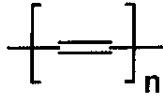


Special polymers

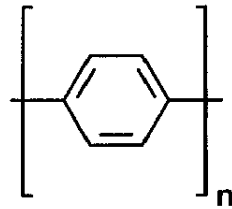
2. Conjugated polymers _ properties and applications

Conjugated polymers

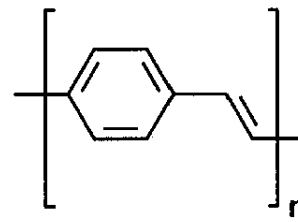
Insoluble conjugated polymers



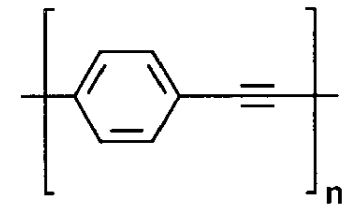
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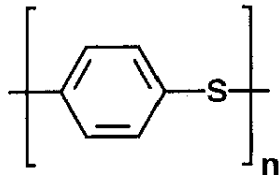
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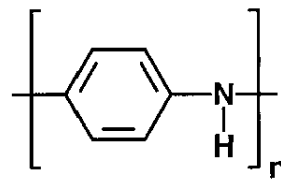
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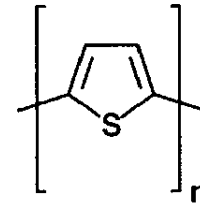
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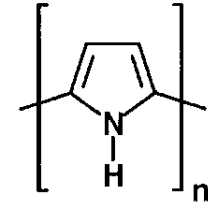
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2



20



21

Conjugated polymers

Soluble conjugated polymers

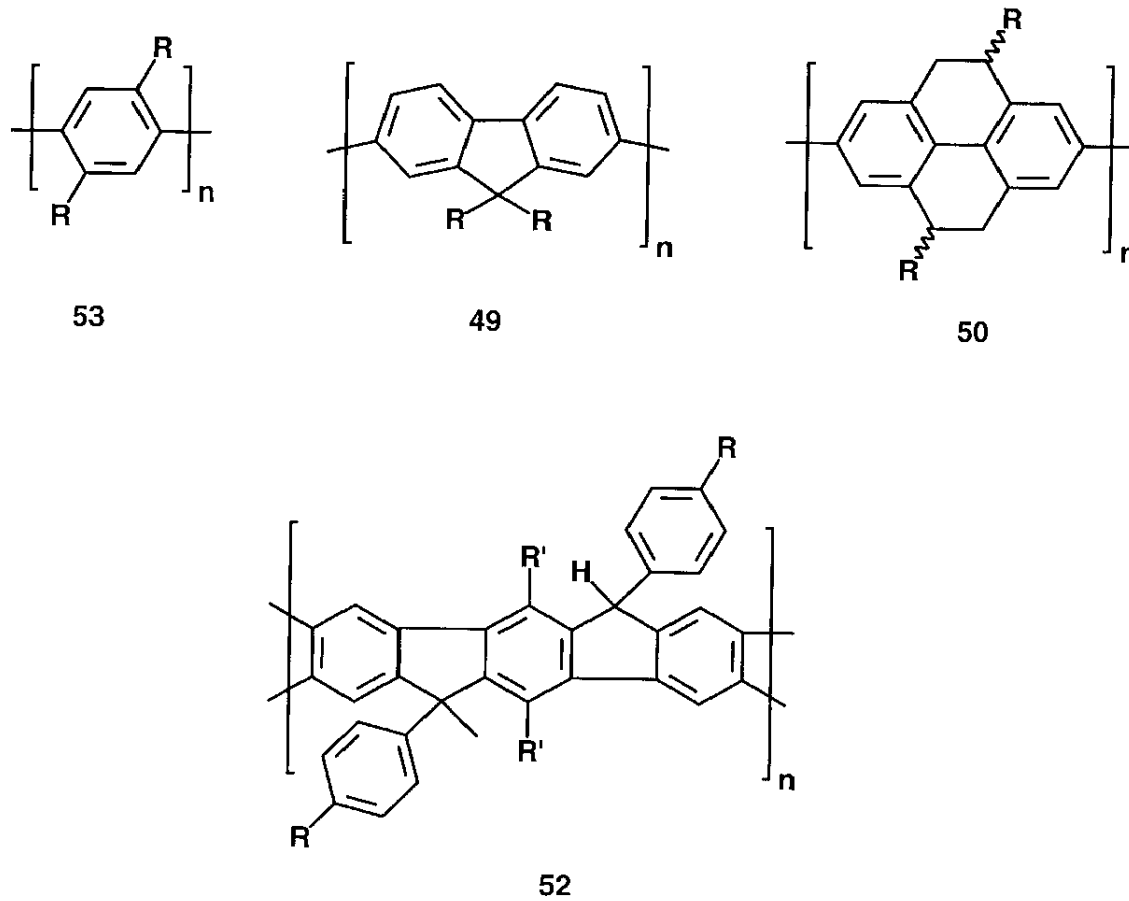
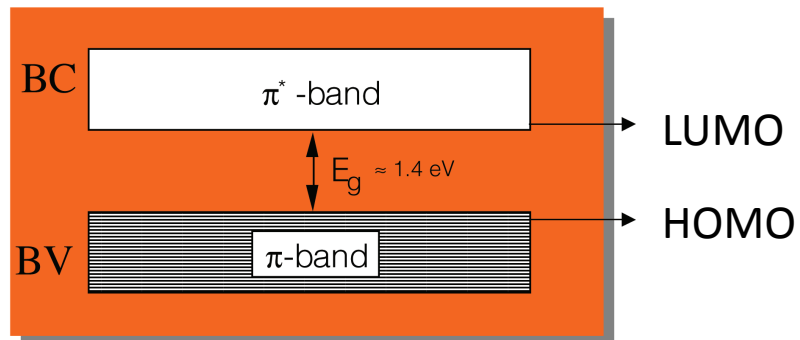


Chart 10 Dialkyl-PPP 53, step-ladder PPP 49 and 50 and LPPP 52.

Conjugated polymers

Electrical properties



In the pristine state should behave as “intrinsic semiconductors”

Conjugated polymers

Electronic conductivity

Crystalline fraction is often present in a minor proportion
Electrical conductivity dominated by disorder

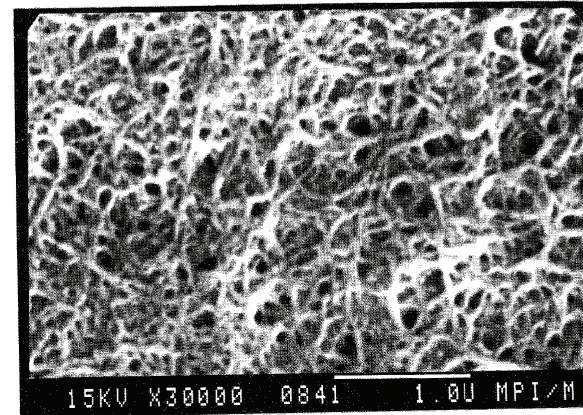
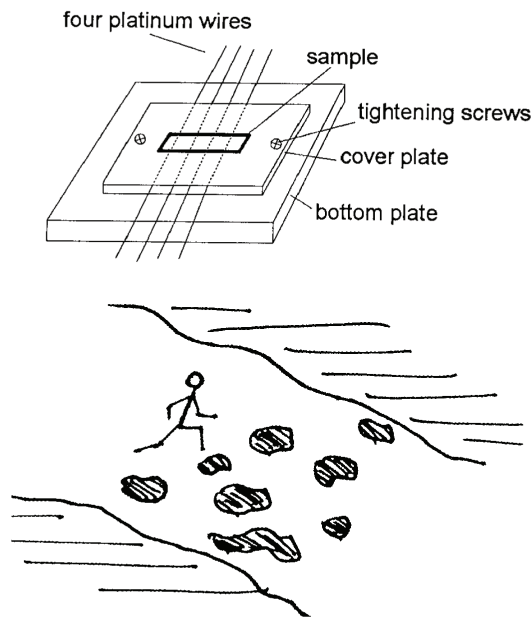


