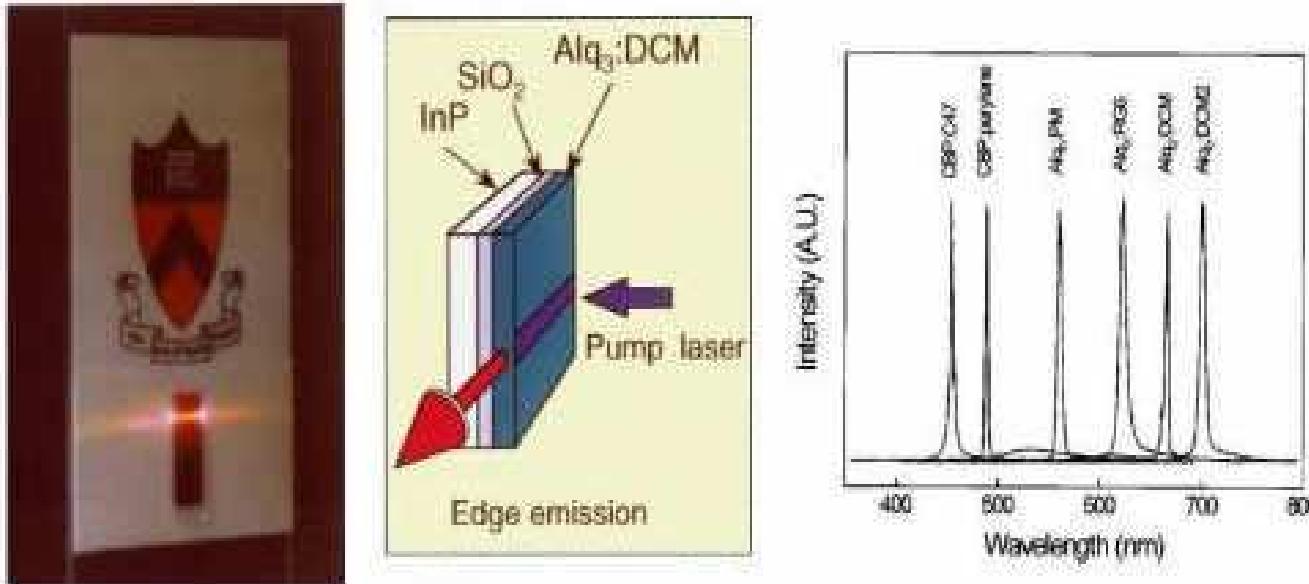
OFET's based on conventional Mosfets



OFET



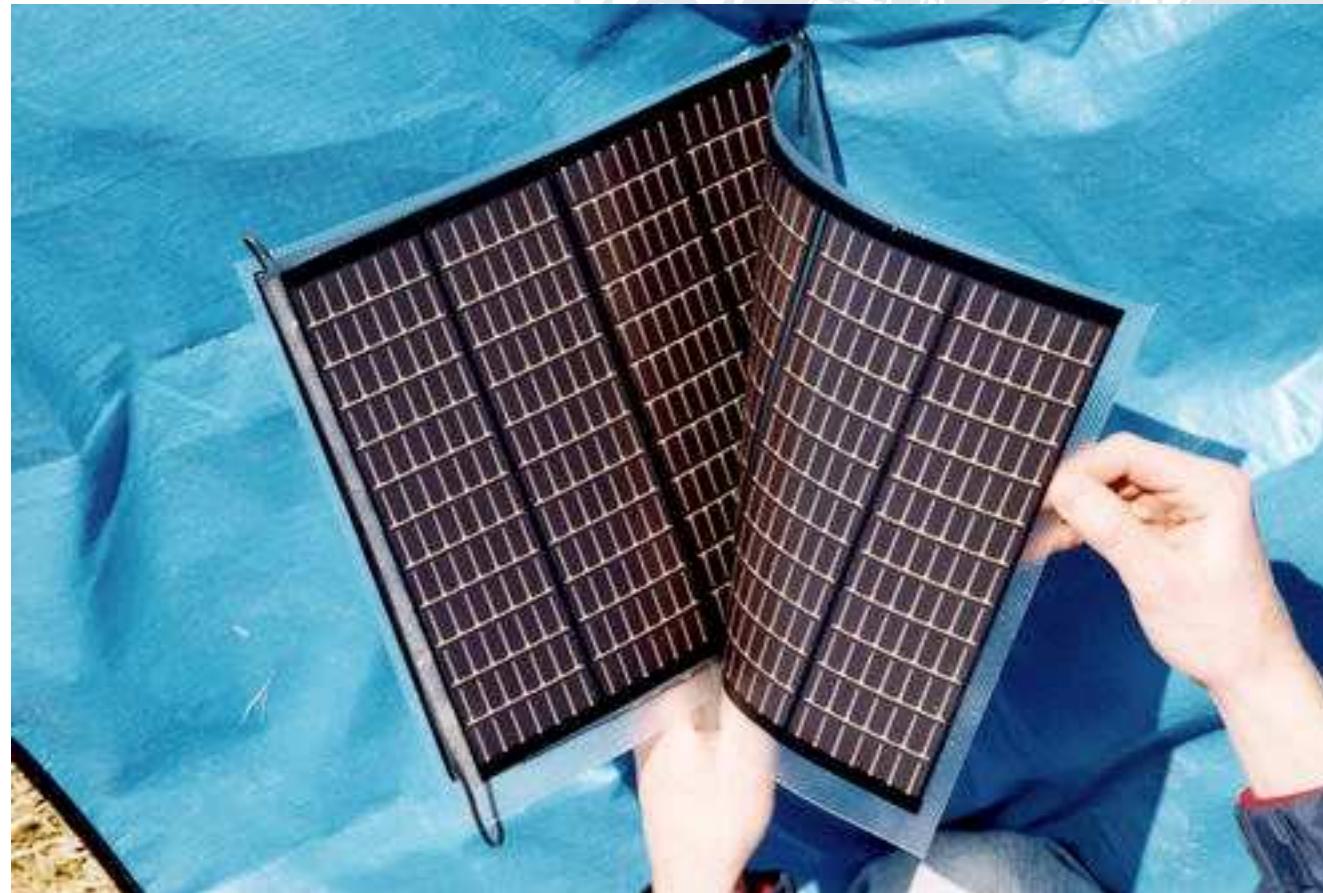
Organic Laser



