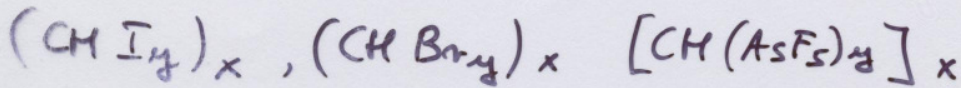
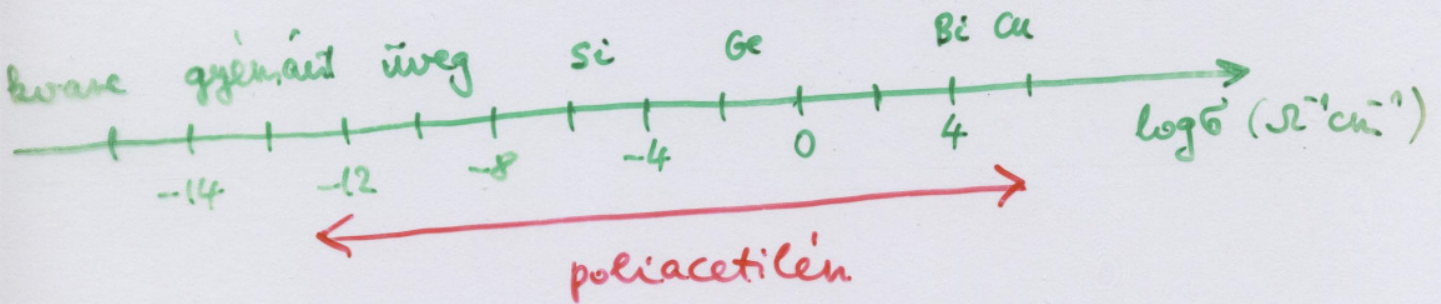
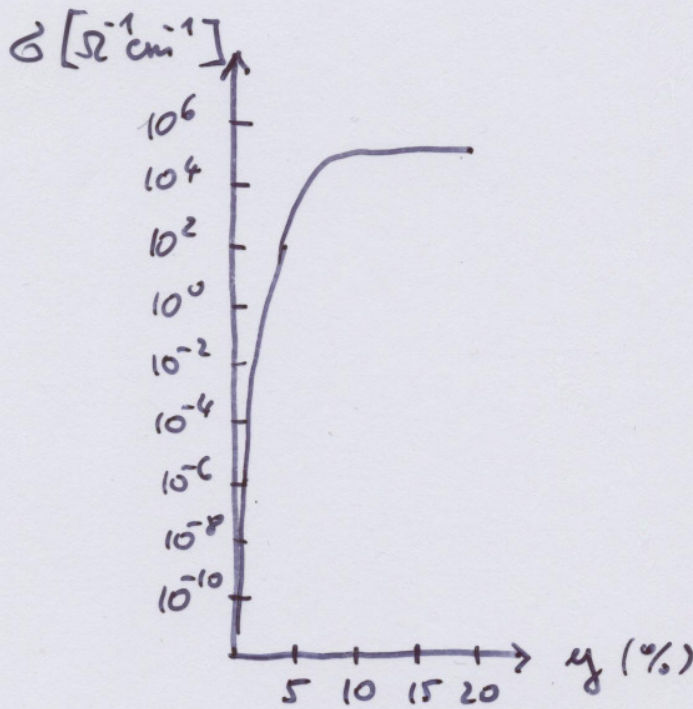


FÉLVEZETŐ → FÉM ÁTMENET

DÓPOLÁS (INTERKALÁCIÓS) HATÁSÁRA

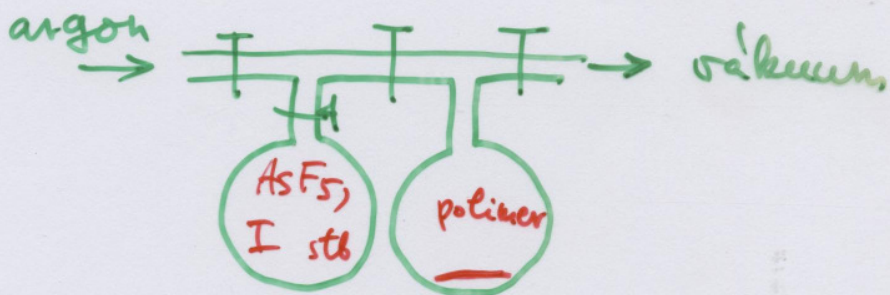


stb

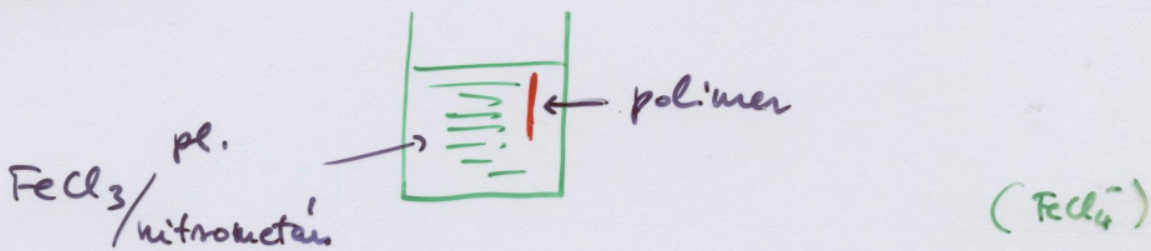


DÓPOLÁS

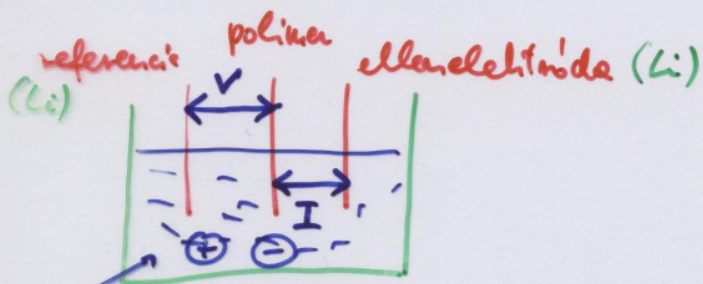
a) Gázfázisból



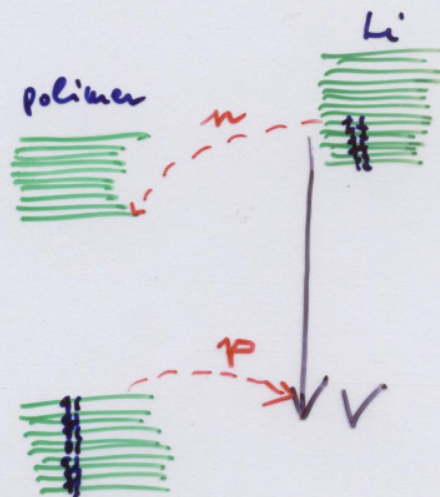
b) Folyadék fázisból



c) Elektrokémiai dőpés



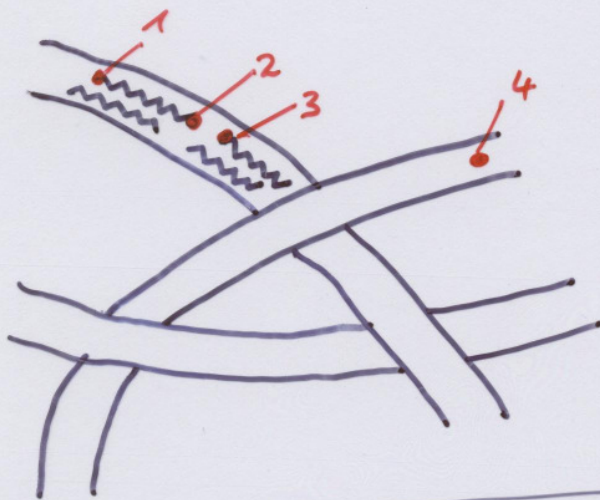
pl. $\text{Li}^+ \text{ClO}_4^-$ / propilén-harbanát (n)
tetrabutil-ammonium (p)



