Organic materials for luminescent devices

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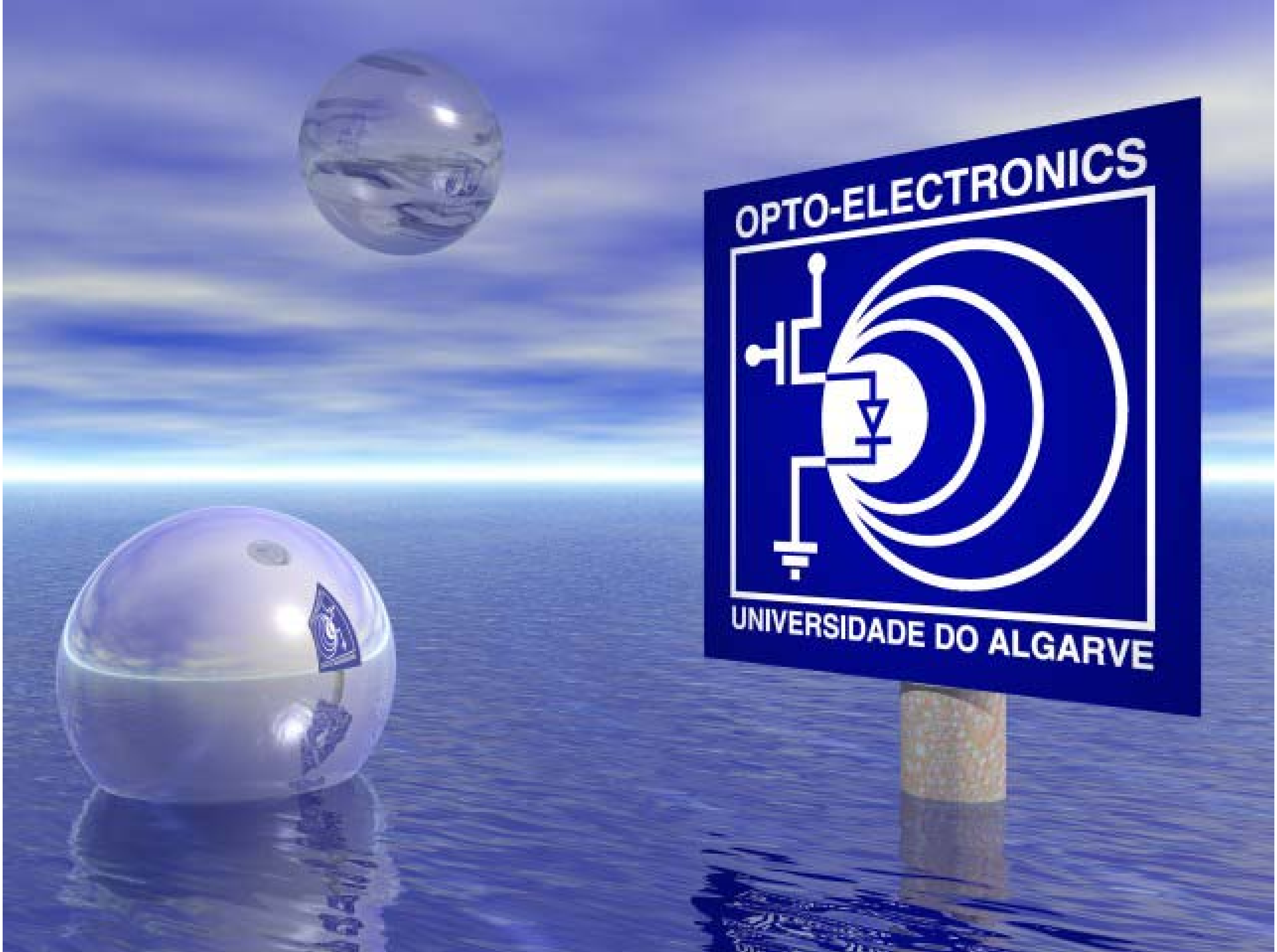
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Research group OptoEl in Faro

- Electronic characterization of semiconductor materials, devices and biological entities.
    - Organic semiconductors
        - Light emitting devices.
            - Material characterization.

