Organic Materials for Flexible Electronics

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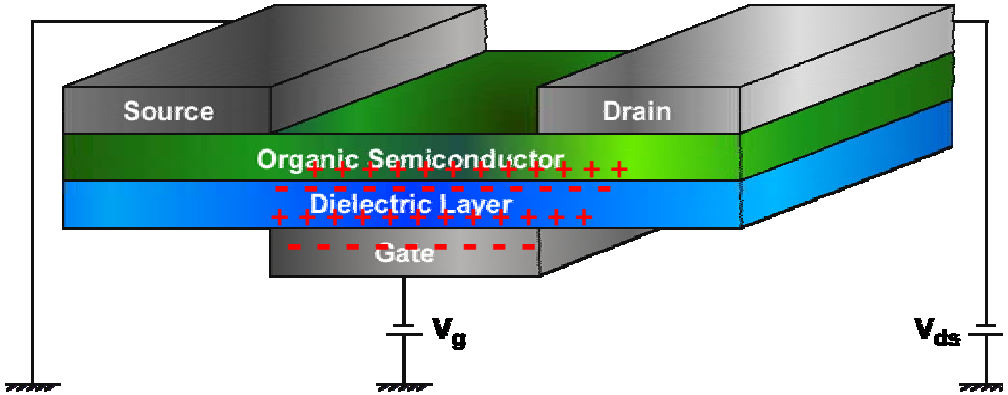
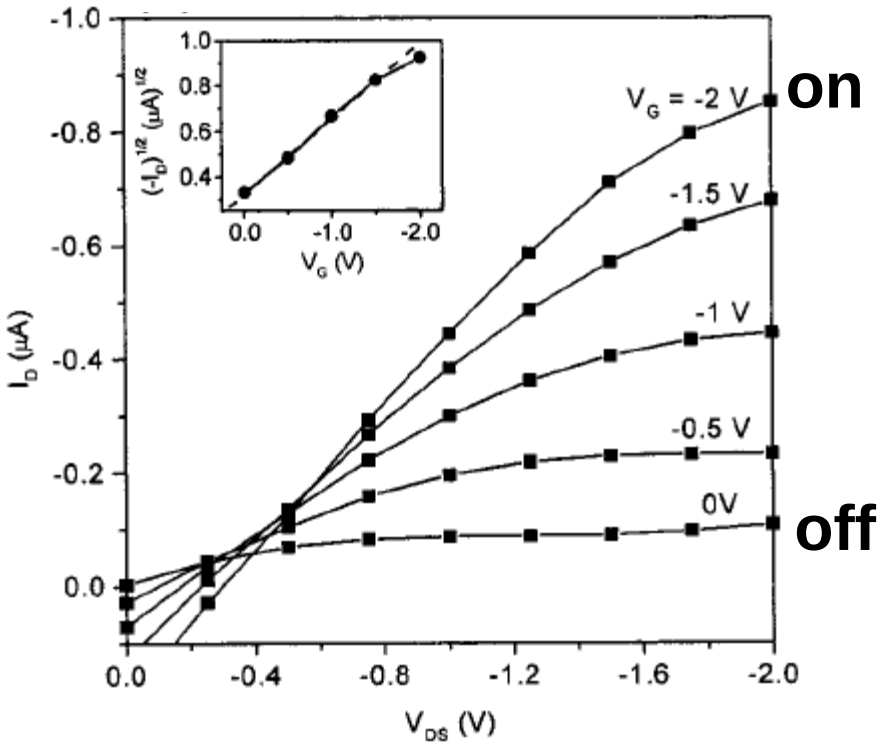
Field-effect transistor (FET)





on

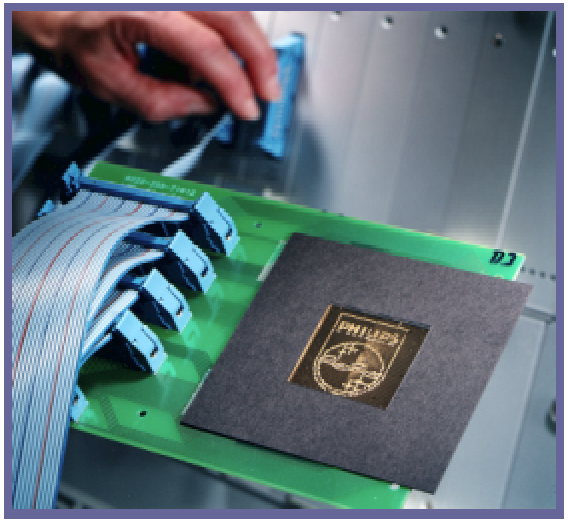
off

Parameters:
on/off ratio
field effect mobility

Colin C. Reese; Mark Roberts, Mang-mang Ling, Zhenan Bao; *Materials Today,* **2004**, 7(9), 22.

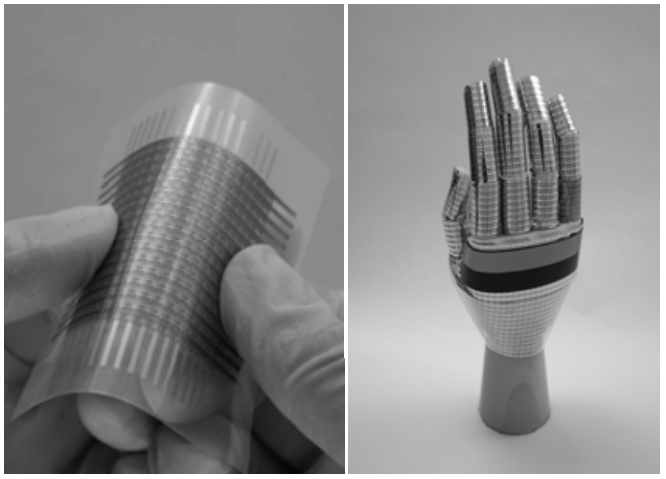
Organic Electronic Devices: Displays, Memory Cards, Sensors