Dópoló polimer: „piszkos fém”
 T csökken \rightarrow σ csökken

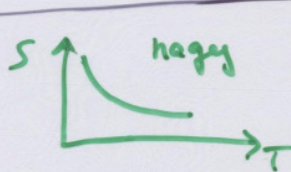
$$\sigma(T) = \sigma_0 e^{-\left(T_0 + \frac{T_1}{T}\right)}$$

(Sheen)

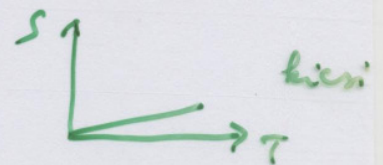


- 1-2 lánc végei
- 2-3 lánc közei
- 3-4 fibrillák közei

Termoelektromos erő (S)



dipolár \rightarrow



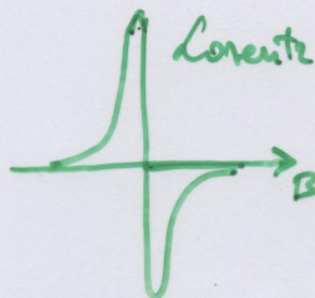
Mágneses susceptibilitás (χ)



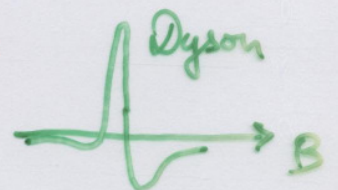
dipolár \rightarrow



ESR

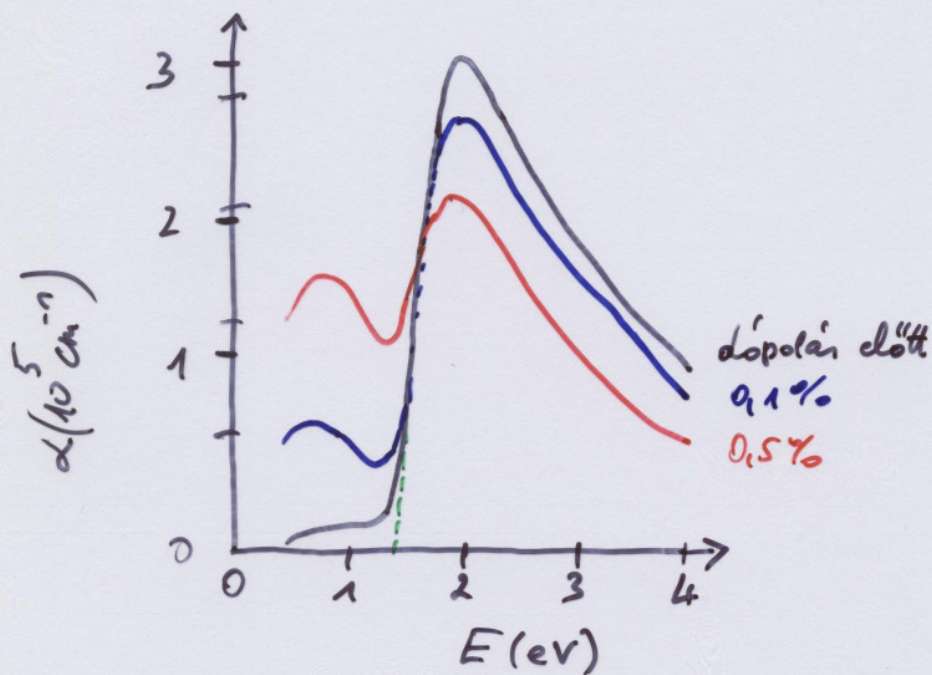


dipolár \rightarrow

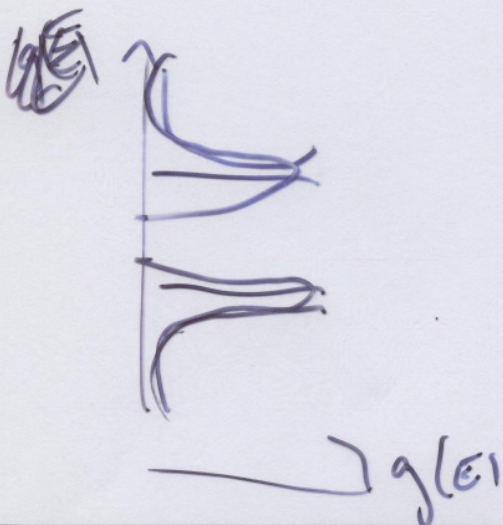


Az optikai abszorpció változása dőpolár kintására

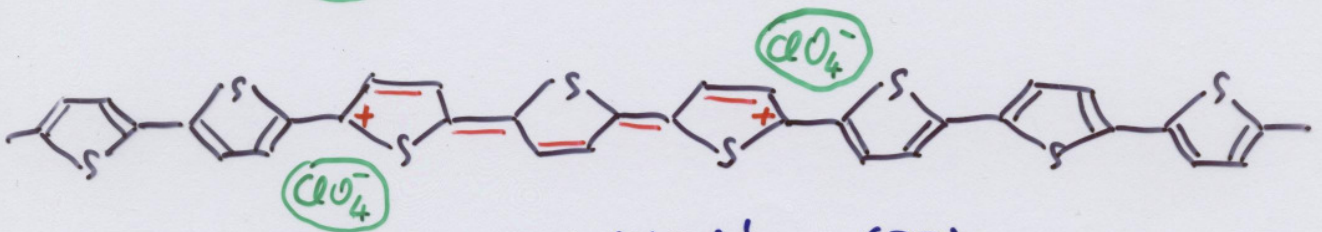
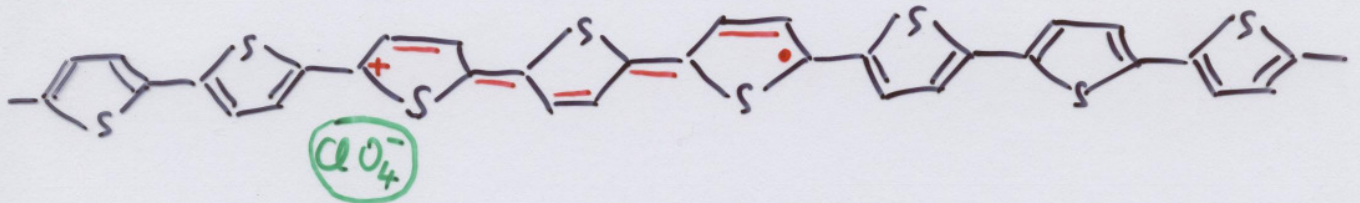
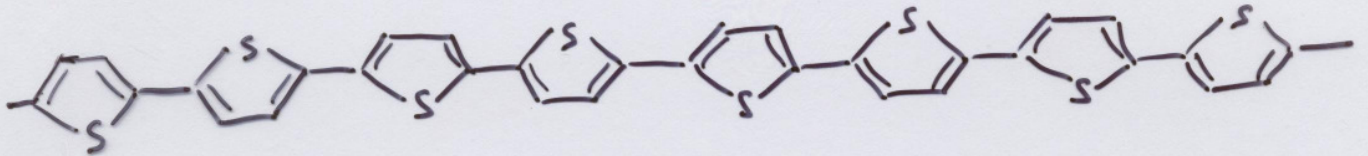
$$I \sim e^{-\alpha x}$$