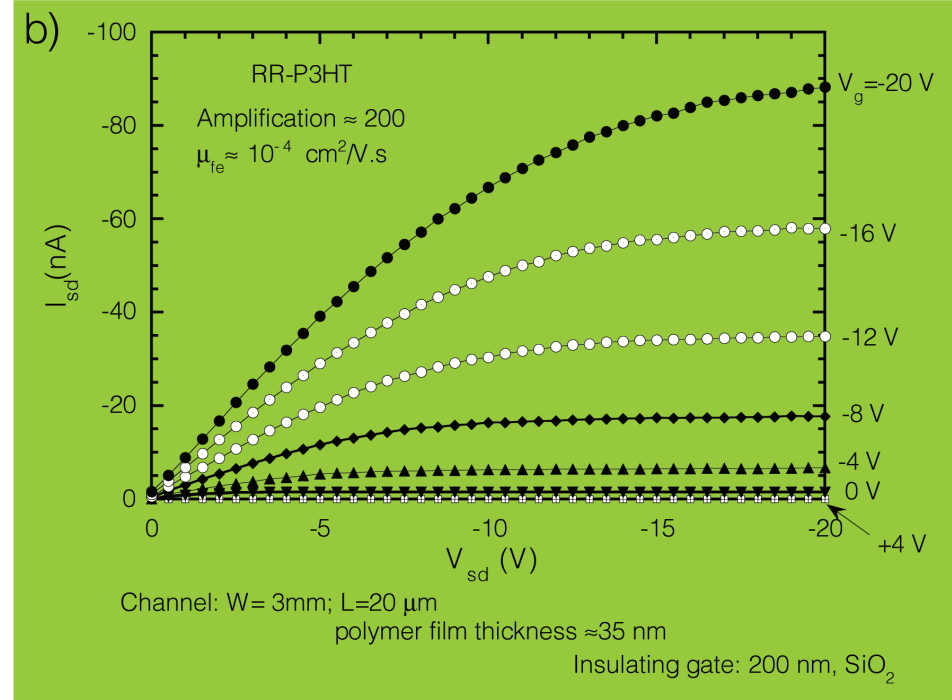
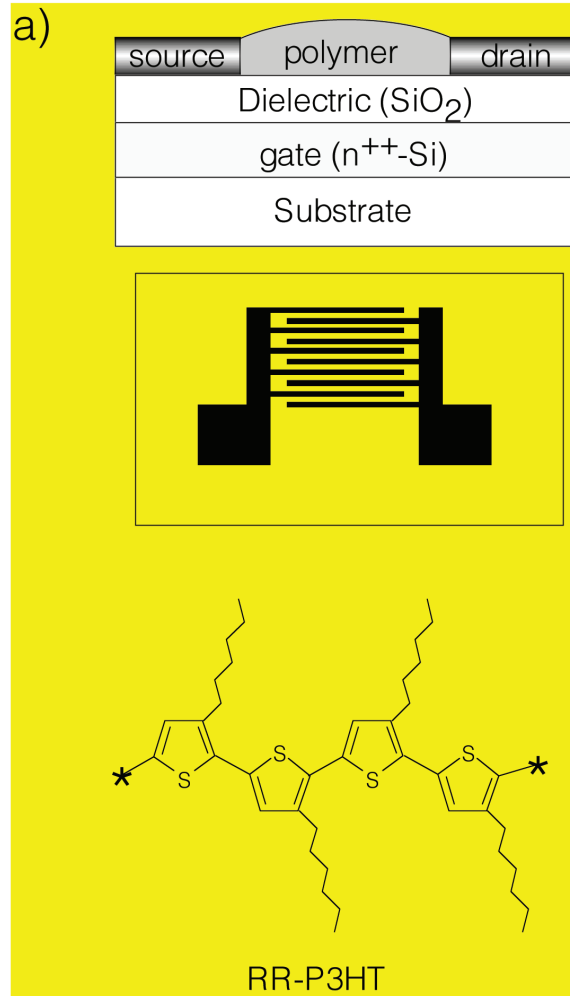
Figure 6-21: Scanning electron micrograph of polyacetylene film showing the "spaghetti" or fleece-like morphology. The scale marked on the rim corresponds to 1 μm .

$$\sigma(VRH) = \sigma_0 e^{-\left(\frac{T_0}{T}\right)^{1+d}}$$

$$\sigma_{\text{exp}} \approx \sigma_0 e^{-\left(\frac{T_0}{T}\right)^{\frac{1}{2}}}$$

Conjugated polymers

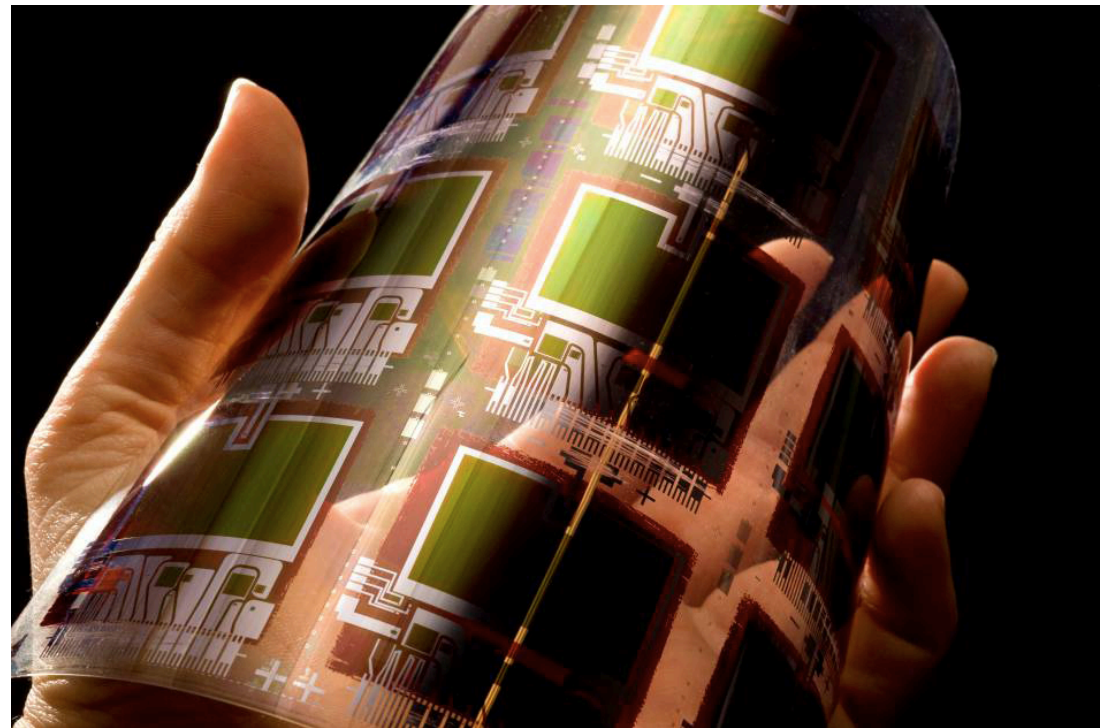
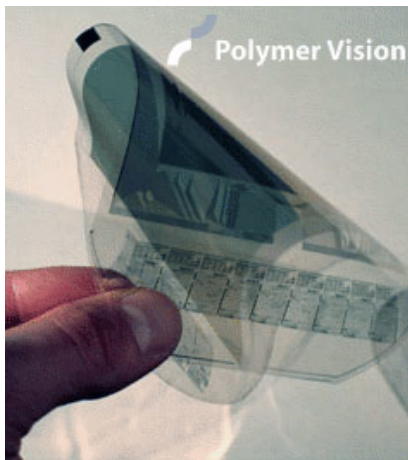
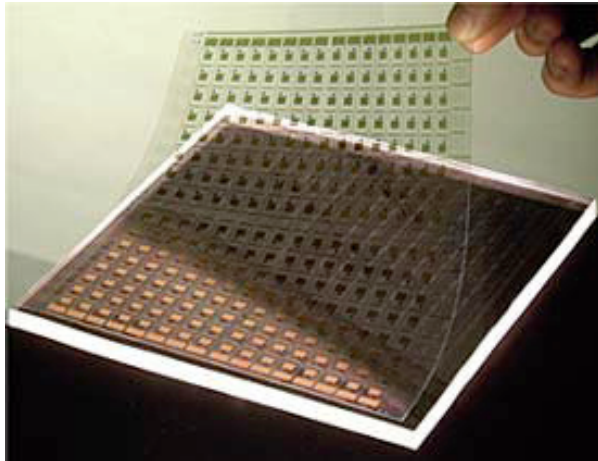
Application as intrinsic semiconductors_transistors



Processo de fabrico ?
Aplicações ?

Conjugated polymers

“Plastic” electronic circuits



Conjugated polymers

Increasing conductivity_doping

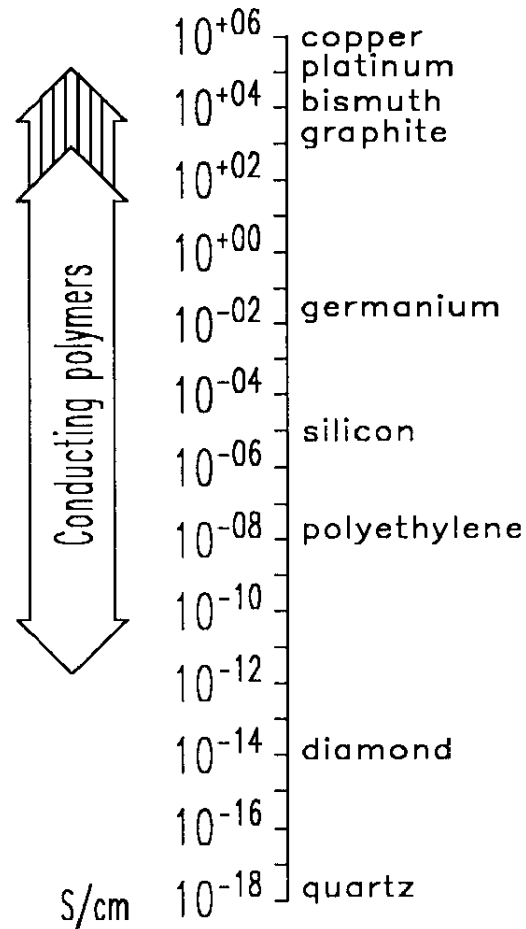
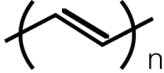
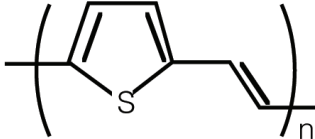
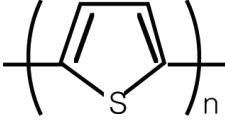
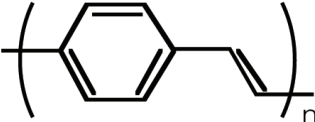


Figure 6–23: Comparison of the room temperature conductivity values of conducting polymers with conductivities of other materials.