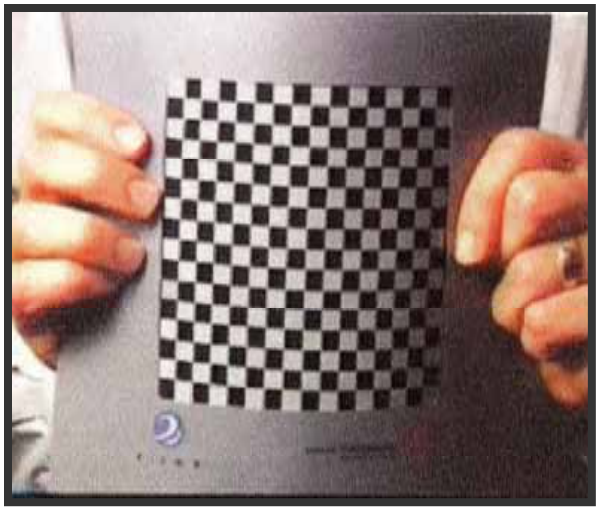
--------Electronics Everywhere



Philips

Sensors

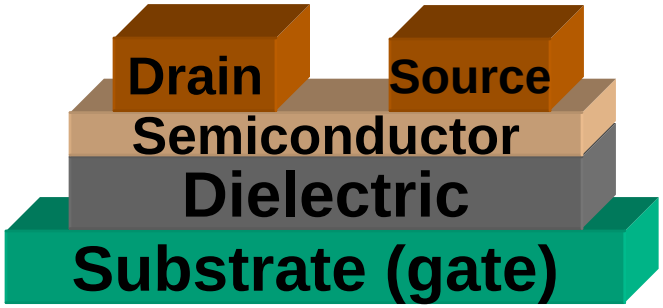




Lucent/E-Ink

Someya et al. PNAS 2004

Materials



Conductor

Semiconductor

Insulator

Conductors

Vacuum evaporated metal: Au, Ag, Pd

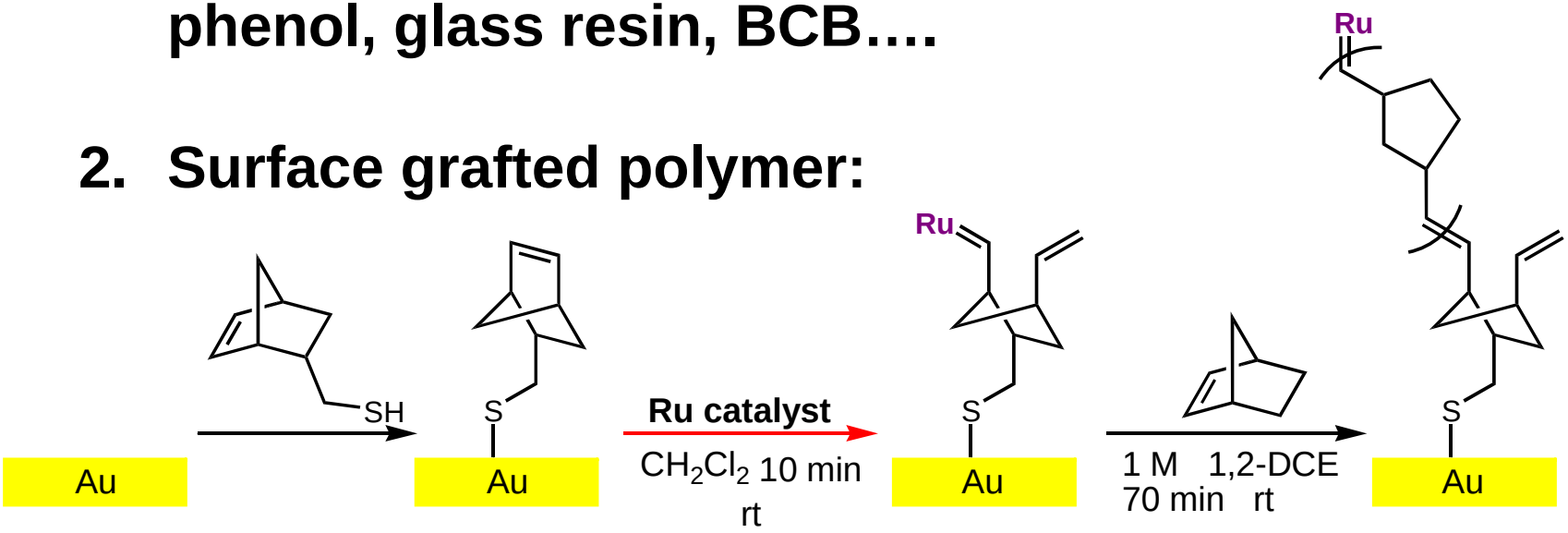
Solution deposited conducting polymers:
polythiophene (PEDOT), polyaniline

Solution deposited Au or Ag nanoparticles:
curing temperature 120-200 ºC

Dielectric Materials

1. **Spin coated polymer: PMMA, polystyrene, polyvinyl phenol, glass resin, BCB….**