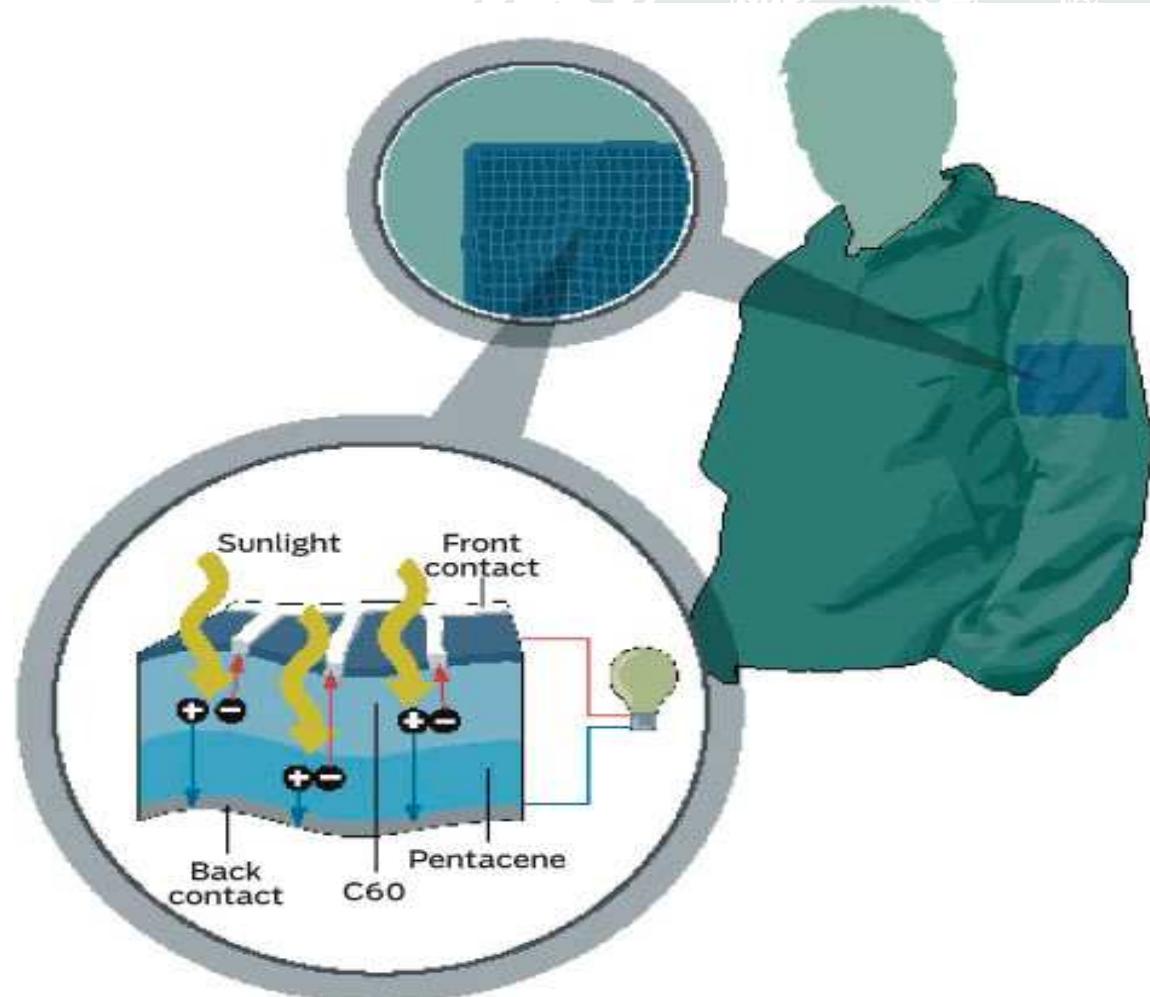
From left to right: Organic laser emitting red light; structure of the first organic laser using external optical excitation; typical laser emission spectra spanning the visible from the blue at a wavelength of 450nm, to the infrared at 700nm.