Conjugated polymers

Increasing conductivity_doping

Polímero	Estrutura molecular	Condutividade (S/m) dopante
trans-poliacetileno, t-PA		10^7 iodo (orientado)
poli(tienileno vinileno), PTV		2.7×10^5 AsF ₅ (orientado)
politiofeno, PT		10^5 ClO ₄ ⁻ , BF ₄ ⁻
poli(p-fenileno vinileno), PPV		10^5 AsF ₅ (orientado)

Conjugated polymers

Increasing conductivity_doping

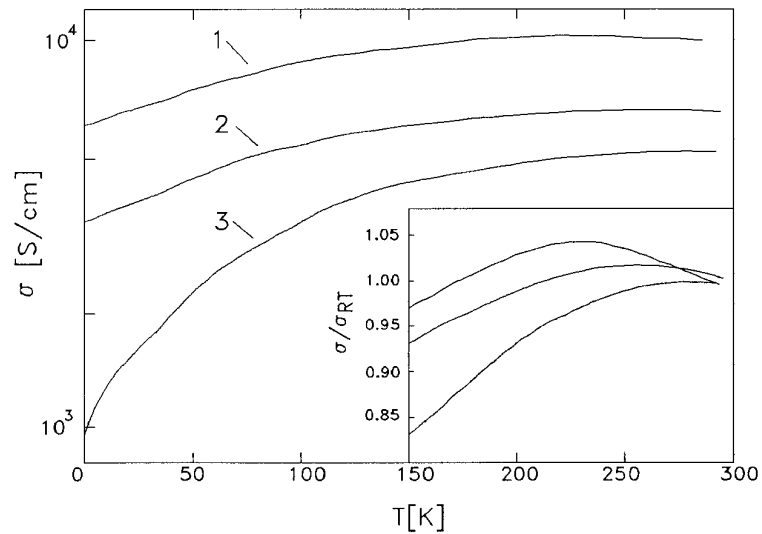


Figure 6-37: Temperature dependency of the conductivity of highly conducting polyacetylene samples. The curves refer to different iodine concentrations

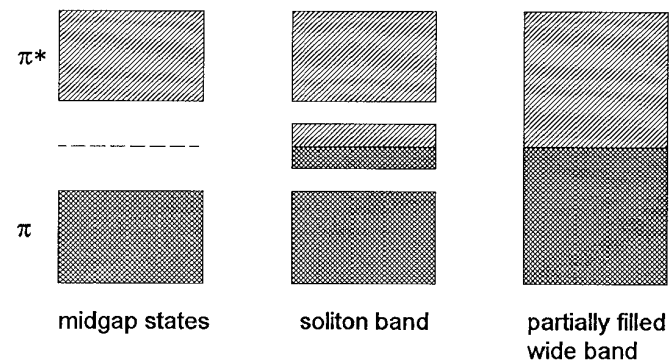


Figure 6-16: Development of a soliton band from midgap states and final suppression of the π - π^* gap upon the increase of soliton concentration.

Conjugated polymers

Optical absorption

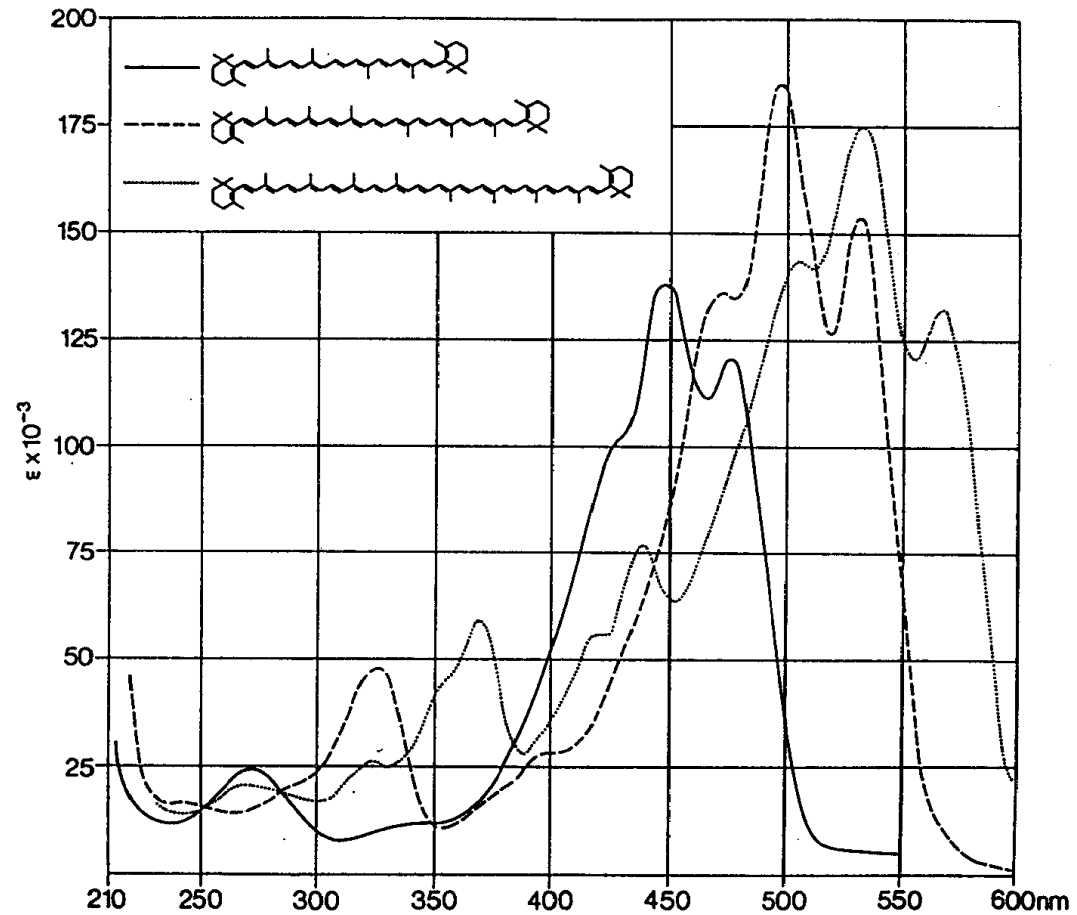
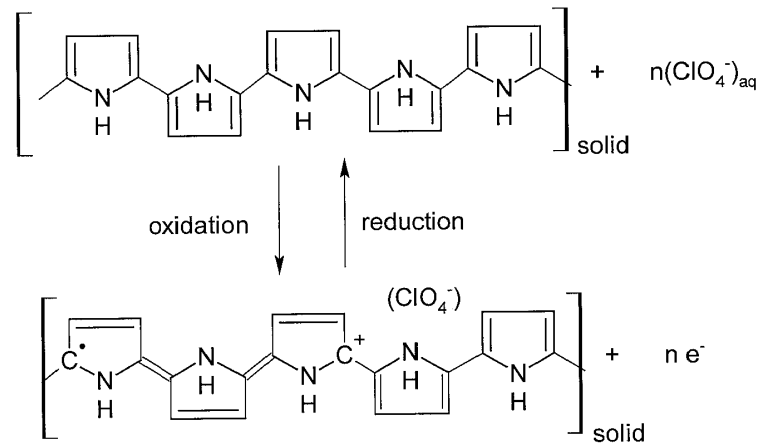
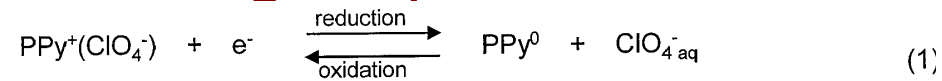


Fig. 10 Ultraviolet and visible light absorption spectra of β -carotene (—), decapreno- β -carotene (- - -) and dodecapreno- β -carotene (.....) (in petroleum ether)