Organic materials for light emission devices

LEDs; directly measuring the device properties (quatum efficiency, wavelength, stability). Not done in Faro, yet.

Electrical properties of the materials used:
Conductivity, charge mobility, impurity density, conduction model (transport mechanism), interface quality, etc.

Examples of measurements performed in Faro:

Diodes: p-n junctions and Schottky barriers:
impurity density determination: capacitance methods (shallow states), DLTS (deep states)
stability upon exposure to different ambients.

Field effect transistors:
mobility (as function of macroscopic and microscopic details of device and materials).
conduction model, for example VRH versus band conduction.

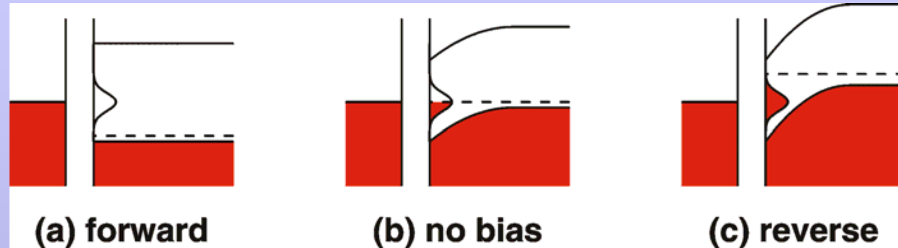
Field effect transitors

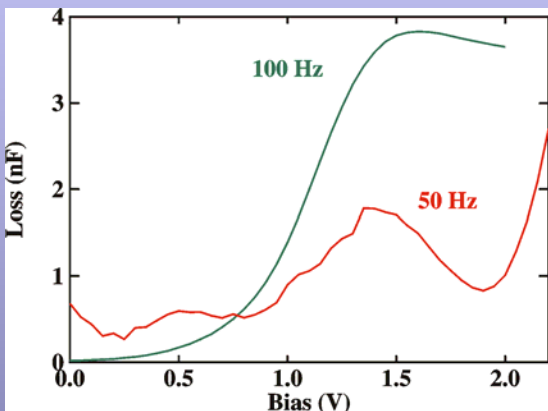
As used in studying the material (science).

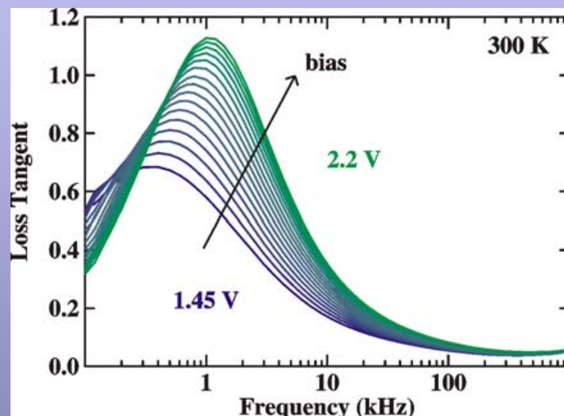
As used in driving the LEDs in all-organic displays.

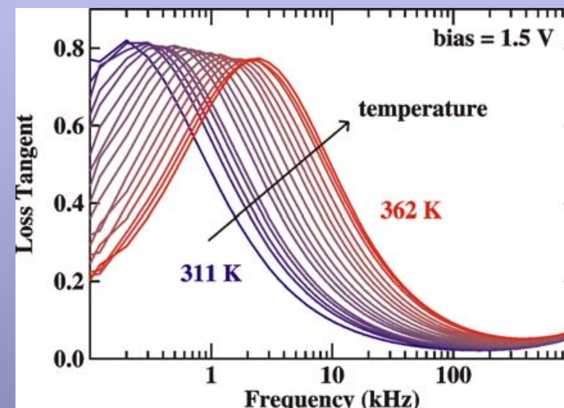
Future ambition: LEFET (light emitting FET).