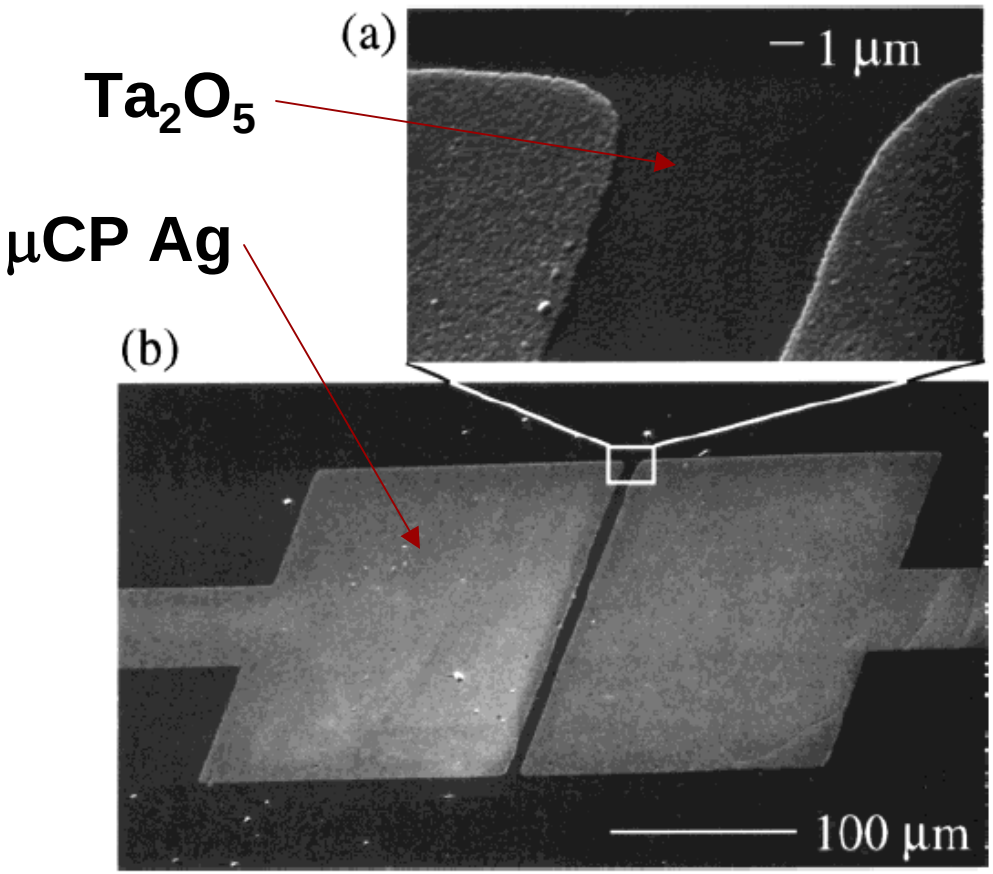
2. **Surface grafted polymer:**

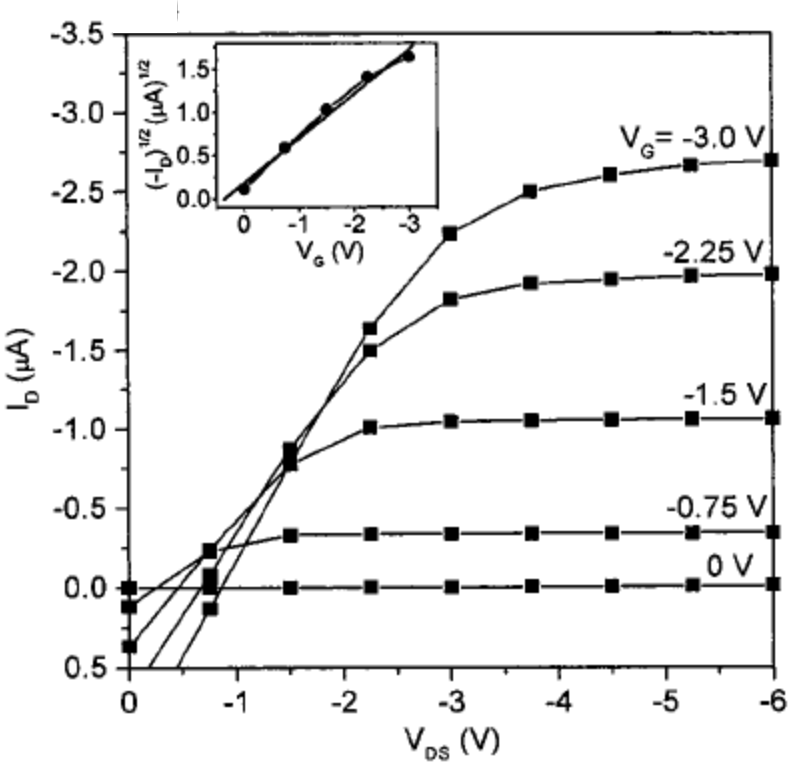


1) I. Rutenburg, O. Scherman, Z. Bao, R. Grubbs, **J. Am. Chem. Soc., 126, 4062-4063, 2004.**

Dielectric Materials, con'd

3. Anodized Ta_2O_5 and Hf_2O_5

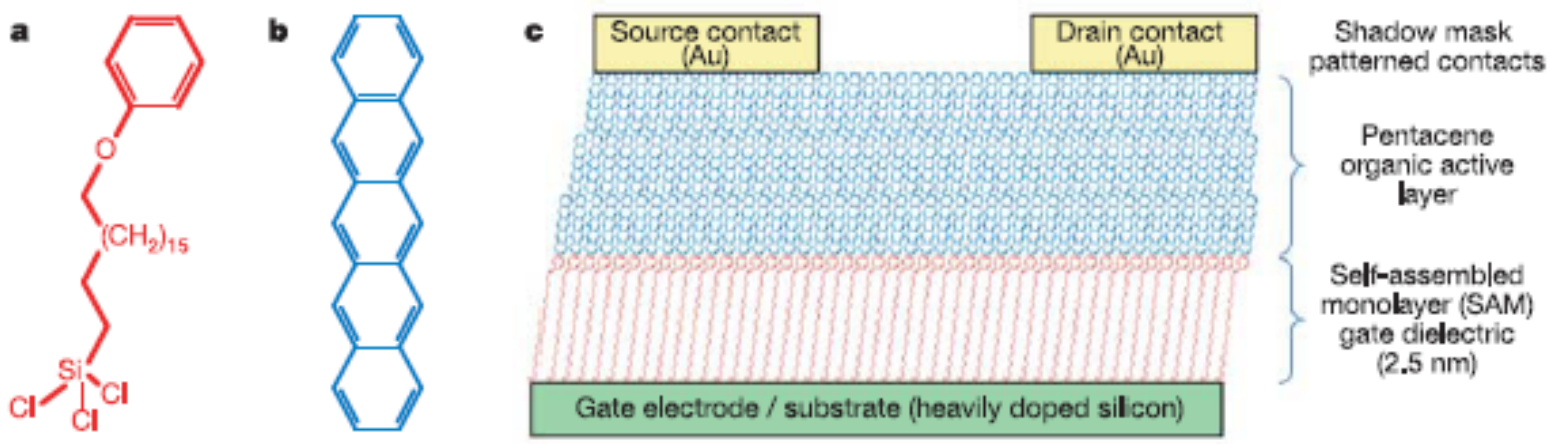


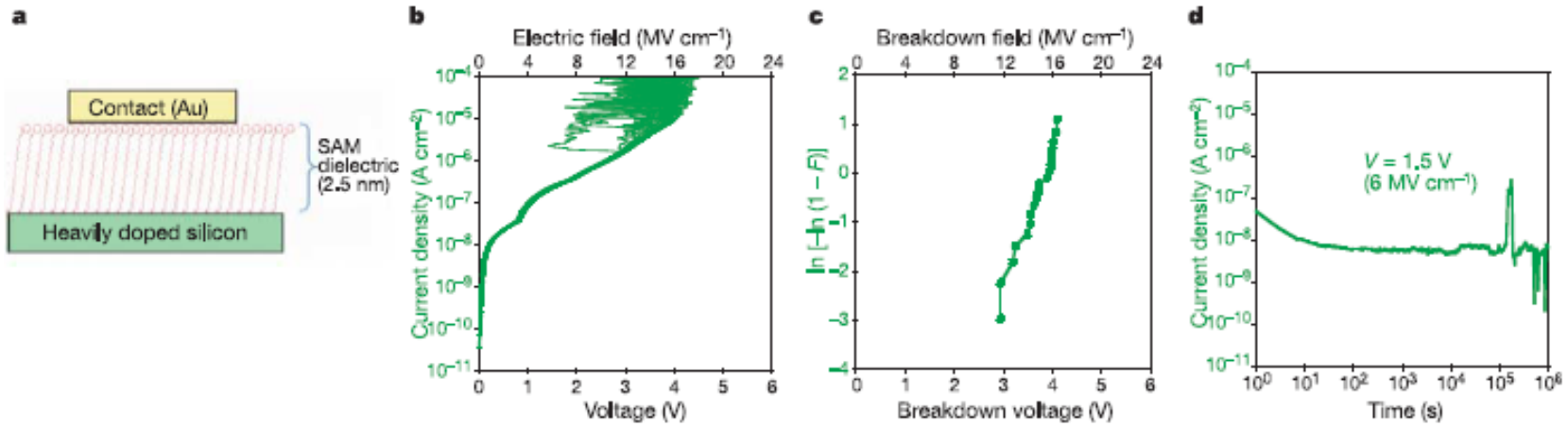


J.Tate, J.A. Rogers, C.D. W. Jones, B. Vyas, D.W. Murphy, W. Li, Z. Bao, R.E. Slusher, A. Dodabalapur, H.E. Katz, *Langmuir* **2000,** *16,* 6054-6060