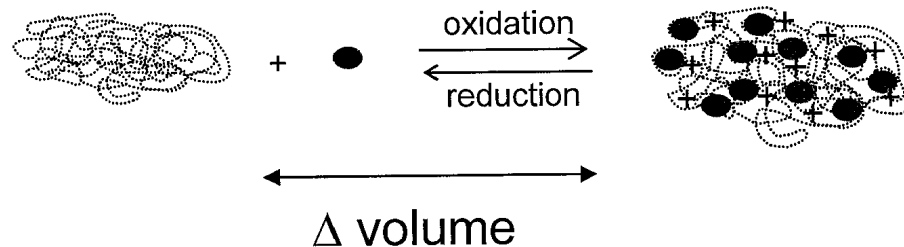
Conjugated polymers

Actuators

Volume changes upon oxidation/reduction



- Solvated counterions



Conjugated polymers

Actuators

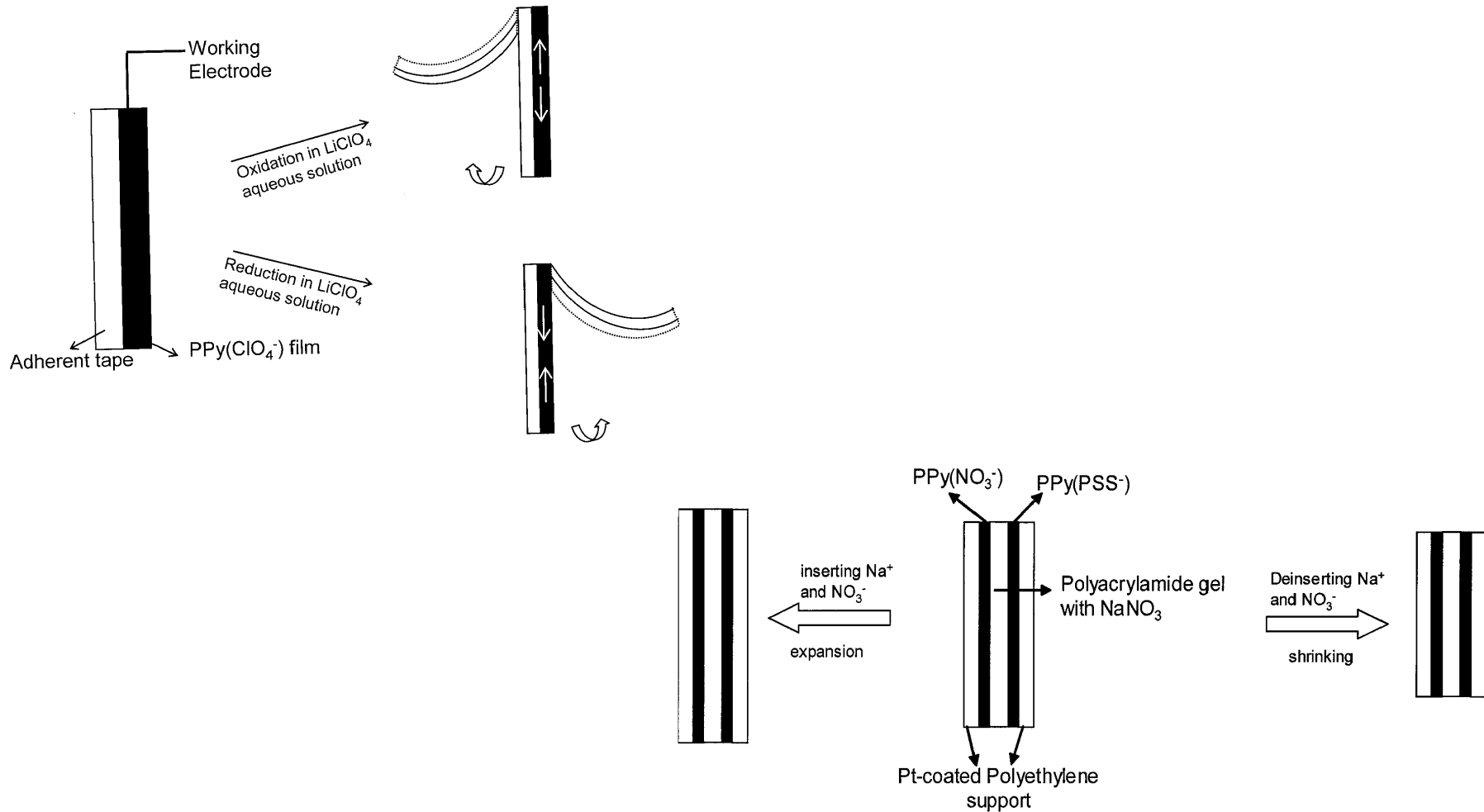


Fig. 19. Design and operation of a linear solid-state actuator: PPy(NO₃⁻) on Pt-coated PE layer/hydrogel/PPy(PSS⁻) on Pt-coated PE layer

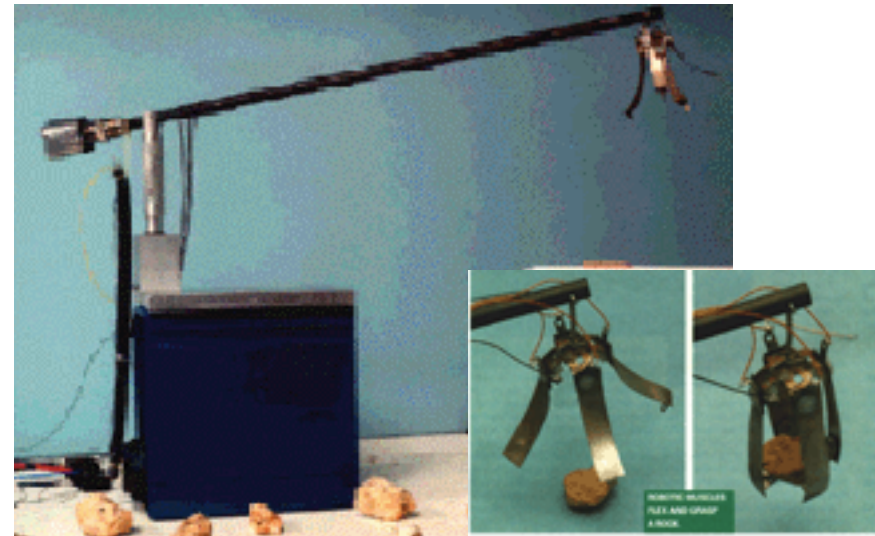
Conjugated polymers

Actuators

Platforms for EAP demonstration



Android facial expressions (photographed at JPL)
Courtesy of David Hanson, U. of Texas at Dallas



Conjugated polymers

Electrochromic displays

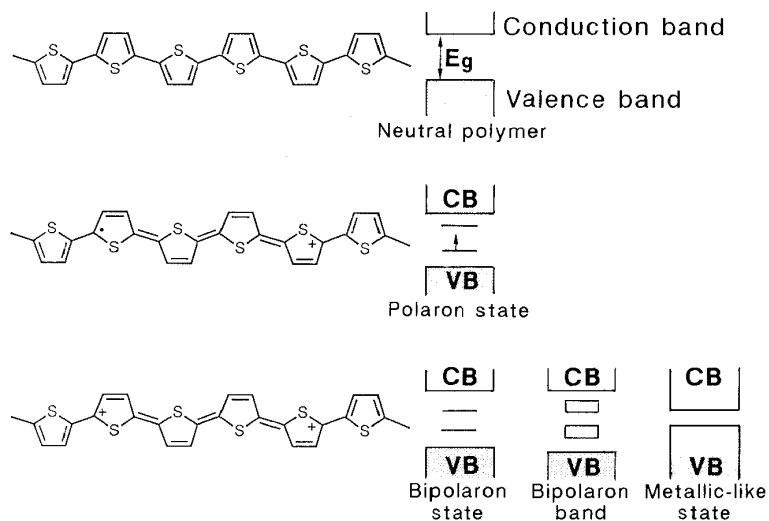


Figure 7.2 Evolution of electronic band structure with p-doping for conjugated polymer with non-degenerate ground state.