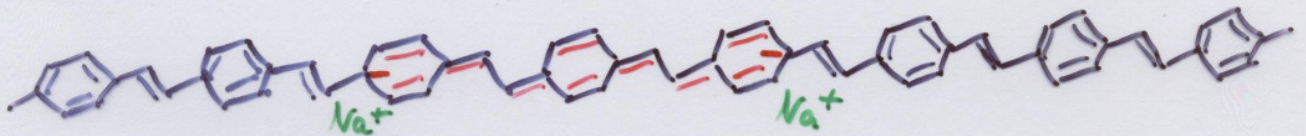
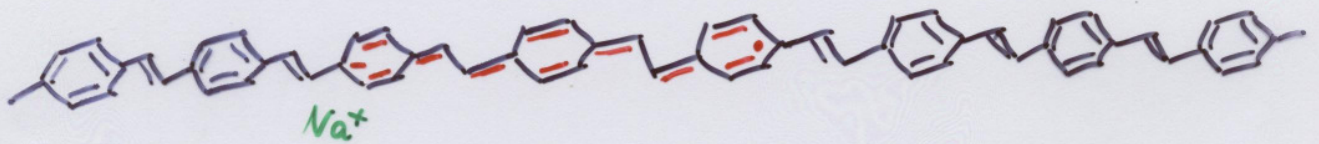
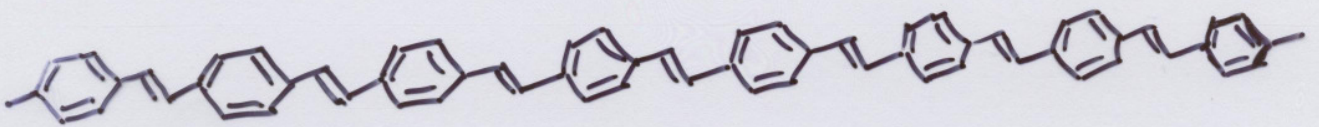
trans-(CH)_x



POLARONOK, BIPOLARONOK ... (gyök-ionok)



politiofén (PT)

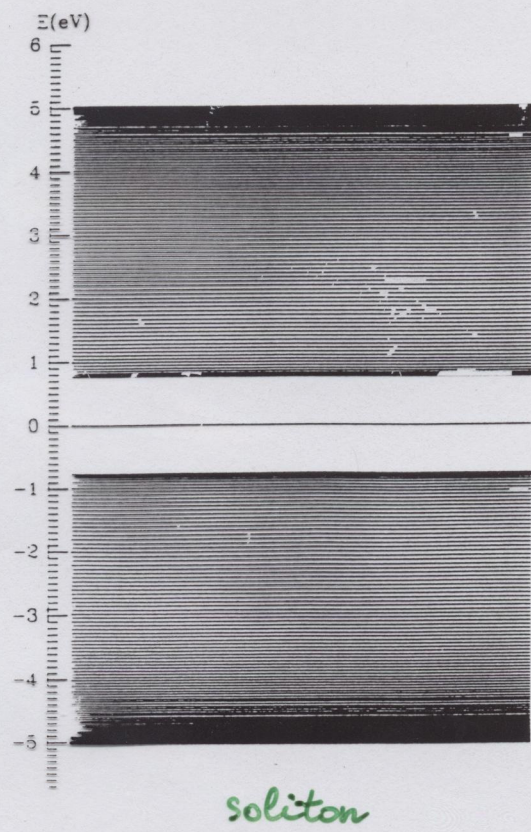
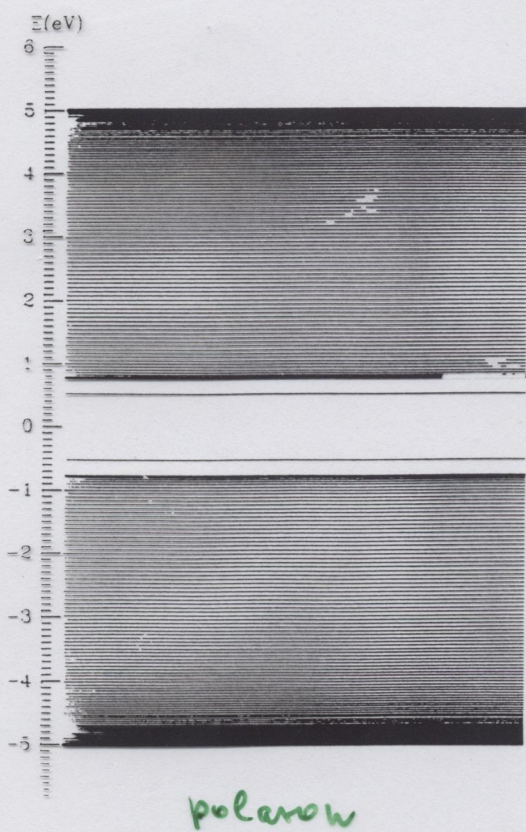
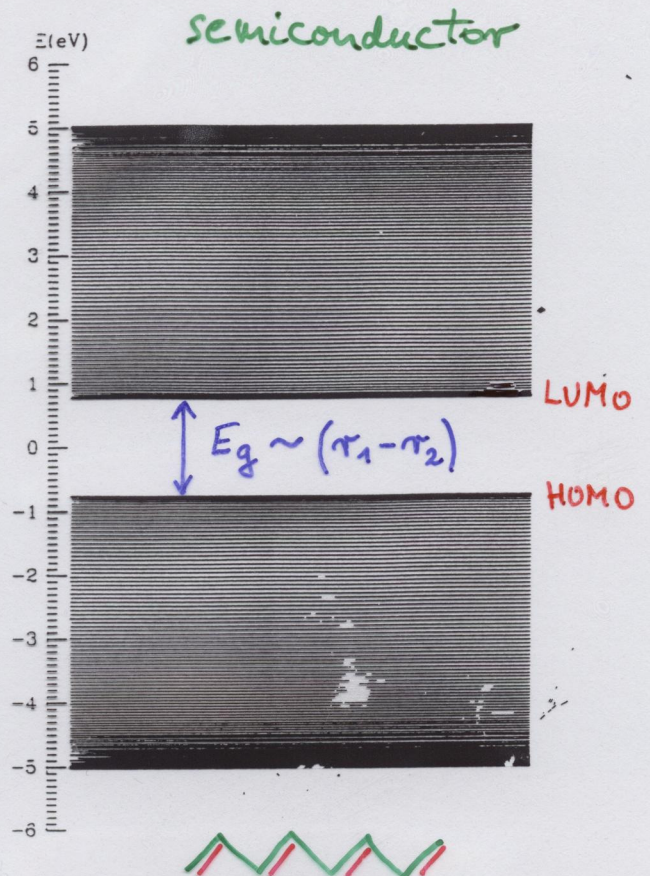
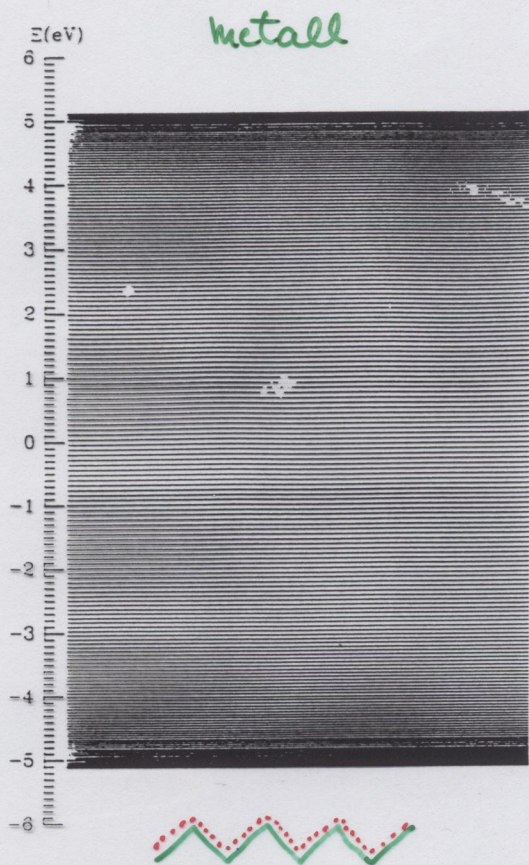