Dielectric Materials, con'd

4. Self-assembled monolayer



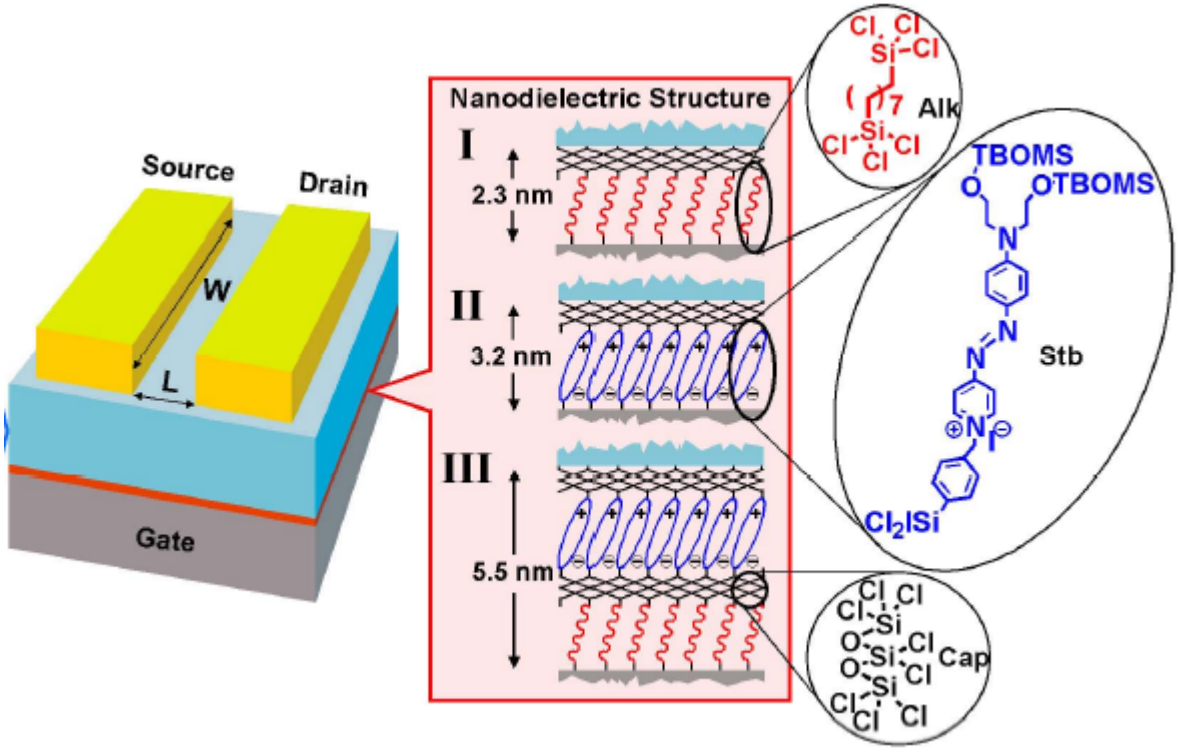


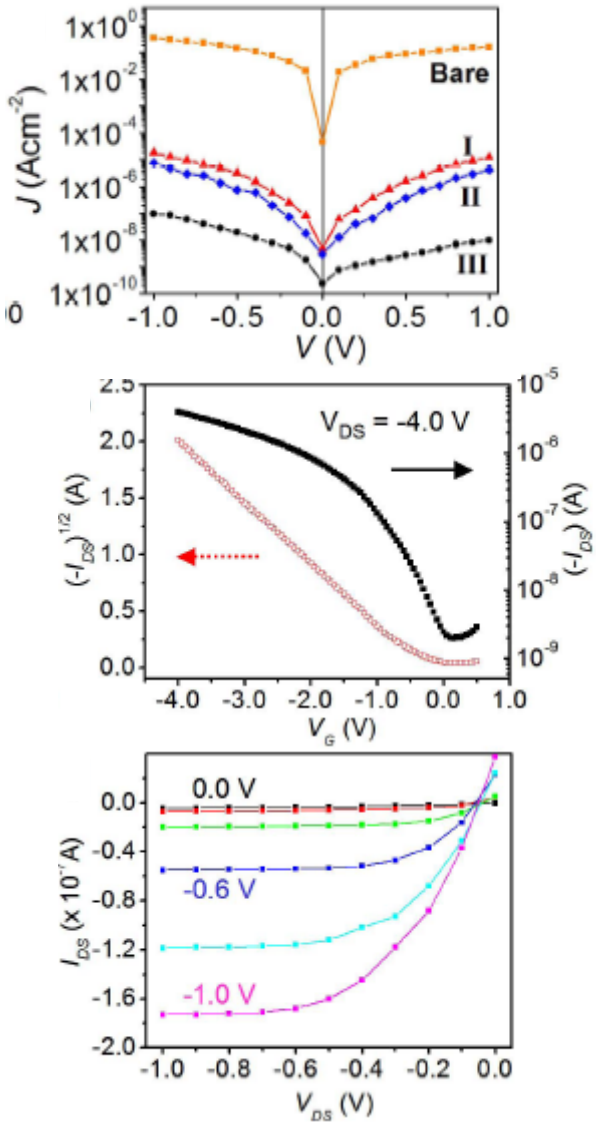
M. Halik et al., Nature, 2005

Dielectric Materials, con'd

4. Self-assembled monolayer

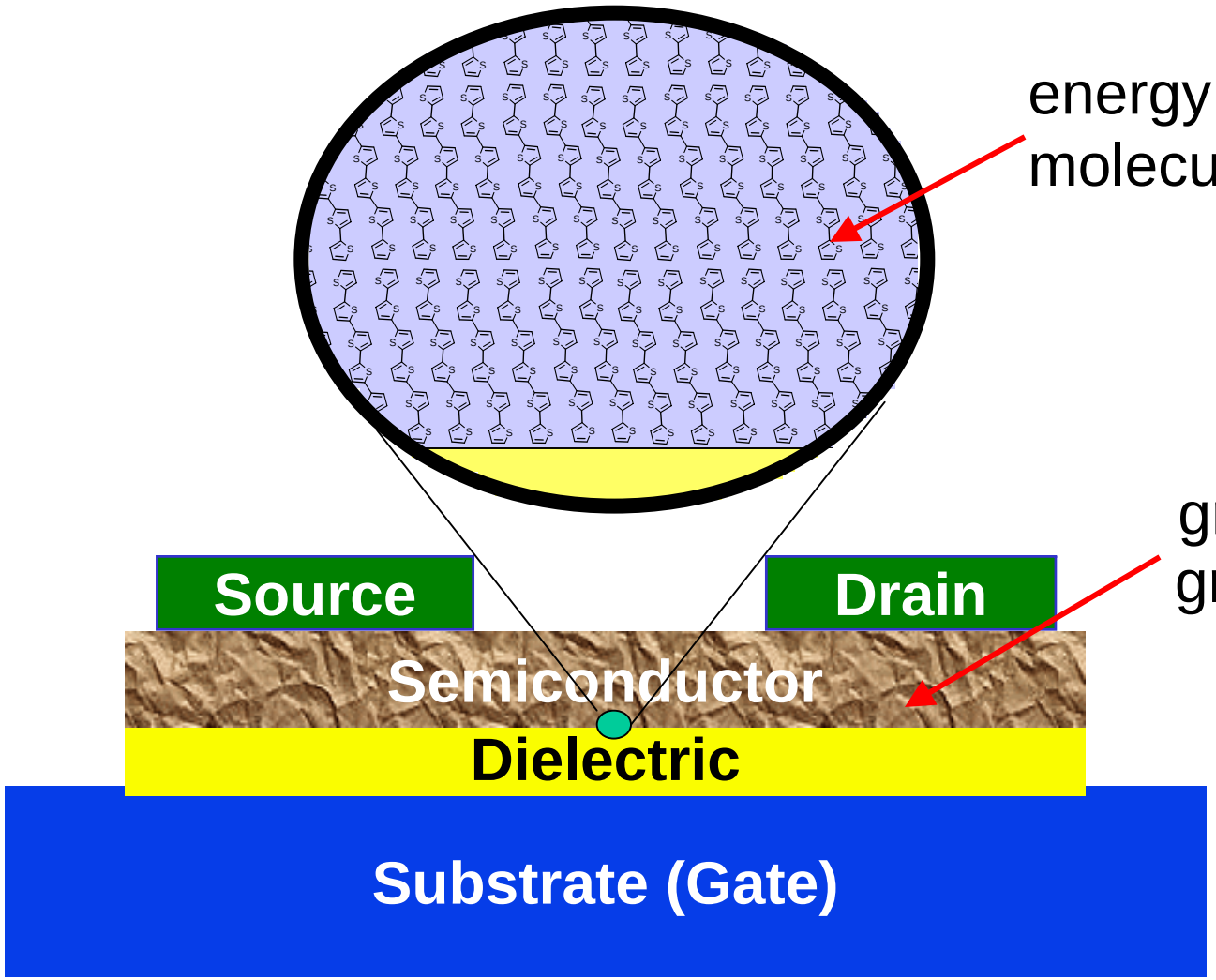
***k* = 16**



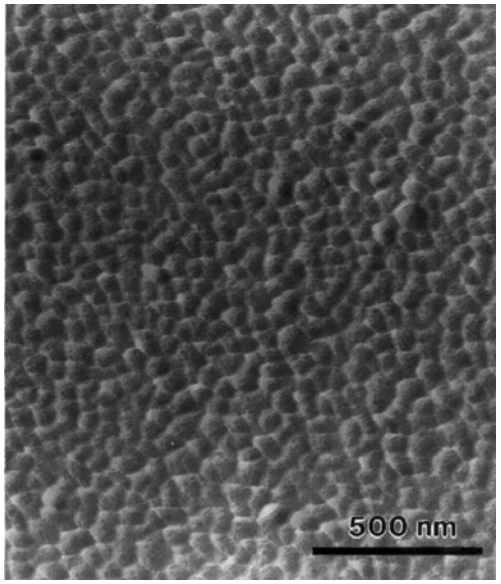


M.H. Yoon, A. Facchetti,T.J. Marks, *PNAS*, 2005

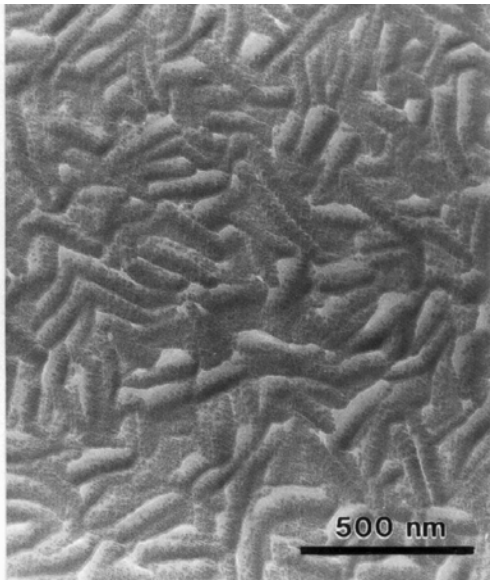
Semiconductor

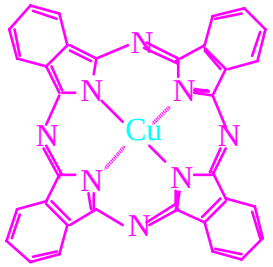