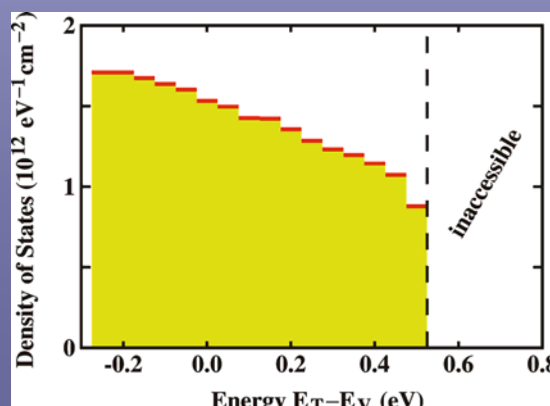
An example: interface state mapping











Why is it important to know the interface quality?

Interface states are deep ($Eg/2 = 1.5$ eV) and therefore slow (up to days and beyond). Especially important in FETs.

Interface states can cause Fermi level pinning and can cause a barrier for charge injection in LEDs.

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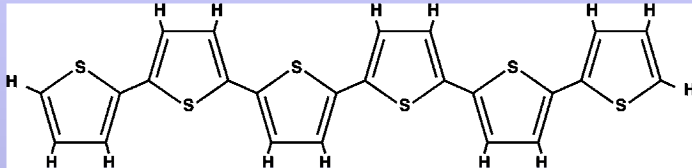
Field Effect Transistors



Theory (LIN): $I_{ds} = (W/L)\, C_{ox}\, \mu\, (V_g - V_t)\, V_{ds}$

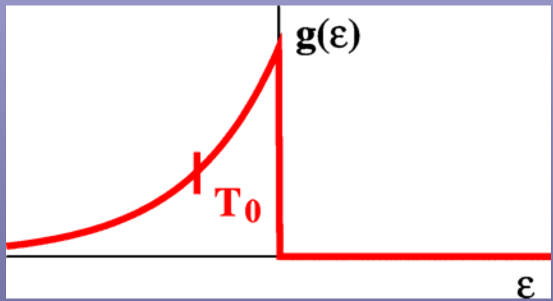
Experiment (LIN): $I_{ds} = (W/L)\, C_{ox}\, \mu\, (V_g - V_t)^{1+\gamma}\, V_{ds}$

γ not a small perturbation; up to 5

Existing models

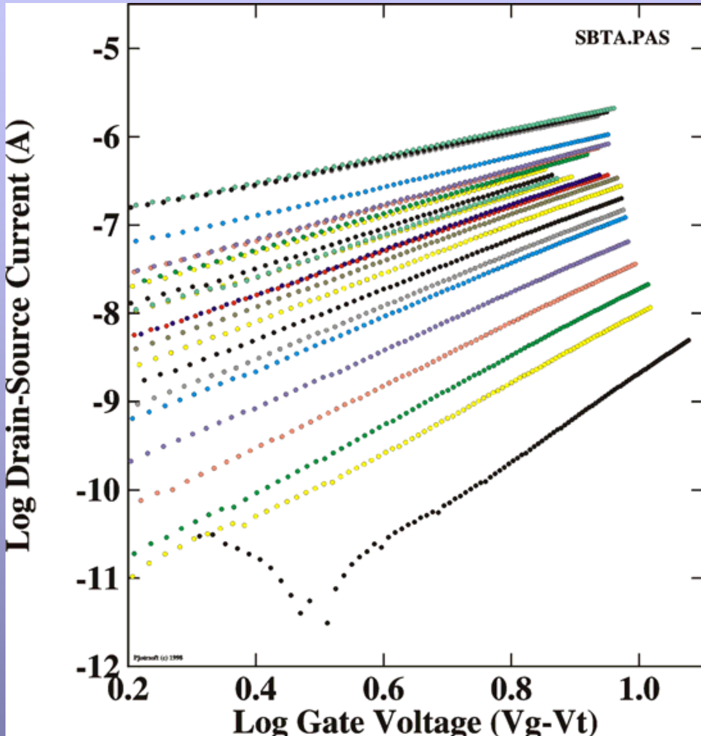
- Multi-trap and release, MTR (Horowitz)
- Variable-range hopping, VRH (Look, Vissenberg)