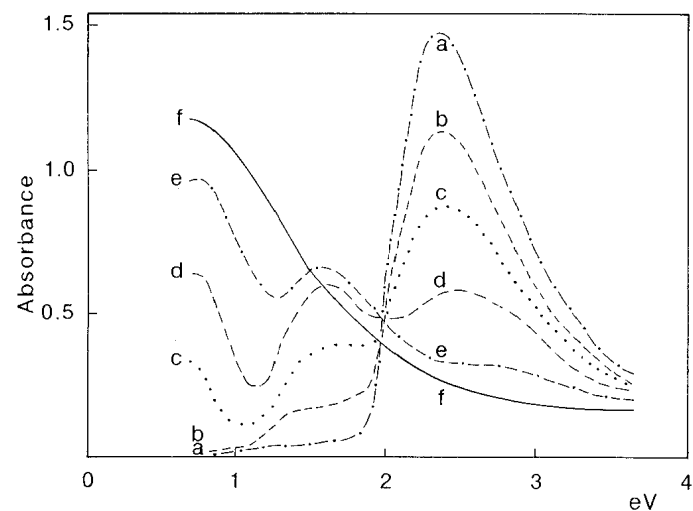
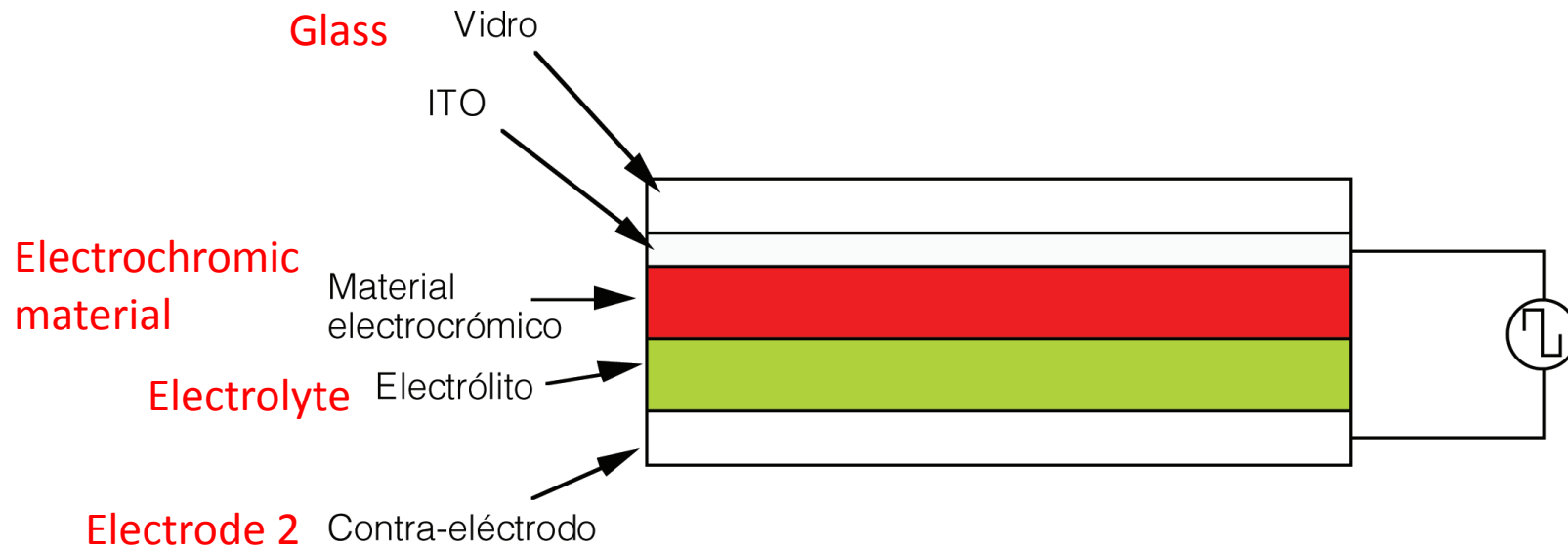


Figure 7.3 Visible and near IR spectra of poly(3-methylthiophene) recorded *in situ* during electrochemical p-doping: (a) undoped and (b,c,d,e,f) doped at increased doping levels, after [7].

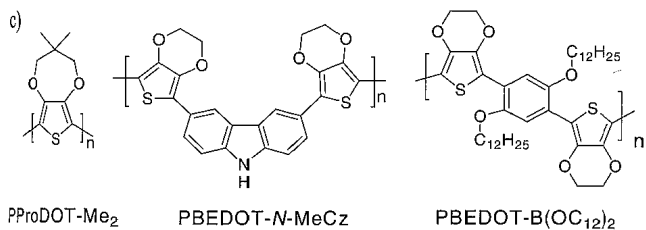
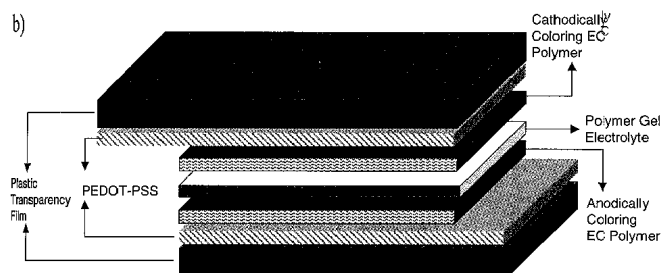
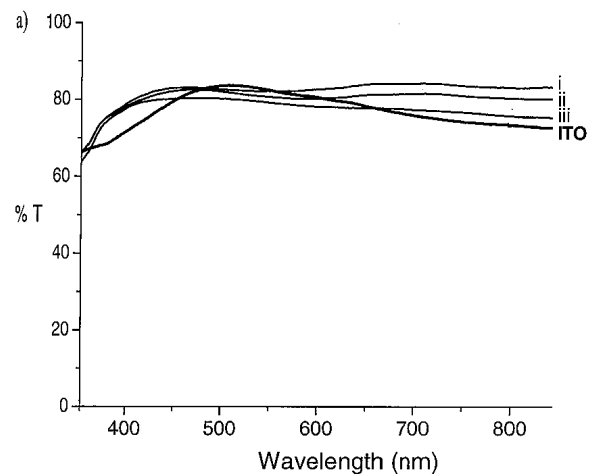
Conjugated polymers