Substrate temperature = 25 °C



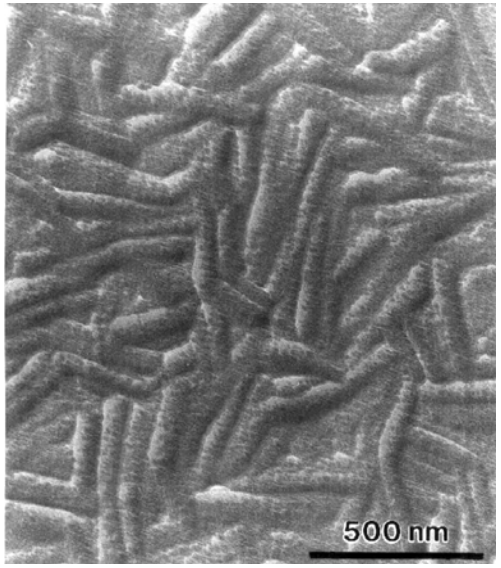
Substrate temperature = 100 °C



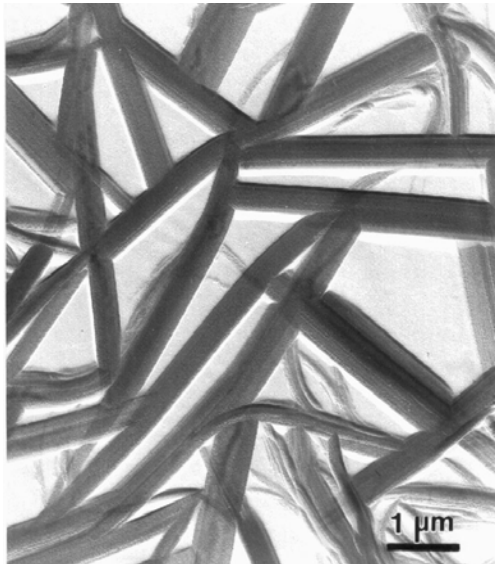


Cu-Pc

Substrate temperature = 125 °C

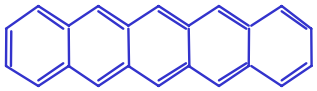


Substrate temperature = 225 °C

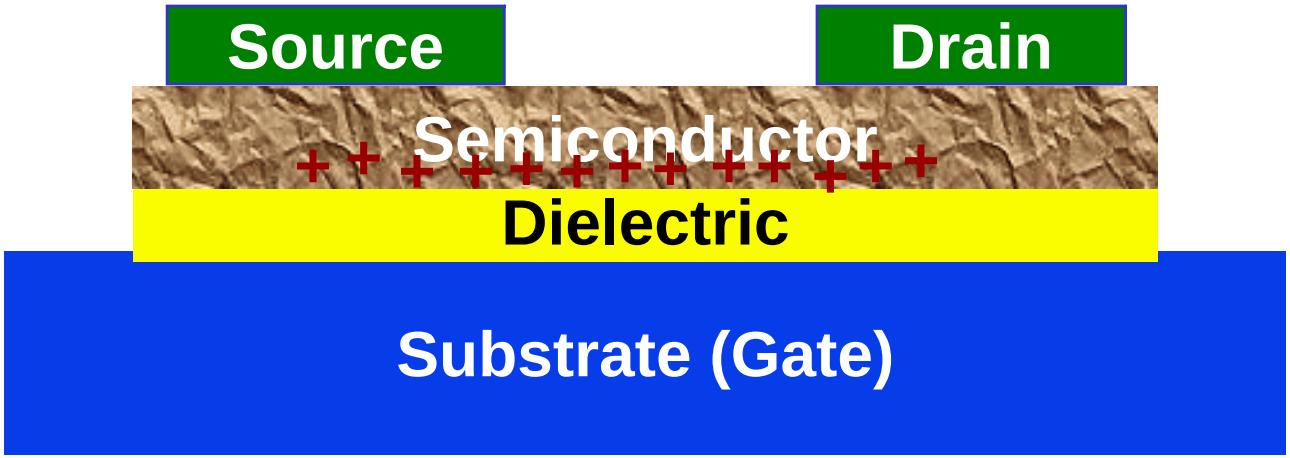


Z. Bao, A.J. Lovinger, A. Dodabalapour, **Adv. Mater**. 9, 42, 1997.

Room temperature mobility of Inorganic semiconductors