poli-parafenilén-vinilén (PPV)

p-dópolár

n-dópolár

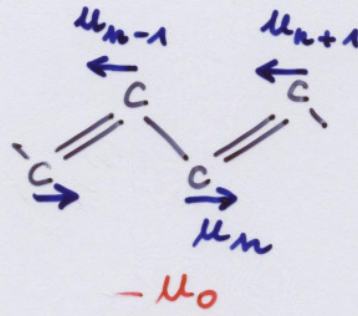
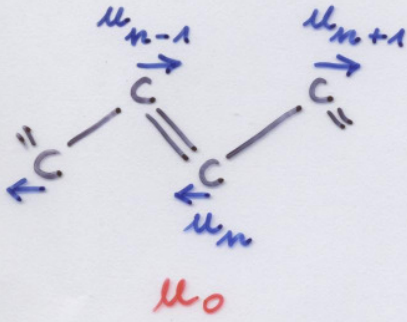
C₂₀₀



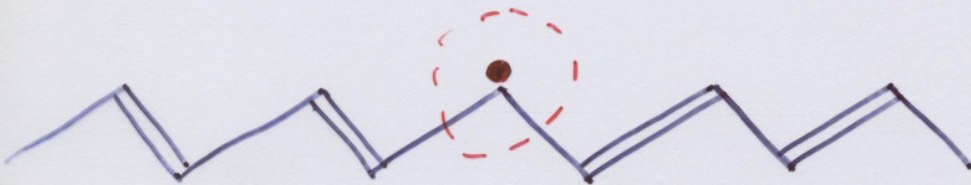
The energy levels for a linear chain of 200 C-atoms, calculated by LHS - model.

SZOLITON

(transz-poliacetilénben)

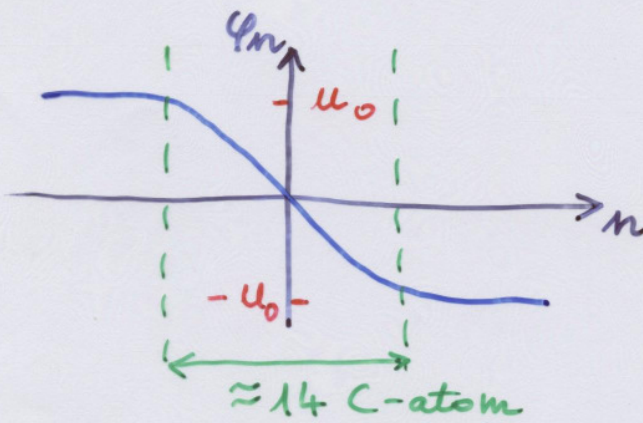


degenerált
alapállapot!



(semleges)
szoliton

rendparaméter: $\varphi_n = (-1)^n \cdot \mu_n$



E_{c-t}

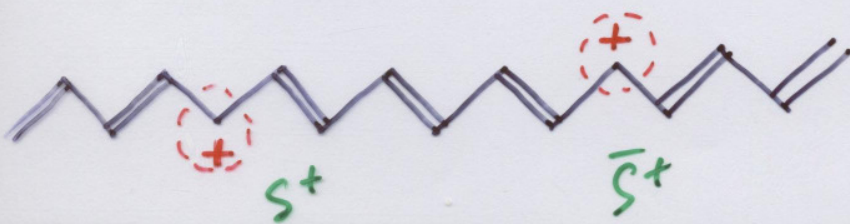
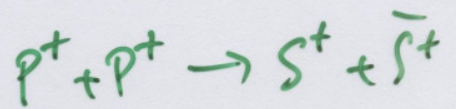
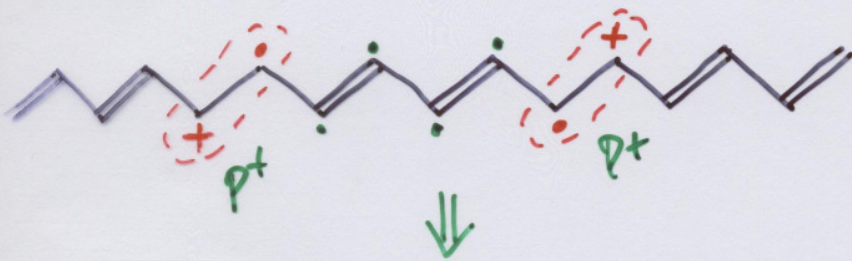
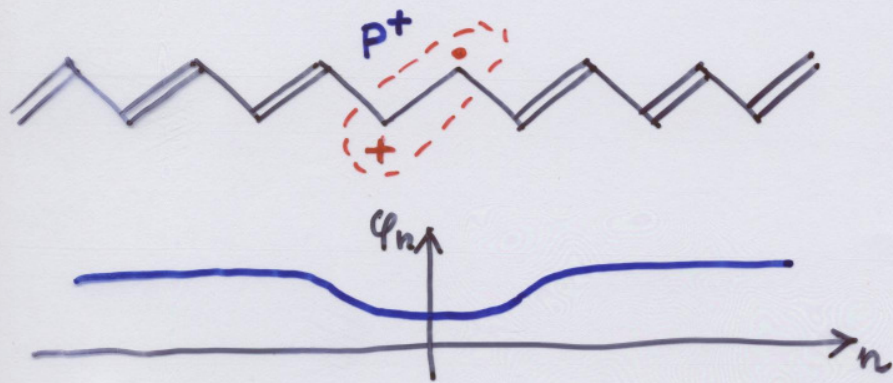
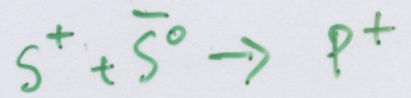
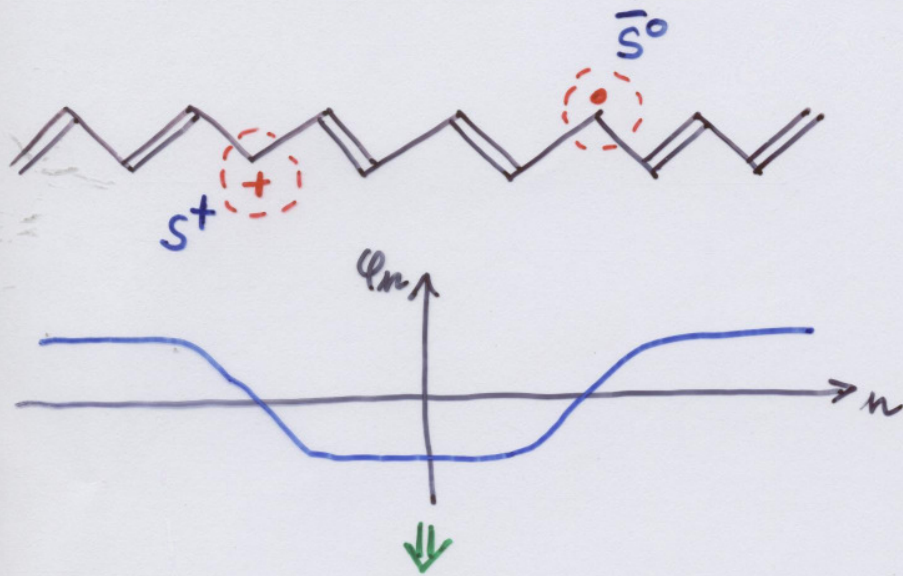