Electrochromic displays

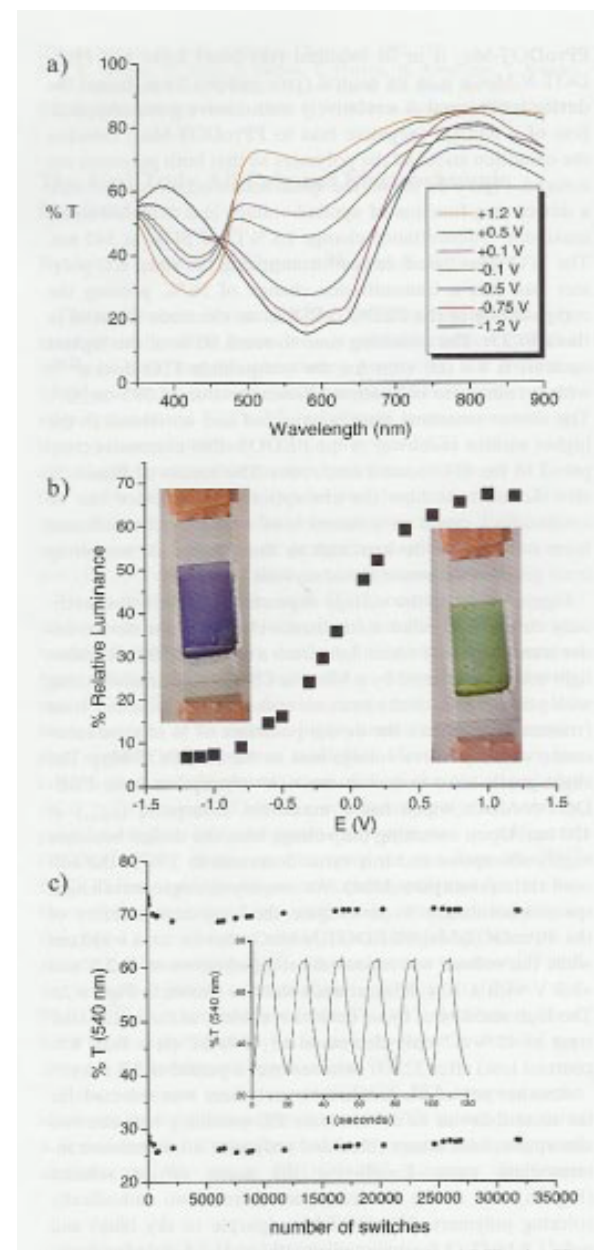


Conjugated polymers

Electrochromic displays

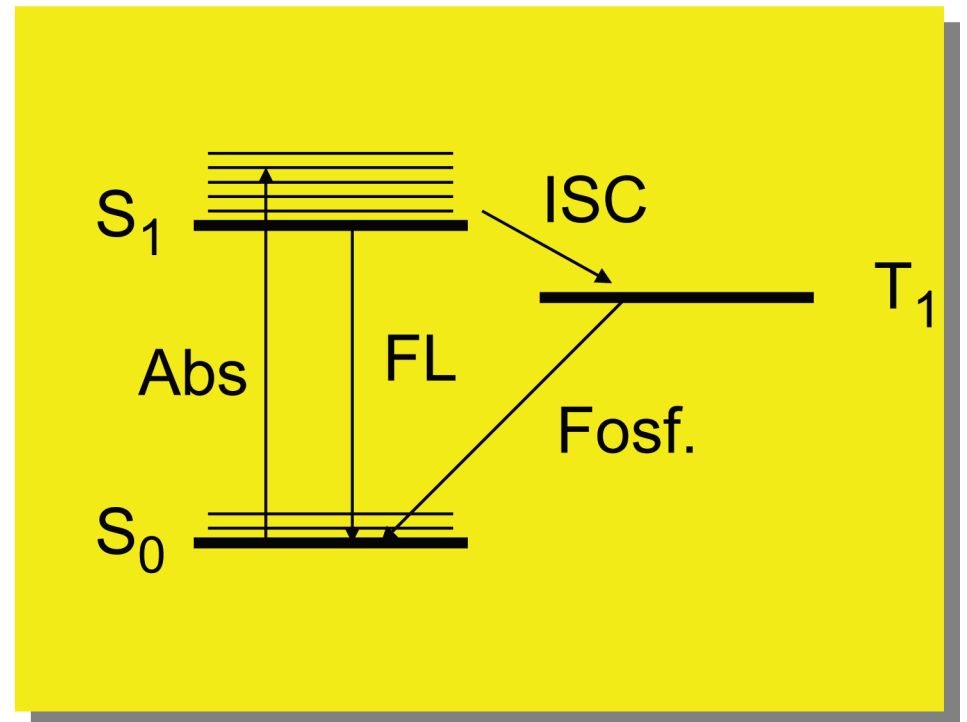
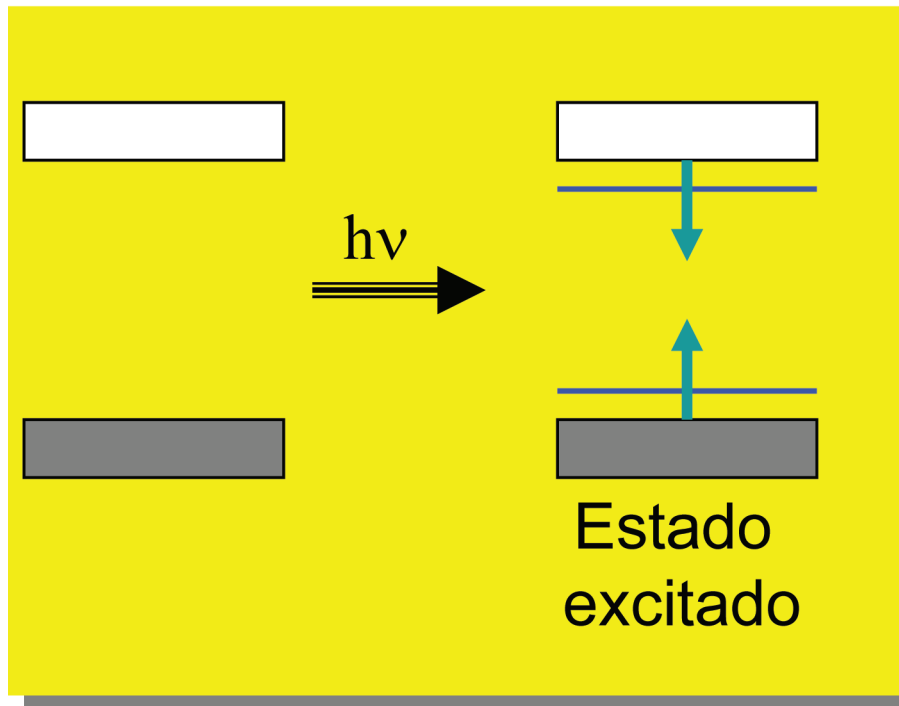


(Reynolds et al., Adv. Mater. **15**, 1338 (2003))



Conjugated polymers

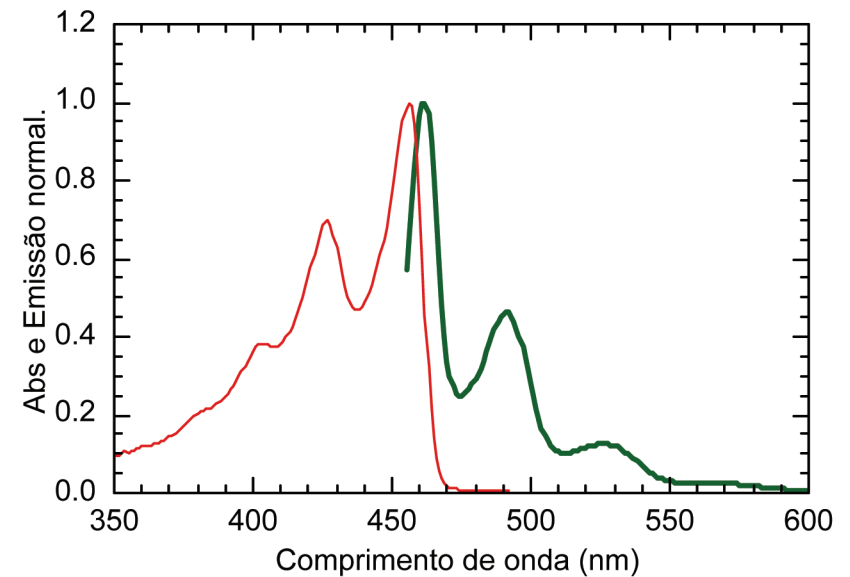
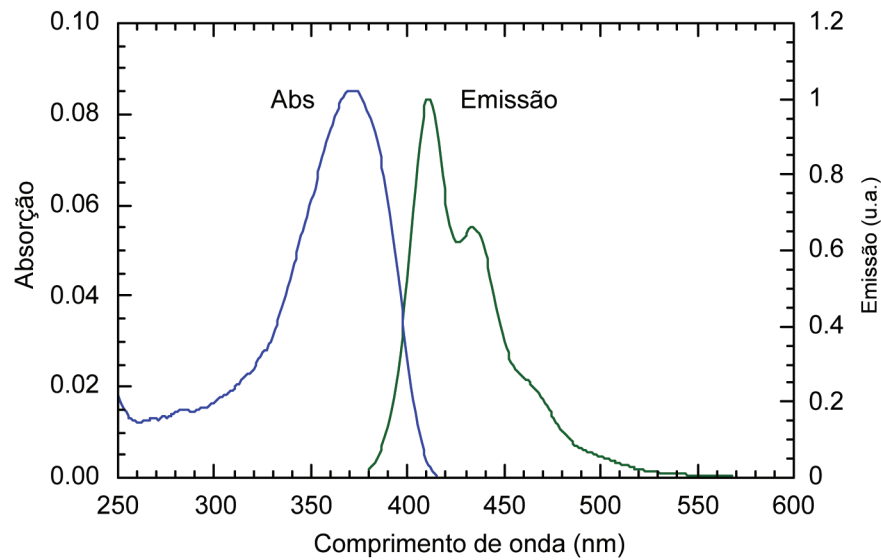
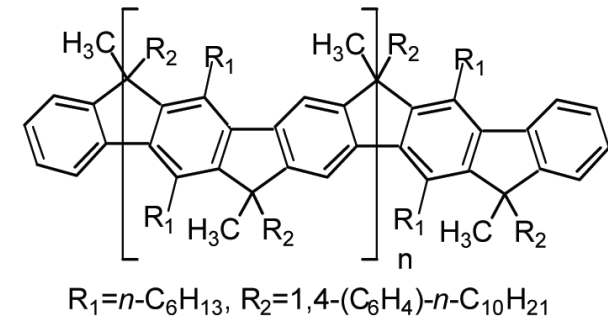
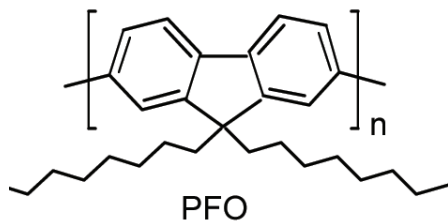
Luminescence