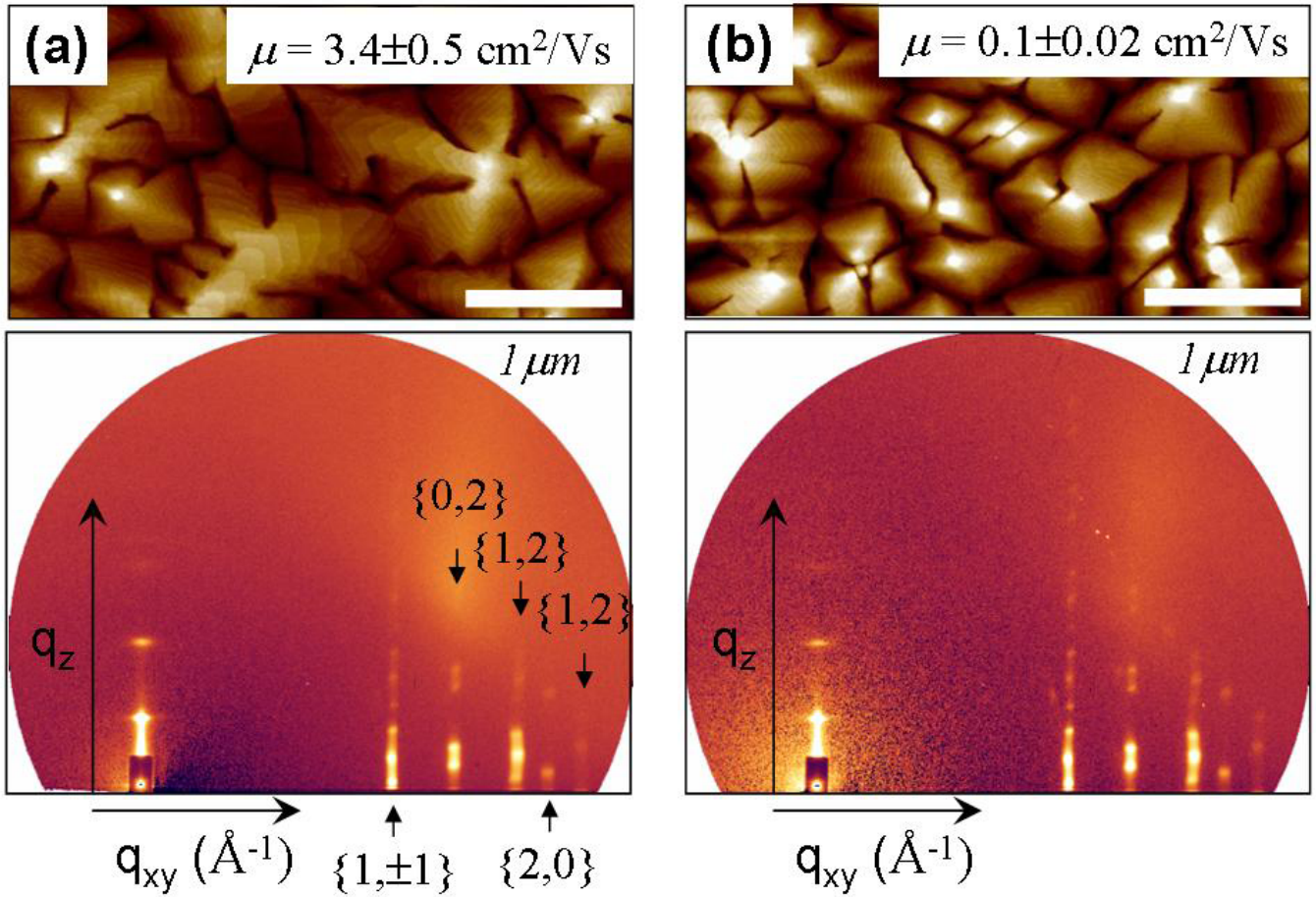
Semiconductor	μ_{hole} (cm^2/Vs)	$\mu_{electron}$ (cm^2/Vs)
Single crystal Si	480	1500
Hydrogenated α-Si	<0.1	0.1-1
 Pentacene	7 (thin film) 35 (single crystal)	
Rubrene	15 (single crystal)	
Regioregular poly(3-hexyl-thiophene)	0.1	

Charge carriers are induced mostly in the first 5nm of organic semiconductor film



AFM and 2D-GIXD of pentacene (60nm) films on different surfaces

Dr. Mike Ling, Dr. Hoichang Yang, Dr. Tae Joo Shin (BNL)