<

E_{t-c}



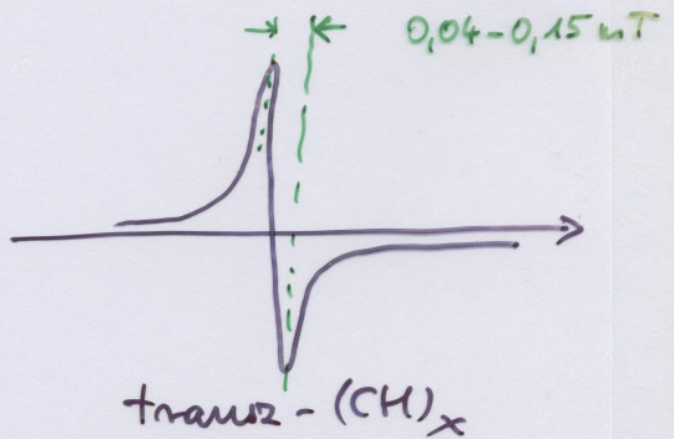
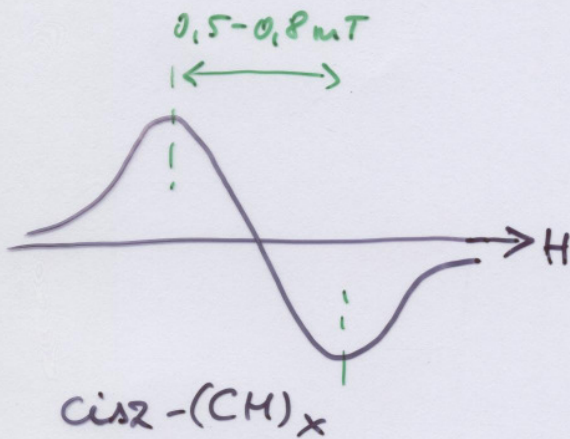
cisz-poliacetilén!
nem degenerált!



Szolonok

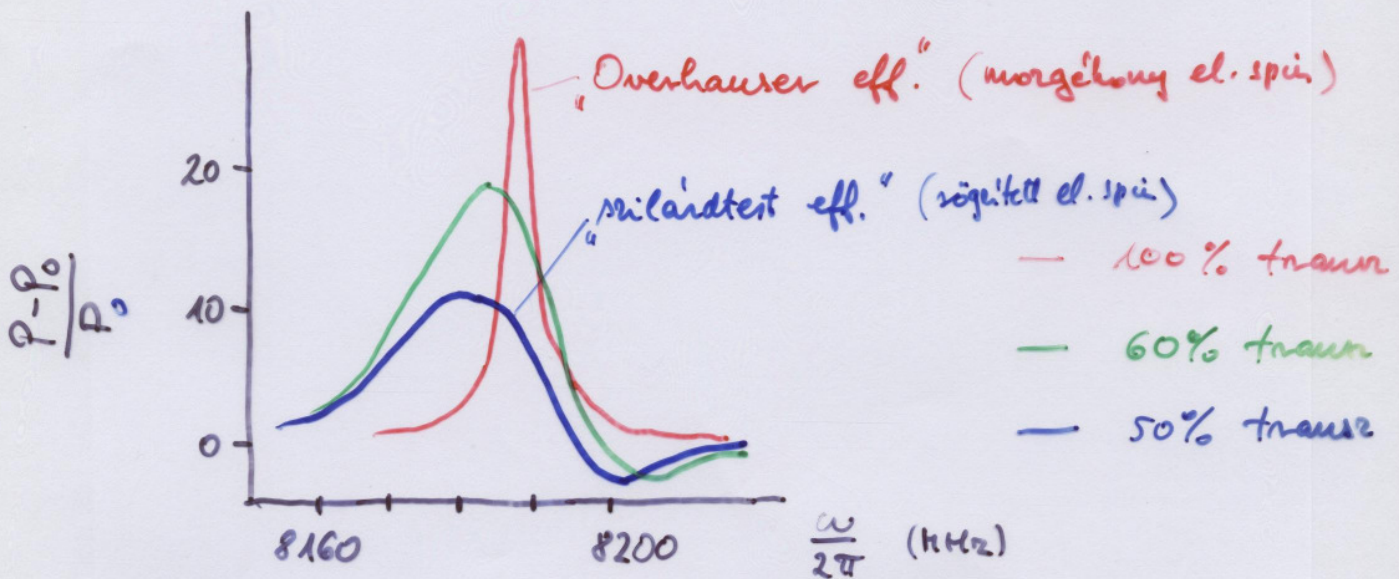
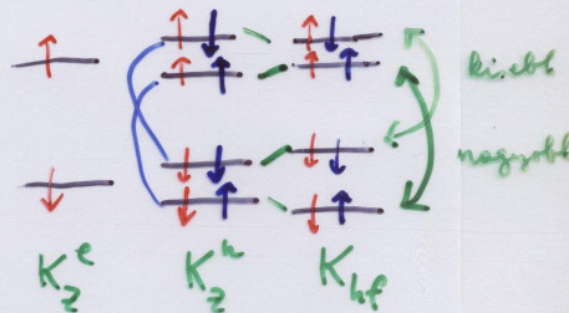
$(CH)_x$ -ben