Organic Solar cells



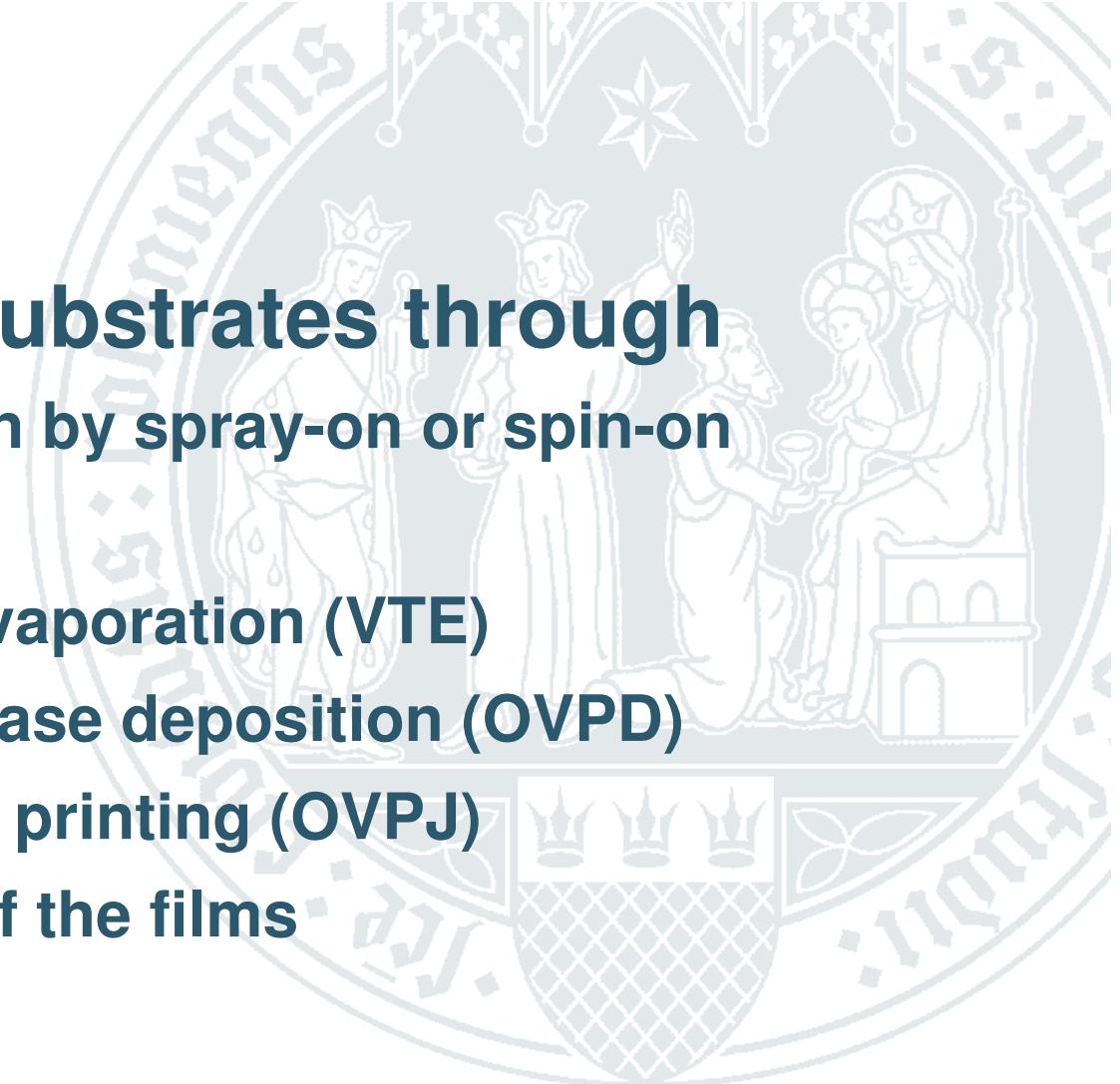
Organic Solar Cells



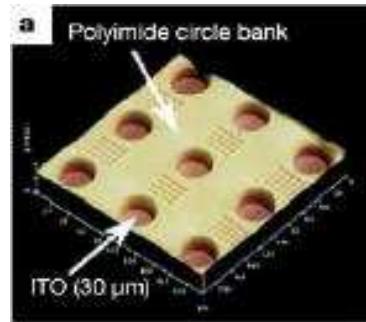
Construction

Deposition on substrates through

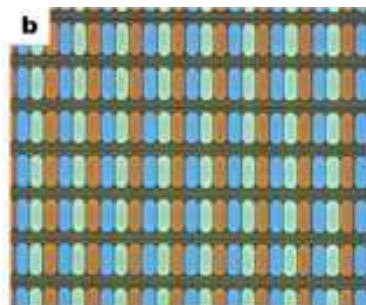
- Solution deposition by spray-on or spin-on
- Ink-jet printing
- Vacuum thermal evaporation (VTE)
- Organic vapour phase deposition (OVPD)
- Organic vapour-jet printing (OVPJ)
- Direct patterning of the films