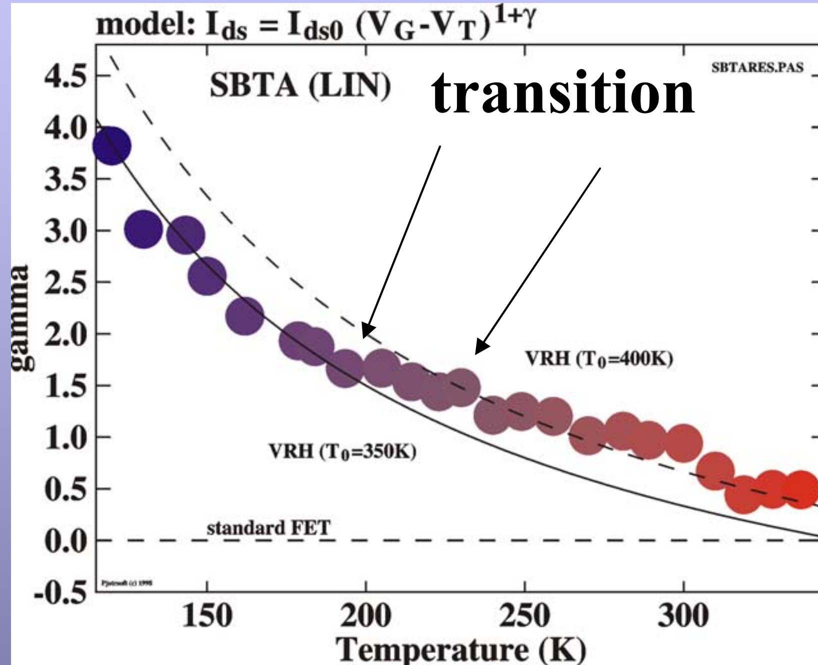
Both involve trap states to explain the data