ESR



Dynamic Nuclear Polarization

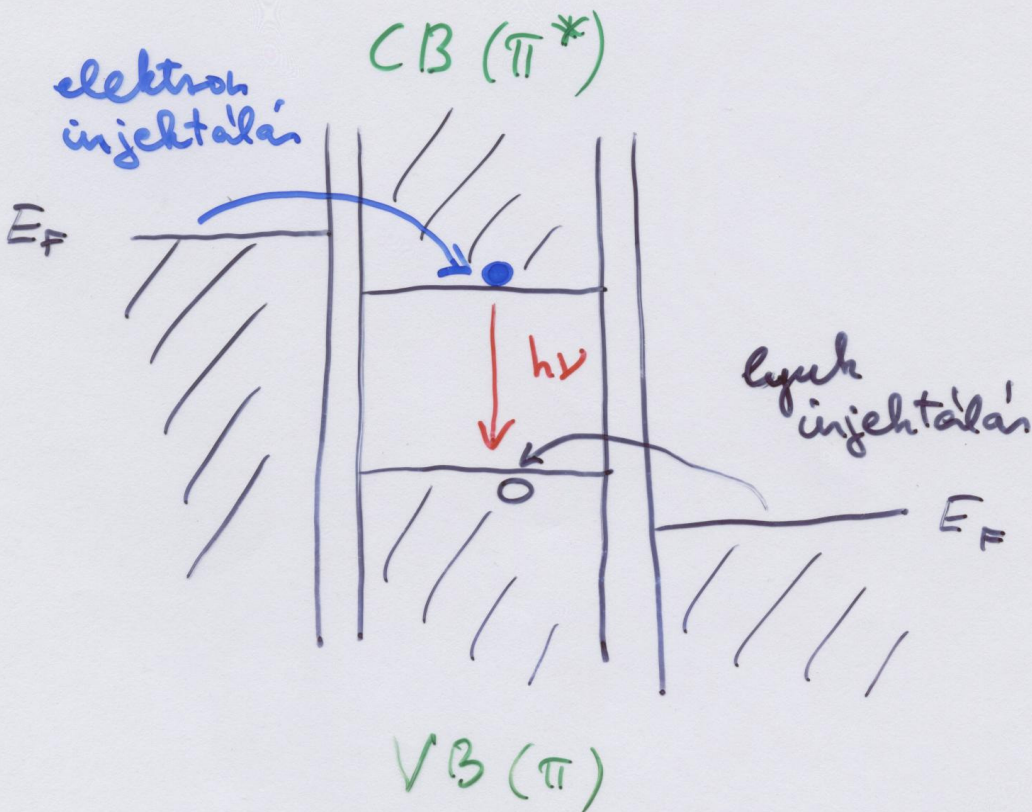
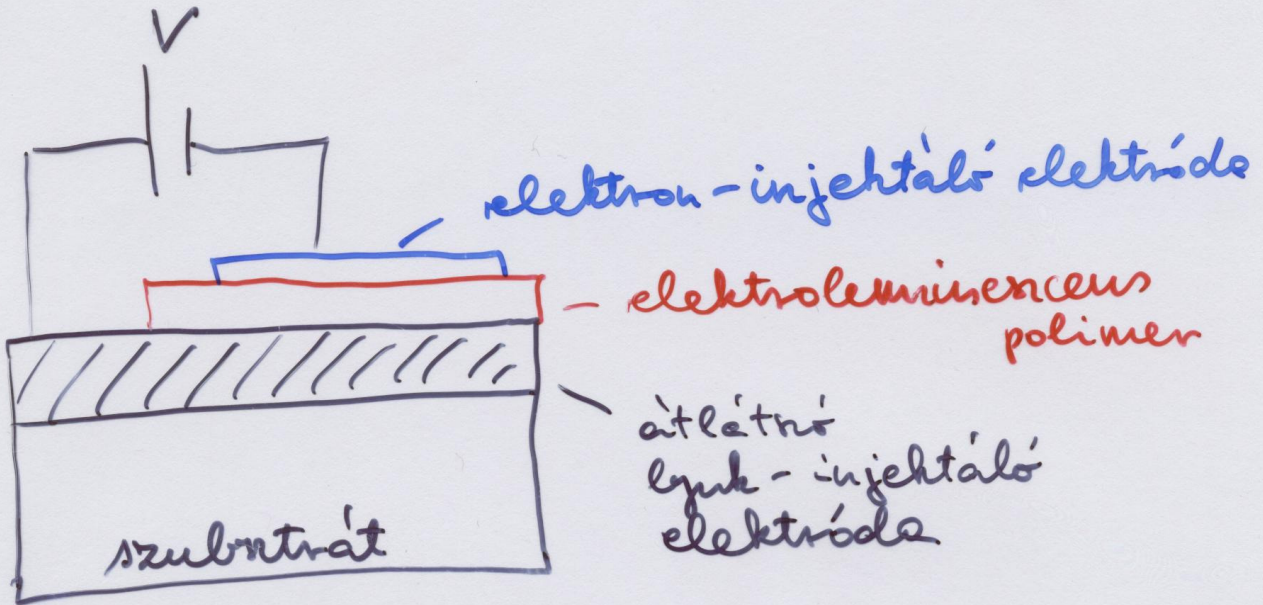
ESR-jel telítése \rightarrow NMR intenzitás változása