Fluorescence and phosphorescence

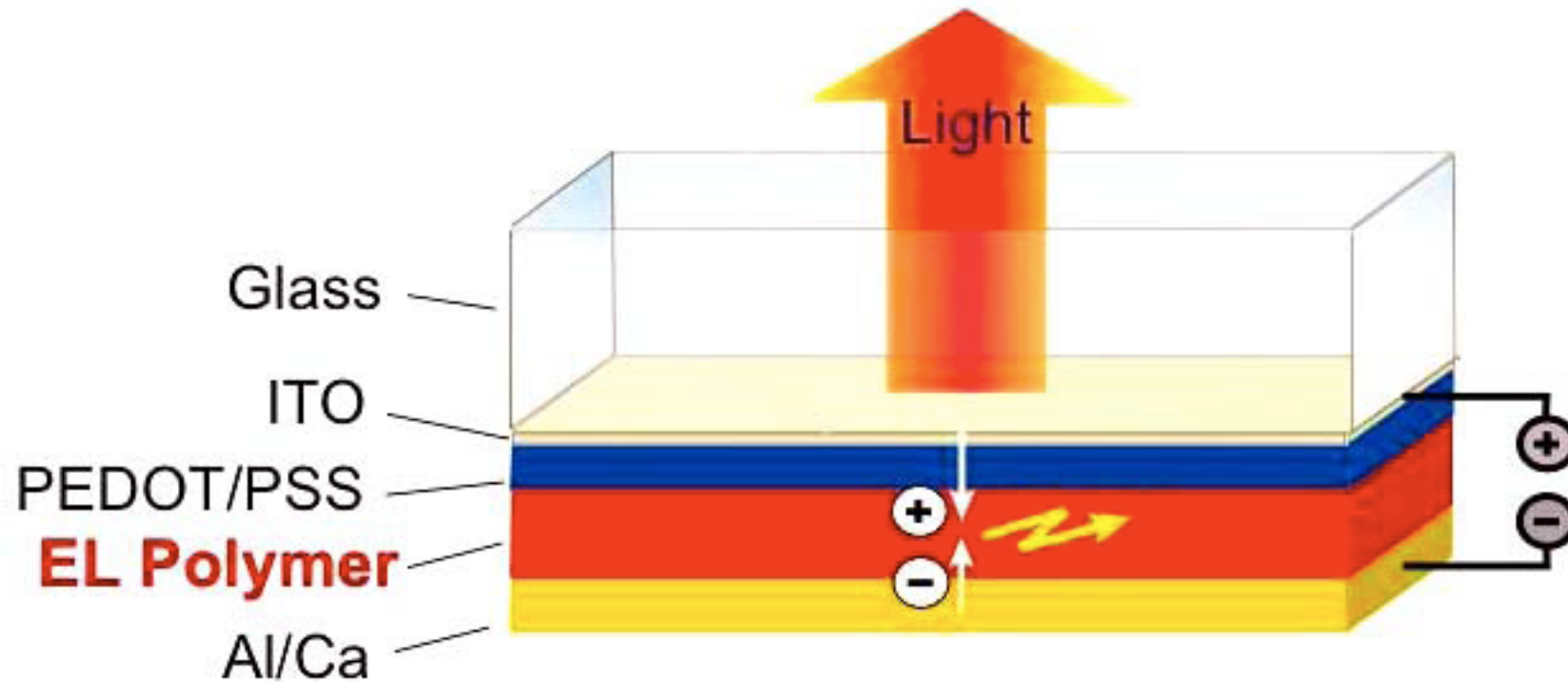
Conjugated polymers

Luminescence



Conjugated polymers

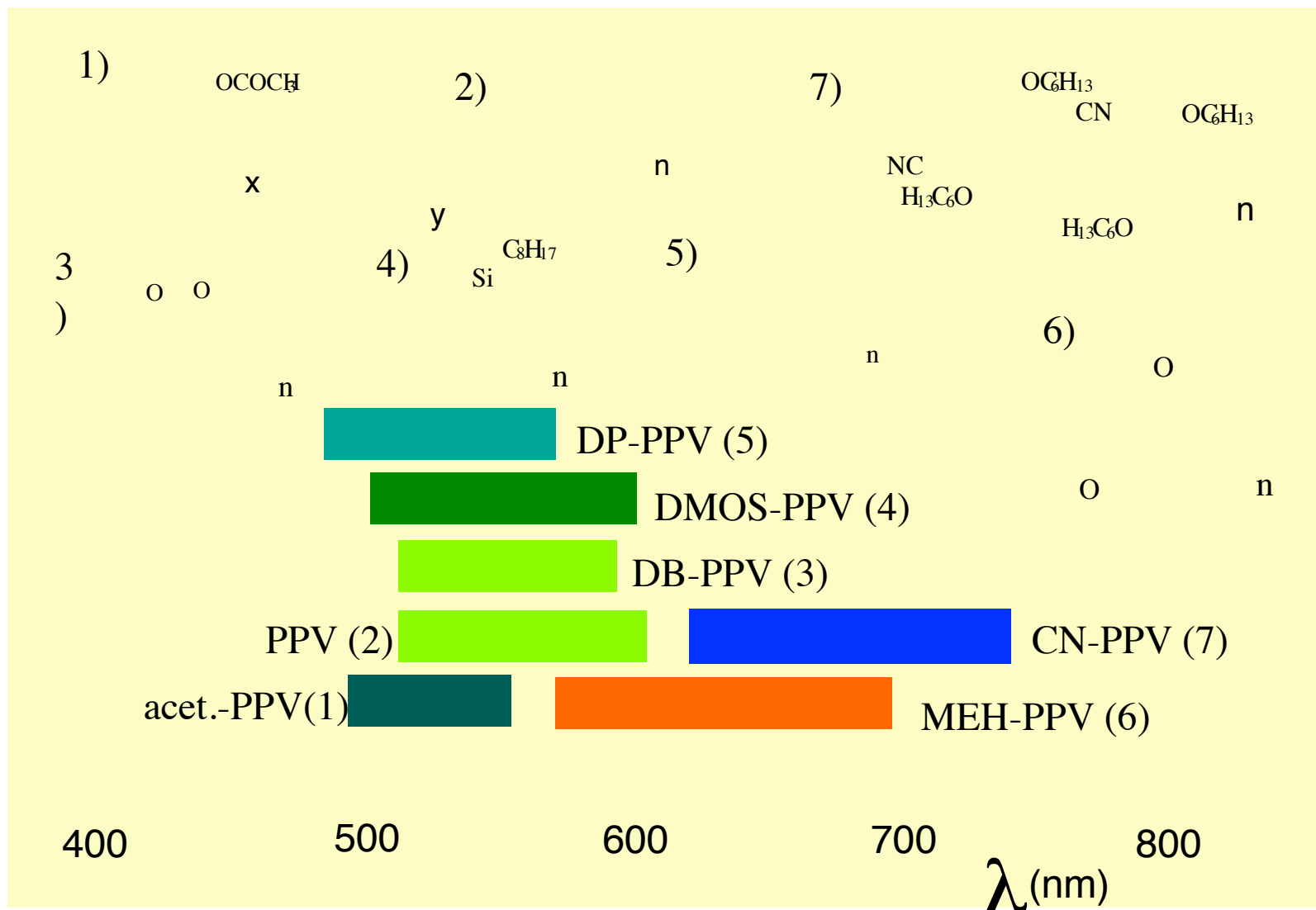
Electroluminescence



Light-emitting diode

Conjugated polymers

Electroluminescence



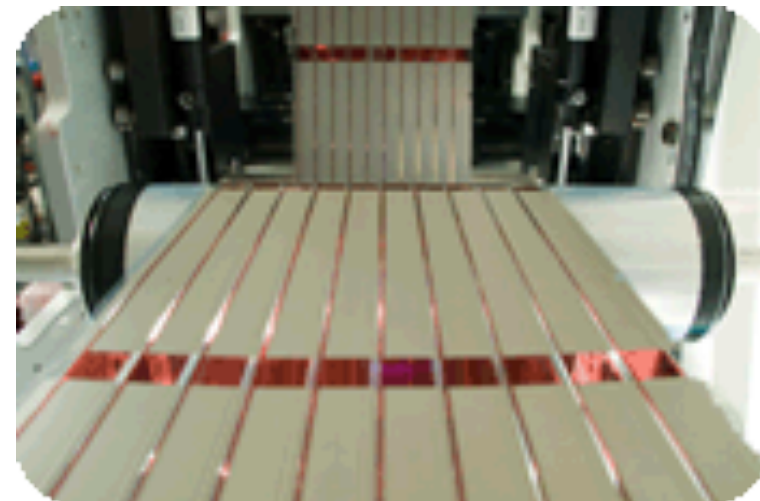
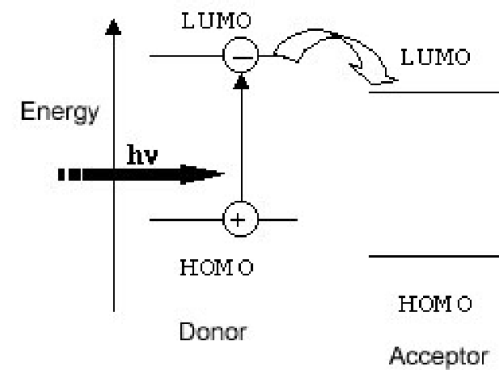
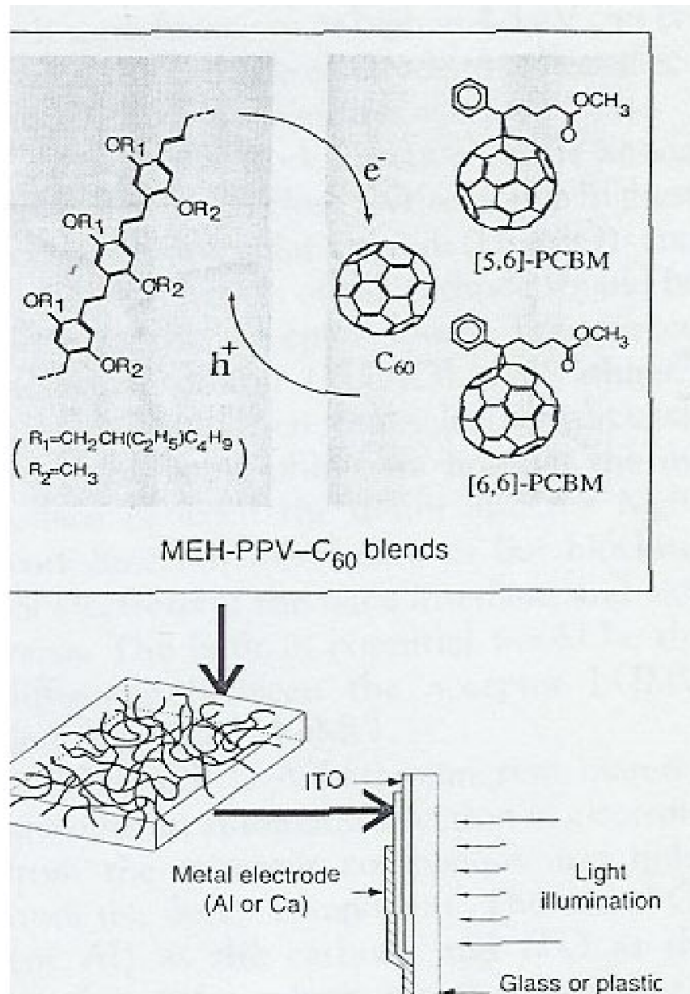
Conjugated polymers