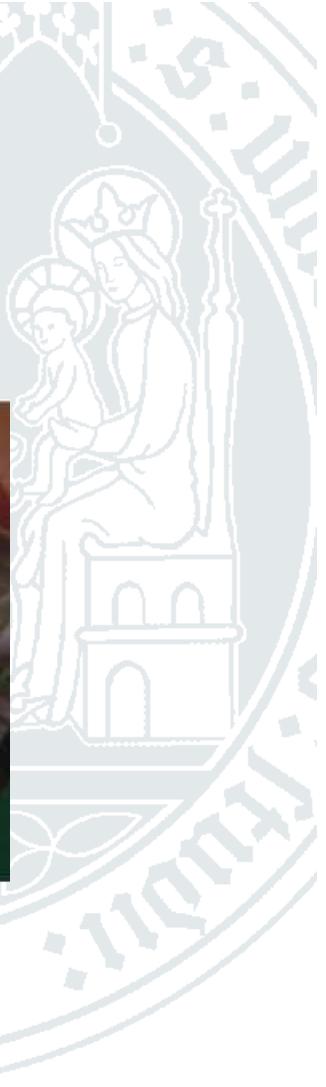
Ink-jet printing



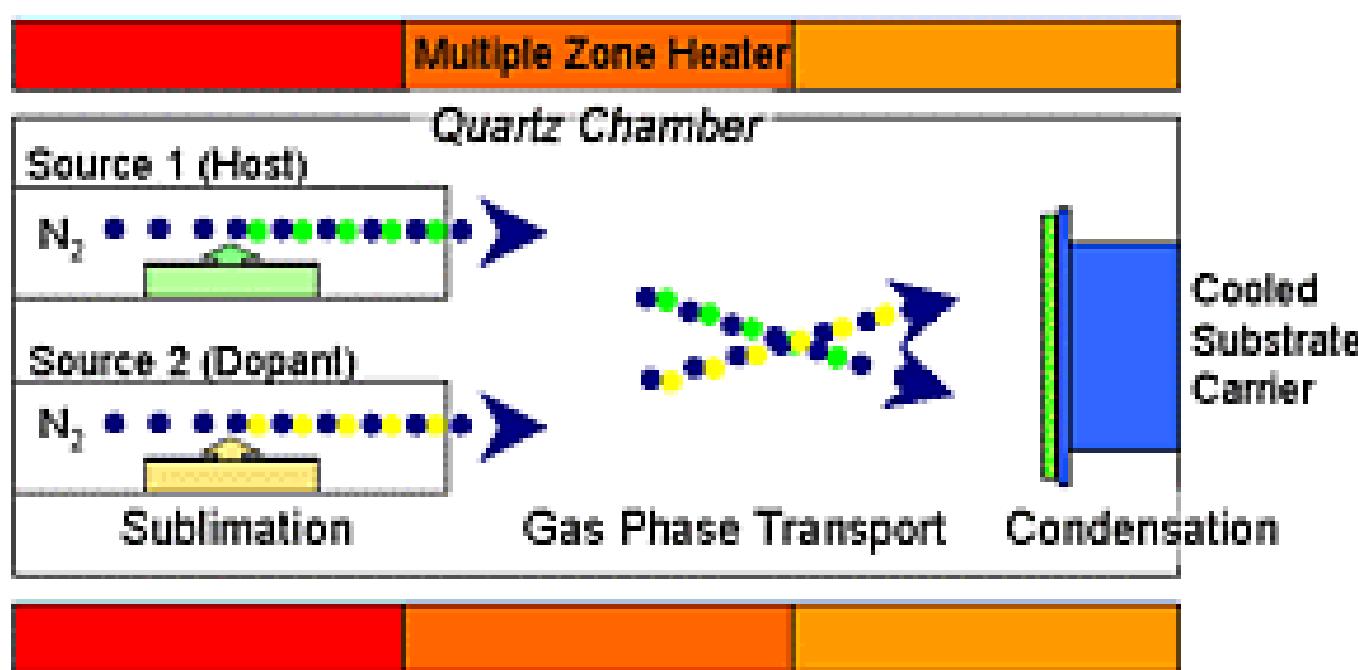
Holes ready for droplets of solution



Display made up of 3 colours



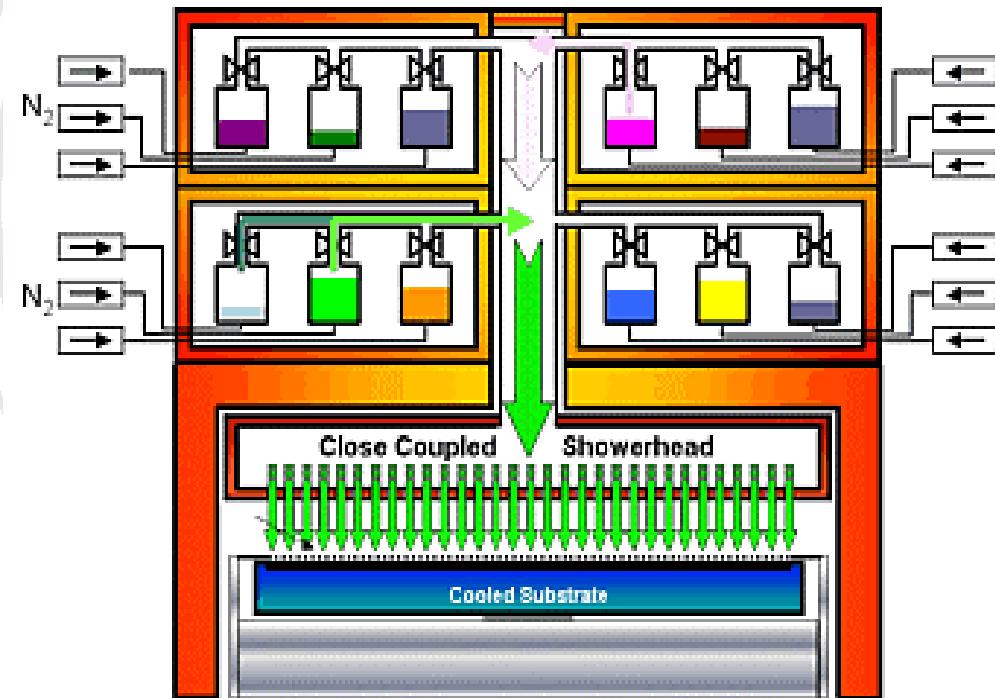
OVPD