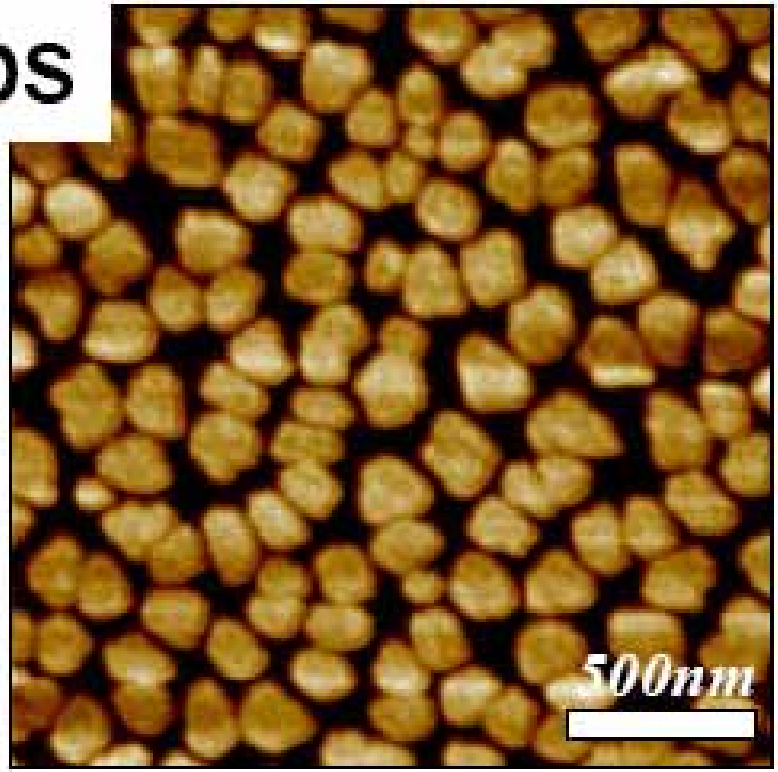
Pentacene on HMDS treated SiO_2

Pentacene on OTS treated SiO_2

AFM Images of Sub-monolayer Pentacene

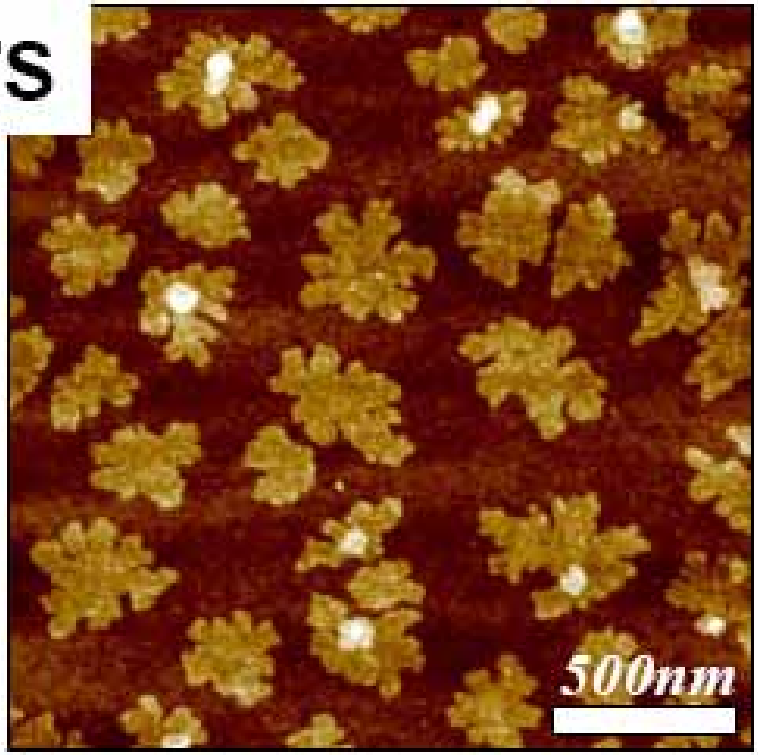
μ = 3.4 cm^2/Vs

HMDS

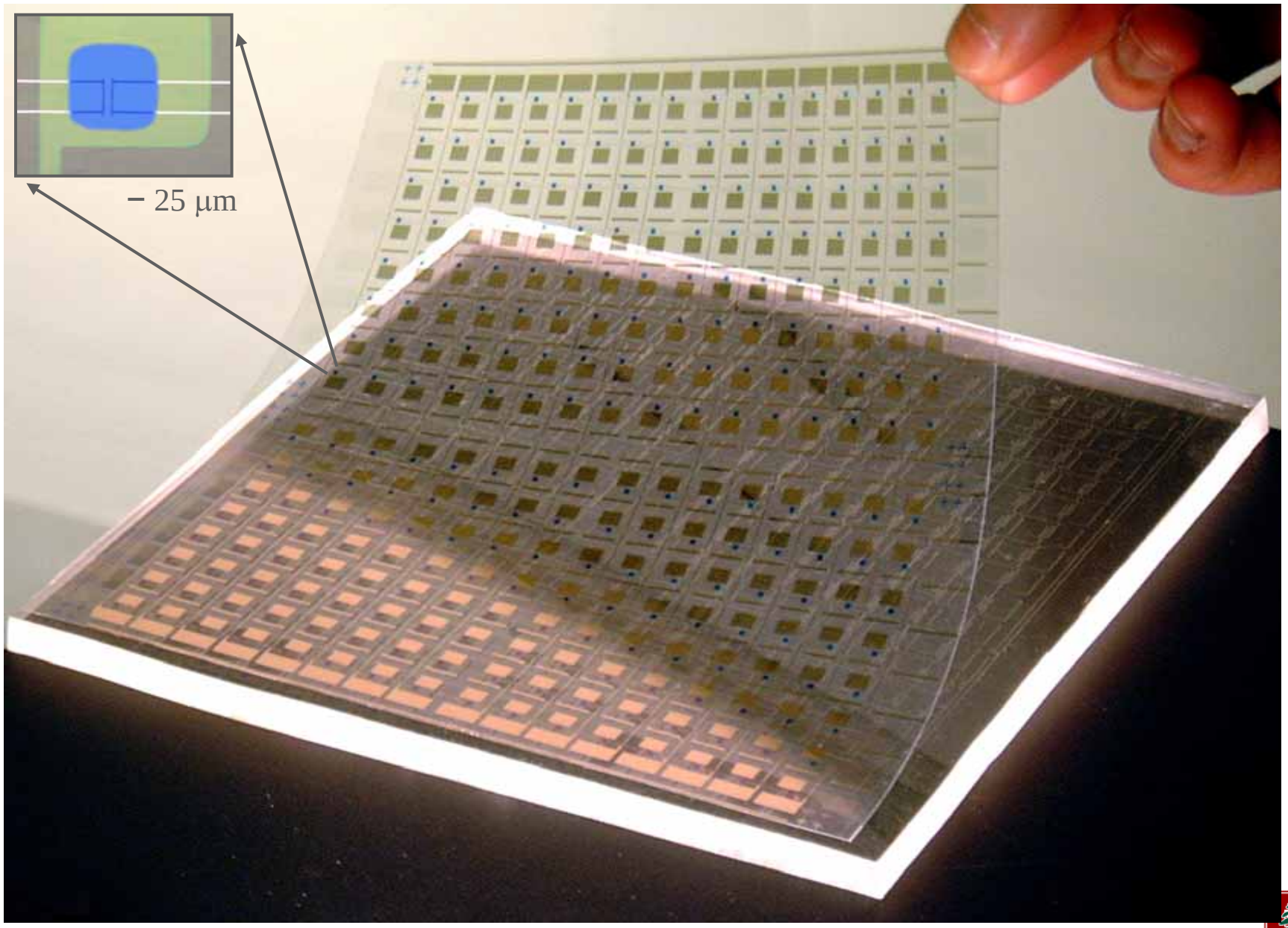


μ = 0.1 cm^2/Vs

OTS



Rubber Stamped Plastic Circuitry for Electronic Paper



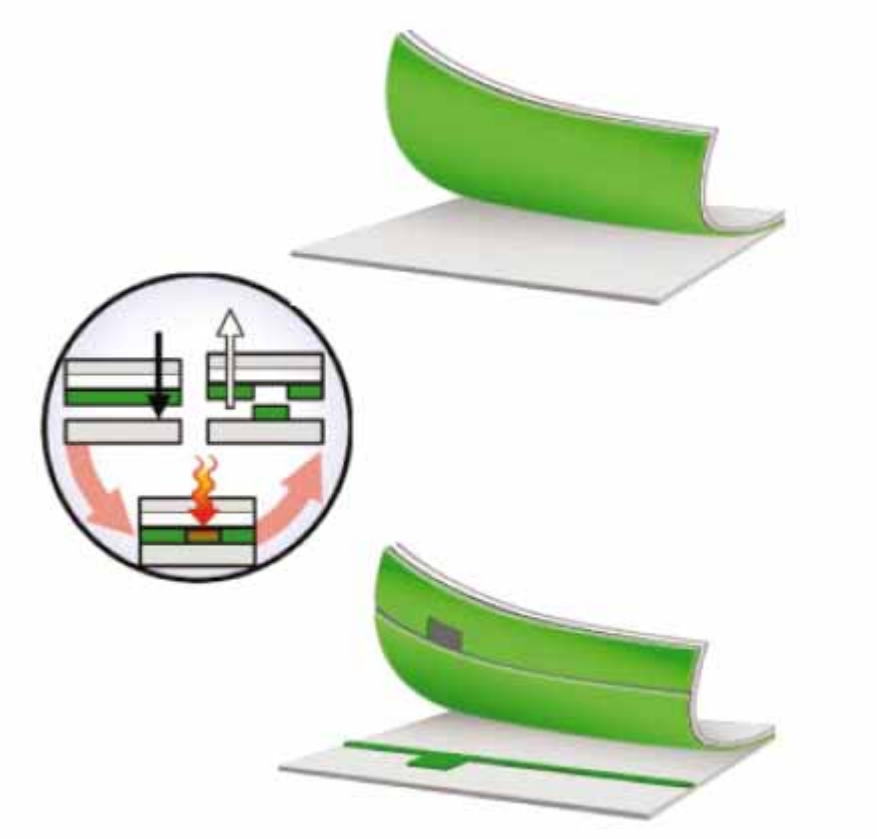
PNAS, 2001

Screen printing

First all-printed plastic circuit
Lucent Technologies

Z. Bao et al. *Chem. Mater*. 9, 1299 (1997)
R. Service, *Science*, 278, 383 (1997)

Patterning Technology: Commercial Printer