Displays



Conjugated polymers

Photovoltaic cells

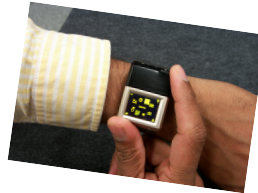




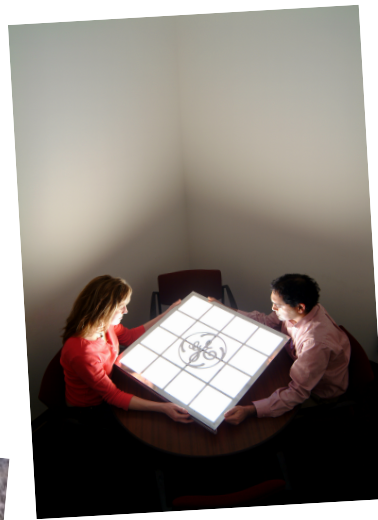
Displays de Plástico



Electrónica de Plástico



Caneta-Display
Universal Display Corp.



Painéis de
Iluminação



Código de Barras Electrónico
RFIDs



Células Solares
(fotovoltaicas)



Papel Electrónico
Tinta Electrónica

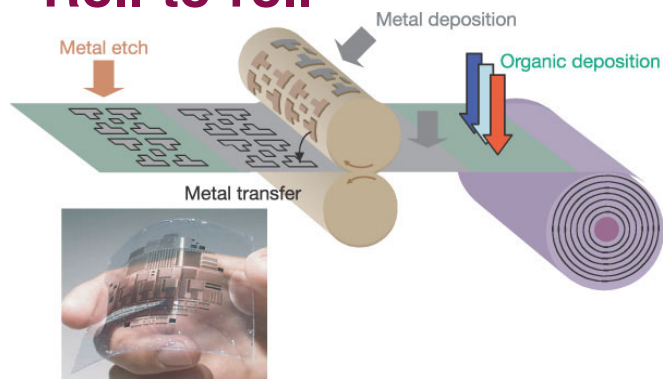


Cartões Inteligentes

Conjugated polymers

Solution processing

Roll-to-roll

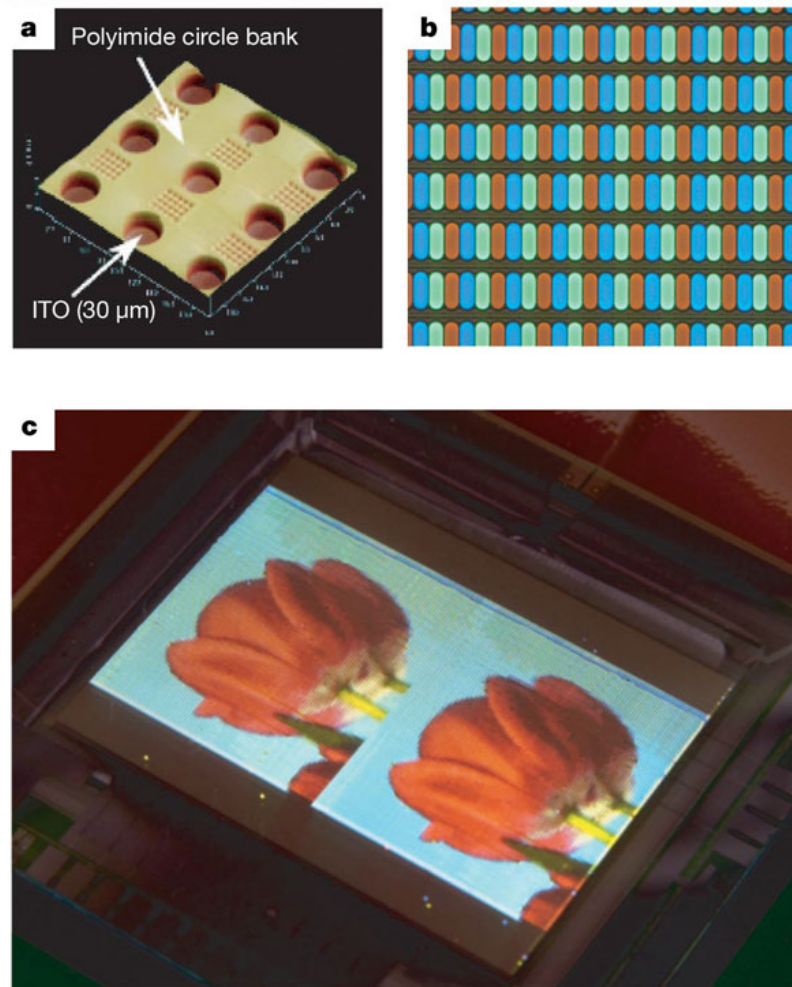


Learning form
Printing Processes



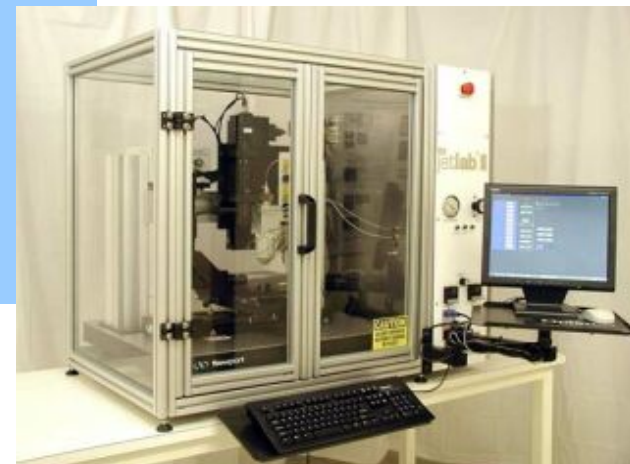
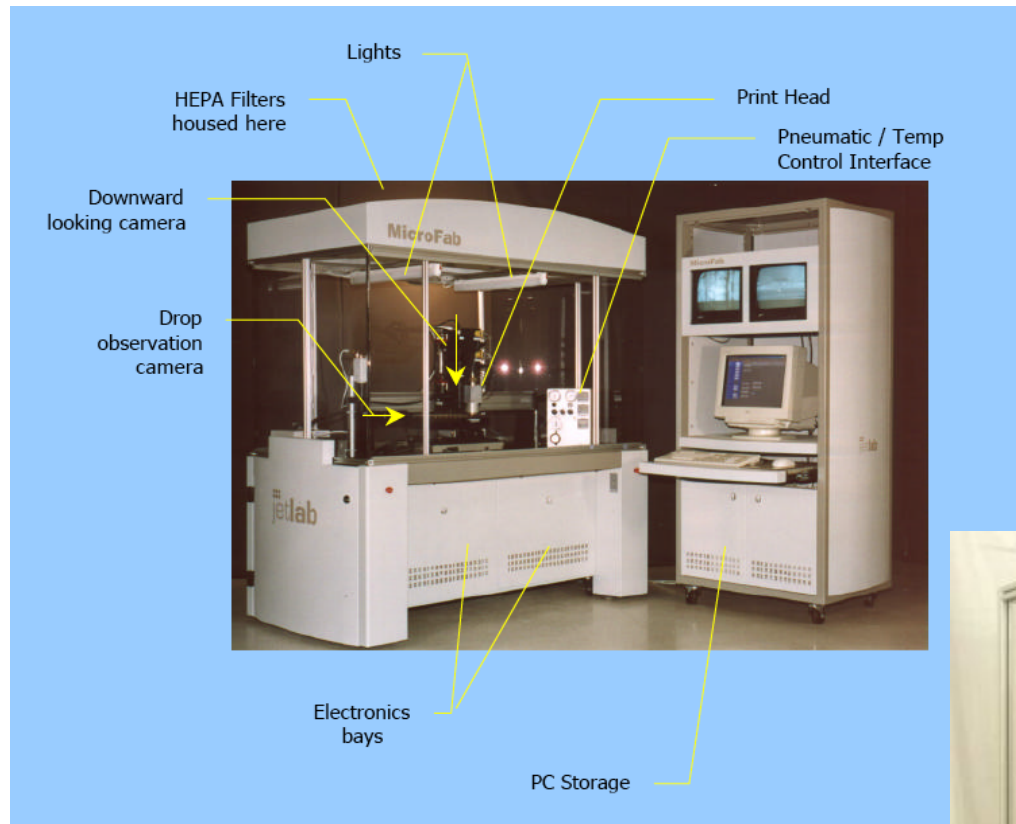
Conjugated polymers

Inkjet printing



Conjugated polymers

Inkjet printing



Jetlab
microfab.com

References

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“One-Dimensional Metals-Physics and Materials Science”, Siegmur Roth, VCH, 1995.