New OVPD process employs a heated carrier gas to transport and deposit organic films on to a substrate

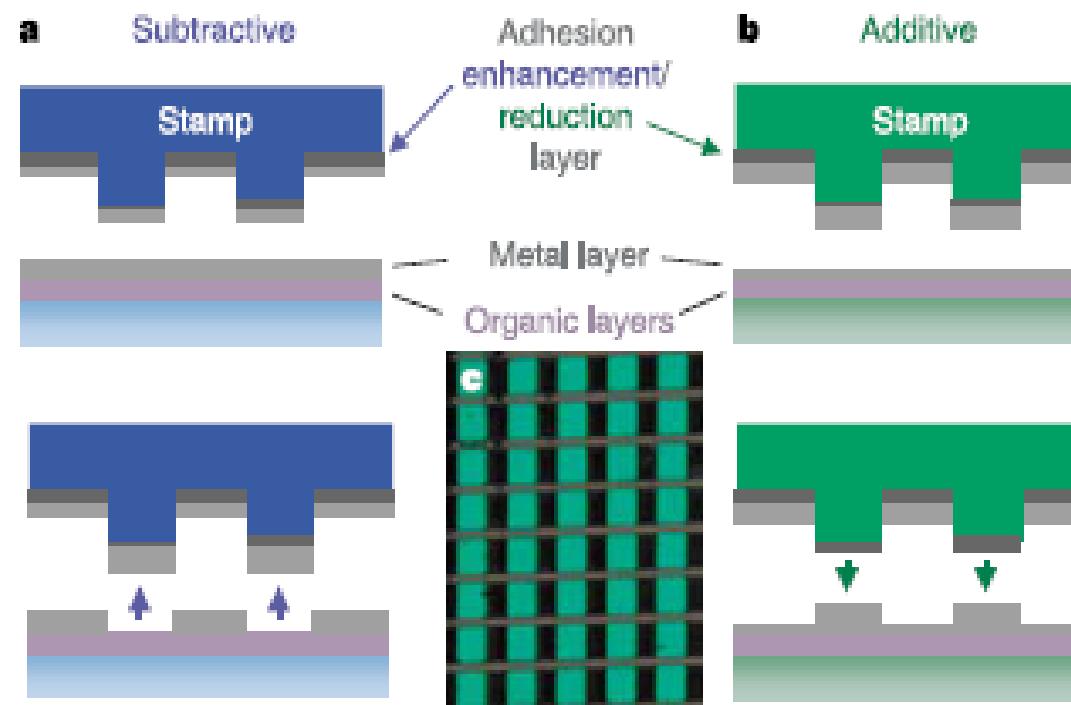
OVPD

- Higher deposition rates
- Higher materials utilization
- Better device performance
- Shadow-mask patterning
- Larger Substrate size