Konjugált polimerek alkalmazási lehetőségei

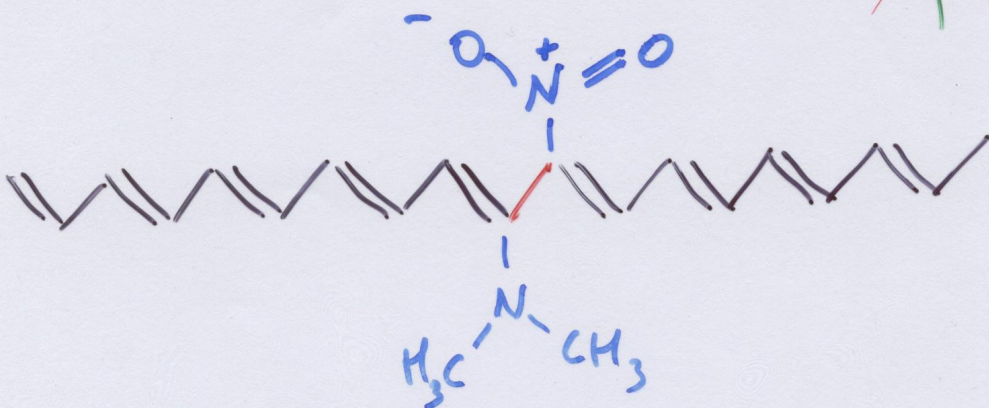
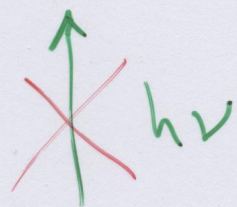
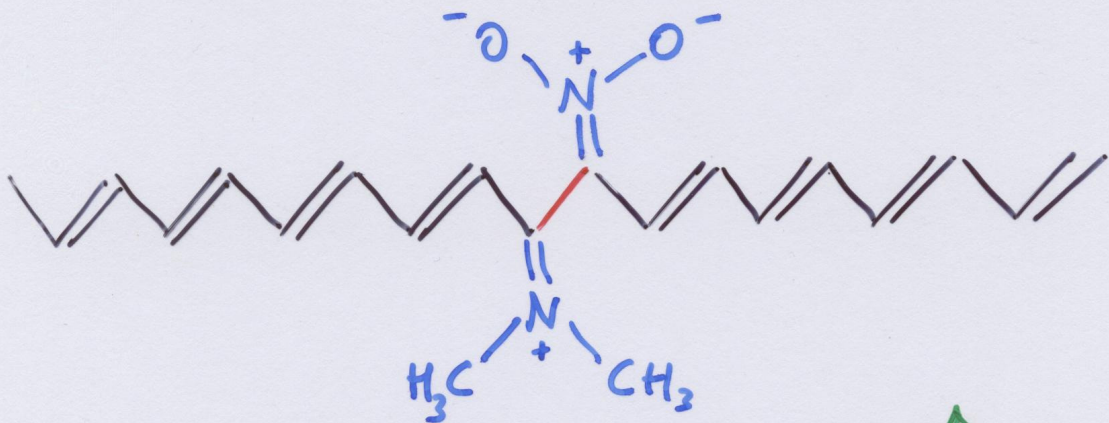
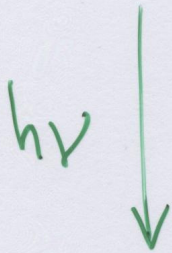
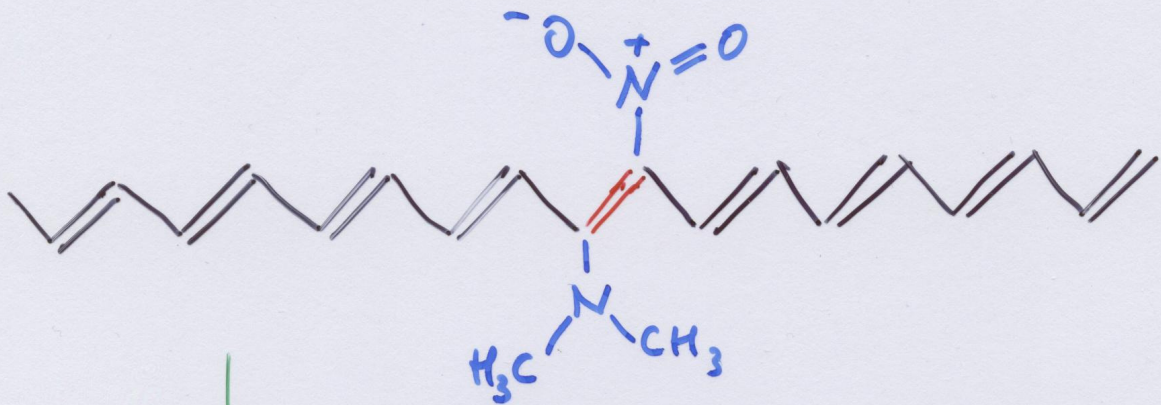
- elektronos (hajlékony vezeték, antirreflexív fólia ...)
MISFET ...
- elektro-kémiai (gomb-akkumulátor)
- optikai (termokrom, LED ...)
- nemlineáris optikai („fotonika”, hiperpolarizálhatóság ...)
- „egzotikus” pl. molekuláris elektronikai

Organic LED Device

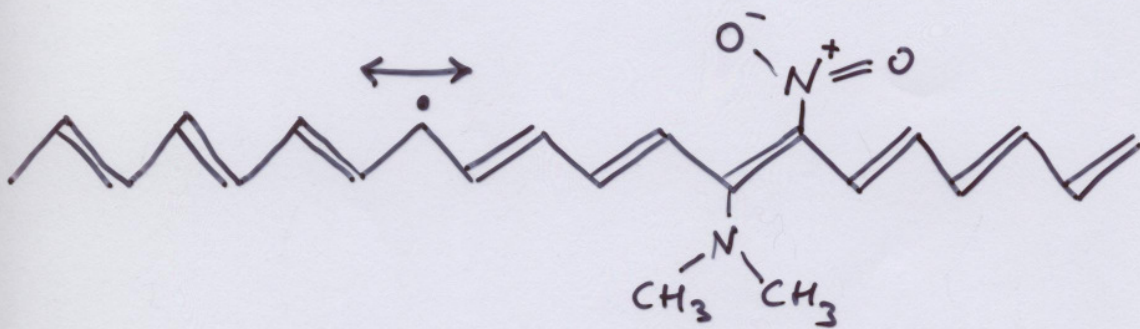


"Molekulari elektronikai alvok"

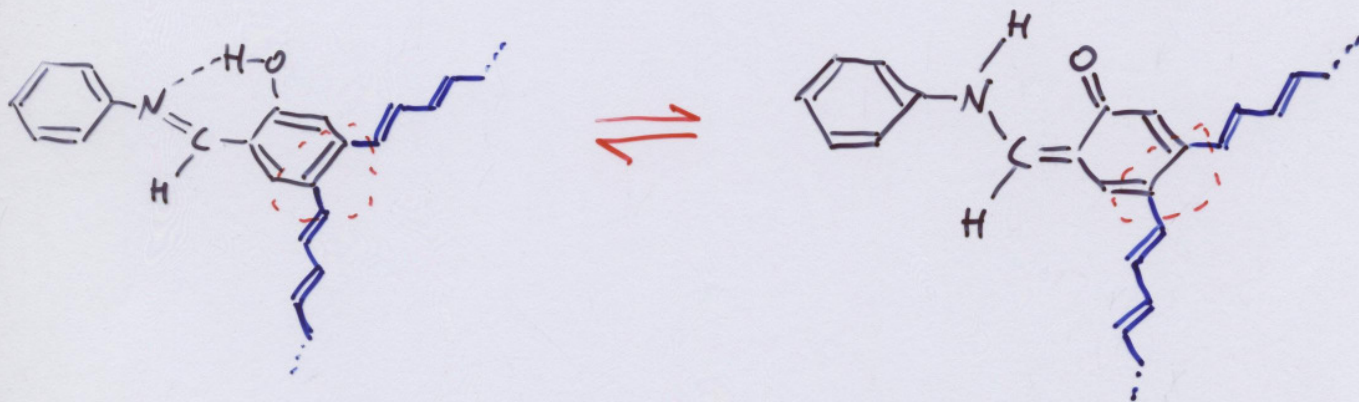
F.L. Carter, 1982



"Molekuláris elektronikai álmok"



Carter, 1988



N-salicyliden
fotokrom átváltás

Arb, Higelin, 1988

Langmuir-Blodgett

technika

LB-filmek

31. Addition of 1 weight % core material to a mantle source will have no effect on the isotopes of Sr, Nd, Pb, and oxygen, which are well correlated with Os isotopes in most OIBs [for example, Hawaii (18, 19)]. Core-mantle interaction would also buffer the f_{O_2} of OIBs to the iron-wustite buffer, which is three to four orders of magnitude lower than f_{O_2} 's actually measured in OIBs [Basaltic Volcanism Study Project (Pergamon Press, New York, 1981)].
32. K. Richter, M. J. Drake, G. Yaxley, *Phys. Earth Planet. Int.* **100**, 115 (1997).
33. J. Myers and H. Eugster, *Contrib. Mineral. Petrol.* **82**, 75 (1983).
34. T. Meisel, R. J. Walker, J. W. Morgan, *Nature* **383**, 517 (1996); H. K. Brueckner *et al.*, *J. Geophys. Res.* **100**, 22283 (1995); L. Reisberg and J.-P. Lorand, *Nature* **376**, 159 (1995); J. W. Morgan, G. A. Wandless, R. K. Petrie, A. J. Irving, *Tectonophysics* **75**, 47 (1981).
35. T. H. Green, *Chem. Geol.* **117**, 1 (1994).
36. We thank C. J. Capobianco, J. Chesley, M. J. Drake, S. Shirey, and P. Warren for discussions; P. Liermann and J. Ganguly for providing samples of Buell Park garnet; and J. Wang for expert assistance with the ion microprobe. This research is supported by NSF grants EAR-9706024 and EAR-9628092.