Blanchet et al., *Appl. Phys. Lett.* 2003, *82*, 463-465

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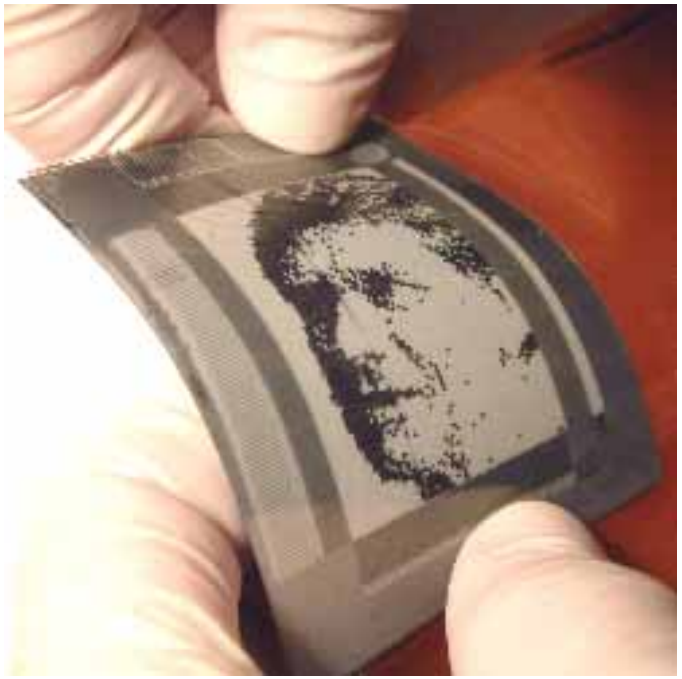
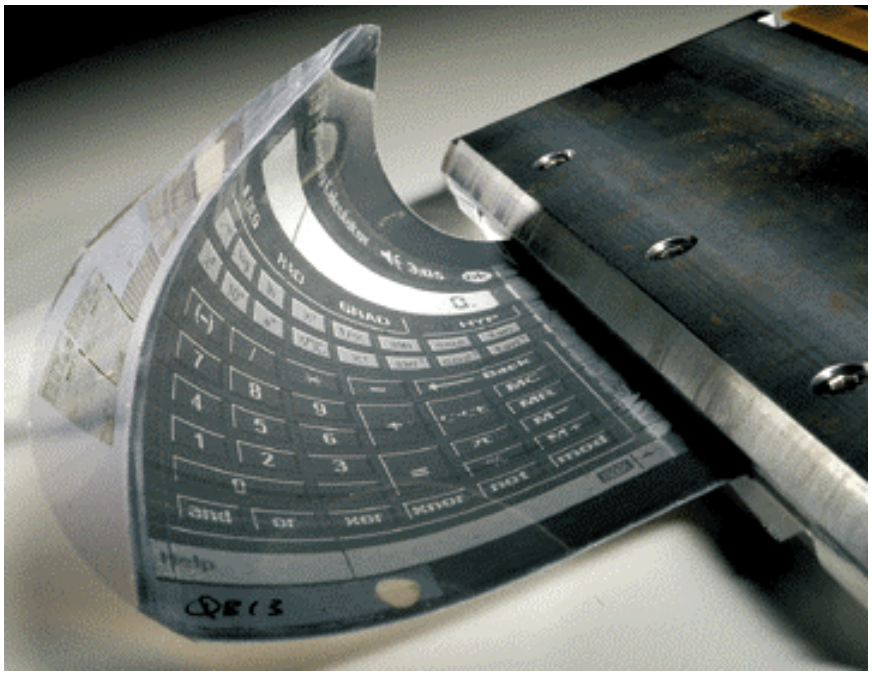


Plastic Logic

E-book



Philips

Summary

Organic materials have great potential for flexible electronics

Suitable applications need to be identified

More investigation of stability and reliability issues is needed

Better fundamental understanding of charge transport mechanism and morphology control is important – further improvement in mobility

Acknowledgement

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