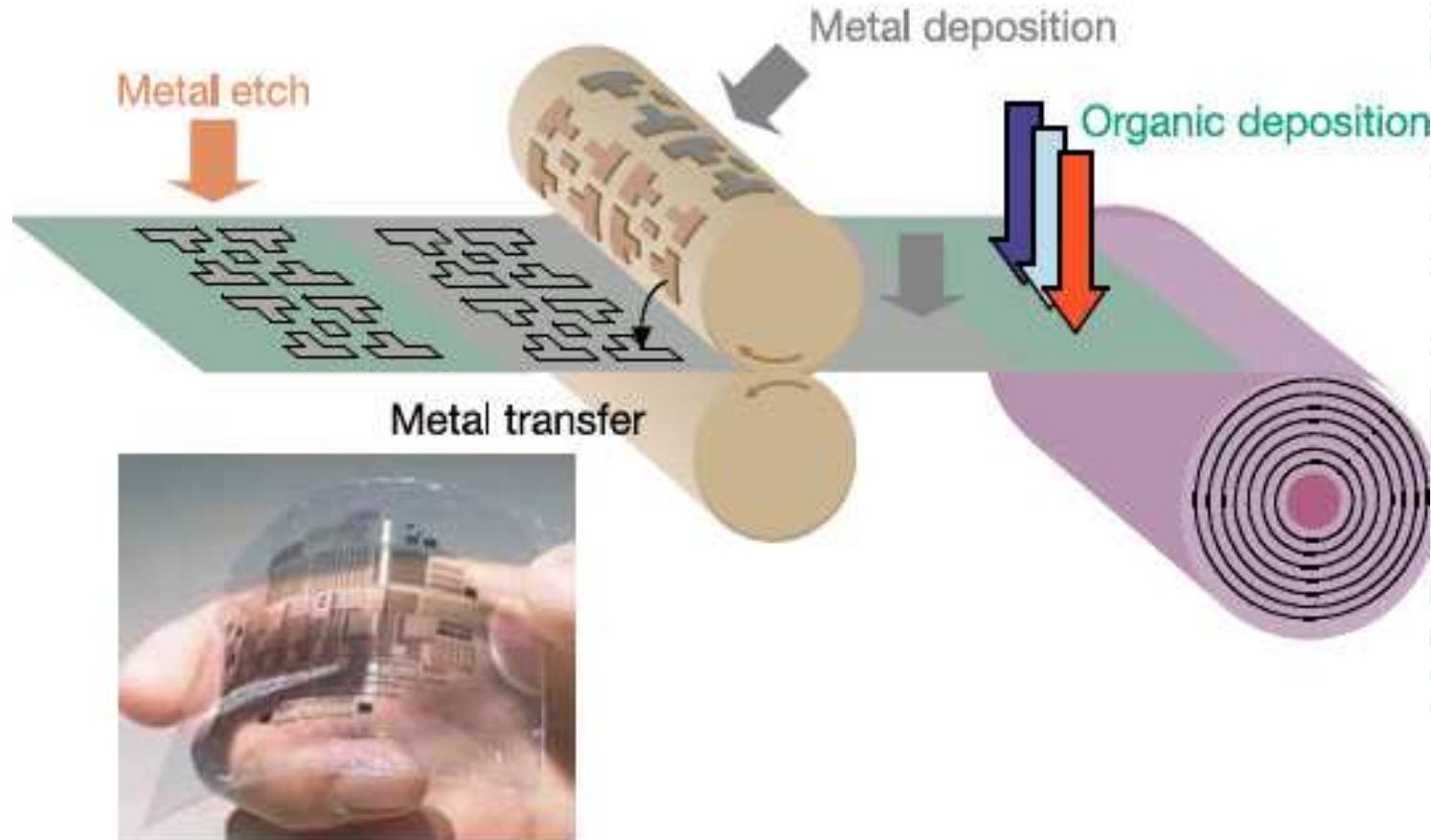
OVPD developed by Stephen Forrest
and Aixtron

Direct Patterning



Direct micro/nanopatterning of an organic electronic device by cold welding

Direct Patterning



Conclusion

- **Monomers and Polymers allow very thin films**
- **Conductivity by hopping**
- **Although not very powerful organic films are easily and cheaply made**
→ offer different uses for displays, lasers, solar cells, bar code labels etc...