24 March 1998; accepted 29 April 1998

Integrated Optoelectronic Devices Based on Conjugated Polymers

Henning Sirringhaus,* Nir Tessler, Richard H. Friend*

An all-polymer semiconductor integrated device is demonstrated with a high-mobility conjugated polymer field-effect transistor (FET) driving a polymer light-emitting diode (LED) of similar size. The FET uses regioregular poly(hexylthiophene) (P3HT) with field-effect mobilities of 0.05 to 0.1 square centimeters per volt second and ON-OFF current ratios of $>10^6$. The high mobility is attributed to the formation of extended polaron states as a result of local self-organization, in contrast to the variable-range hopping of self-localized polarons found in more disordered polymers. The FET-LED device represents a step toward all-polymer optoelectronic integrated circuits such as active-matrix polymer LED displays.

Solution-processible conjugated polymers are among the most promising candidates for a cheap electronic and optoelectronic technology on plastic substrates. Polymer LEDs exceeding peak brightnesses of 10^6 cd m^{-2} (1) and high-resolution video polymer LED displays (2) have been demonstrated. One of the main obstacles to all-polymer

optoelectronic circuits is the lack of a polymer FET with sufficiently high mobility and ON-OFF ratio to achieve reasonable switching speeds in logic circuits (3) and to drive polymer LEDs.

Conjugated polymer FETs (4) typically show field-effect mobilities of $\mu_{FET} = 10^{-6}$ to 10^{-4} $cm^2 V^{-1} s^{-1}$, limited by variable-range hopping between disordered polymer chains and ON-OFF current ratios of $<10^4$ (5). This is much too low for logic and display applications, and therefore all previ-

ous approaches to drive polymer LEDs have used polycrystalline (2) or amorphous silicon (a-Si) (6) technology. Recently, a polymer FET with a mobility of 0.01 to 0.04 $cm^2 V^{-1} s^{-1}$ and an ON-OFF ratio of 10^2 to 10^4 using regioregular poly(hexylthiophene) (P3HT) was described (7). The high mobility is related to structural order in the polymer film induced by the regioregular head-to-tail (HT) coupling of the hexyl side chains. However, a clear understanding of the transport mechanism giving rise to the relatively high mobilities is still lacking.

Here, we report a considerably improved P3HT FET reaching mobilities of 0.05 to 0.1 $cm^2 V^{-1} s^{-1}$ and ON-OFF ratios of $>10^6$, the performance of which starts to rival that of inorganic a-Si FETs and enables us to demonstrate integrated optoelectronic polymer devices. As an example, we have chosen a simple pixel-like configuration in which the FET supplies the current to a polymer LED. This allows us to assess the prospects of active-matrix addressing in all-polymer LED displays.

To construct the multilayer device (Fig. 1A), we first fabricated the FET by spin-coating a film of P3HT (500 to 700 Å) (8) onto a highly doped n^+ -Si wafer with a 2300 Å SiO_2 gate oxide (capacitance $C_i = 15$ nF cm^{-2}). Au source-drain contacts were deposited onto the P3HT through a shadow mask. Then, a layer of SiO_x was thermally evaporated through another, mechanically aligned, shadow mask to define the active LED area on the finger-shaped Au FET drain electrode acting as the hole-injecting anode of the LED. A single layer of poly[2-methoxy-5-(2'-ethyl-hexyloxy)-*p*-phenylene-vinylene] (MEH-PPV) was spin-coated on top. Evaporation of a semitransparent Ca-Ag cathode completed the device. No photolithographic steps were involved. The device

Cavendish Laboratory, University of Cambridge, Madingley Road, Cambridge CB3 0HE, UK.

*To whom correspondence should be addressed.

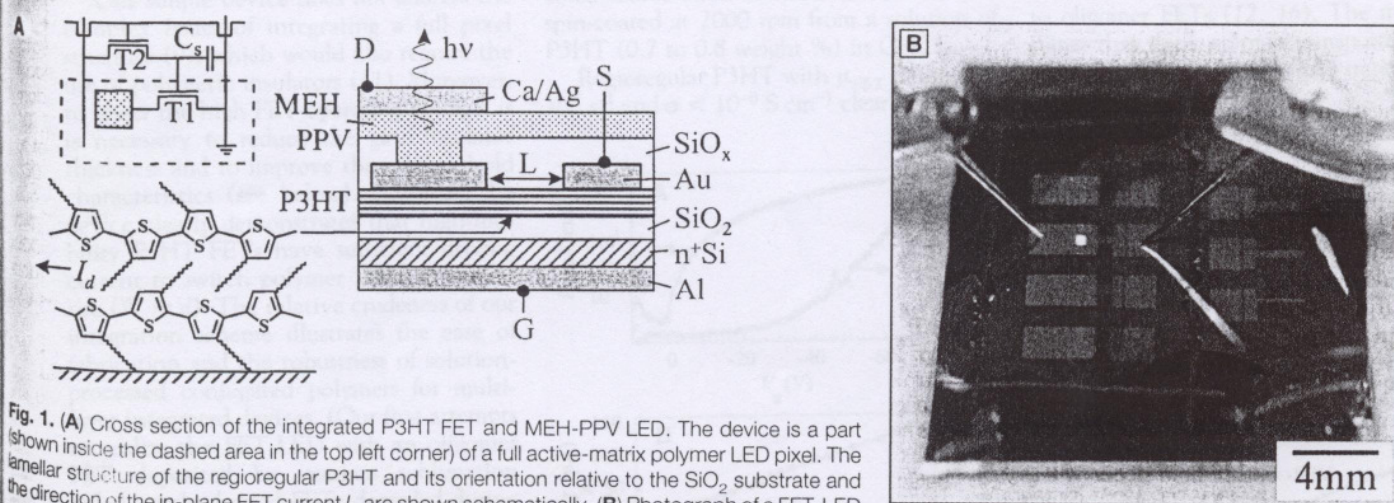


Fig. 1. (A) Cross section of the integrated P3HT FET and MEH-PPV LED. The device is a part (shown inside the dashed area in the top left corner) of a full active-matrix polymer LED pixel. The lamellar structure of the regioregular P3HT and its orientation relative to the SiO_2 substrate and the direction of the in-plane FET current I_d are shown schematically. (B) Photograph of a FET-LED with one of the four "pixels" switched on. The MEH-PPV layer (orange) was made to cover the substrate only partially in order to make the underlying (blueish) P3HT layer visible.