$$\gamma = 2(T_0/T-1)$$

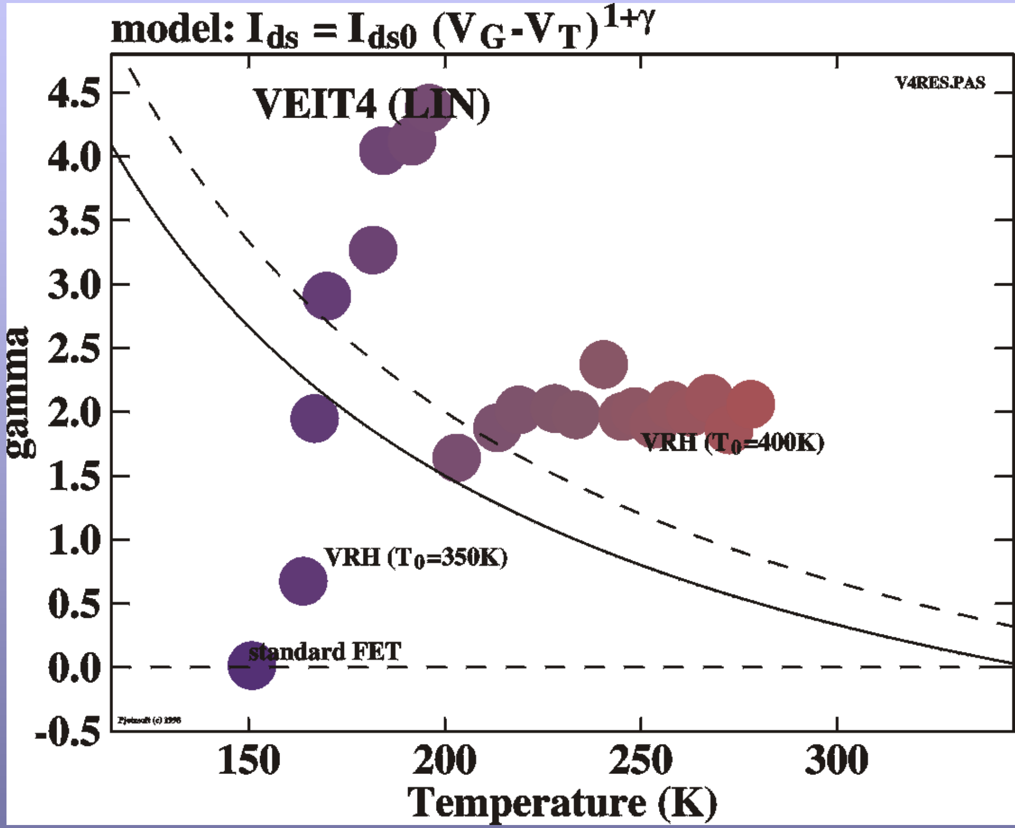
Experiment





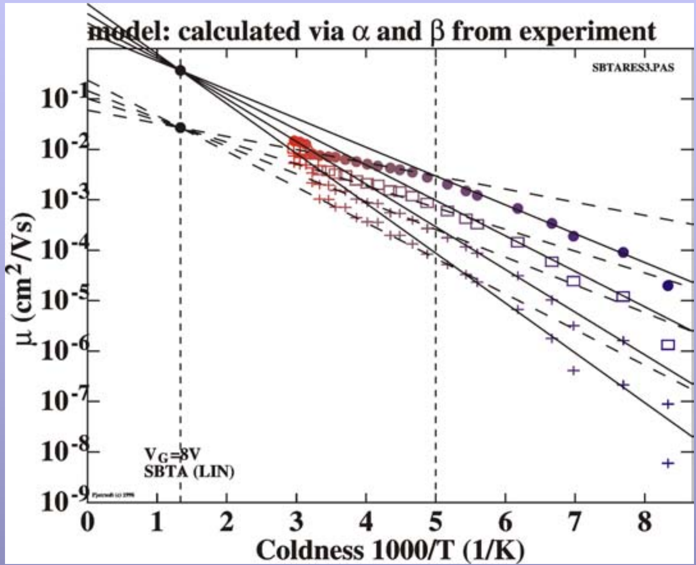
Seems reasonable ….. with phase transition (?)

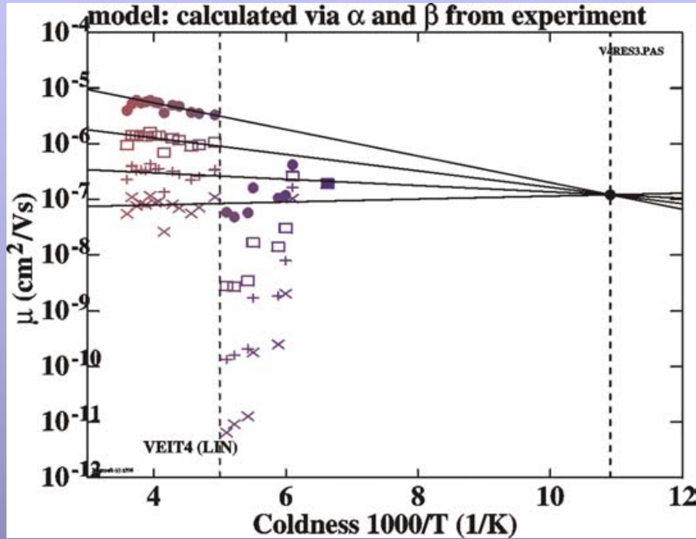
Failure of the model



nano-FET (channel length < 1 um)

Meyer-Neldel rule





micro-FET

nano-FET