

Pentacene-based organic transistors

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Why?



Background

- 1911 – Prediction of conducting organic solids
- 1954 – Akamatu *et al.* report high conductivity in bromine/perylene complex
- 1972 – (TTF)(TCNQ) first organic solid with metallic conductivity over wide temperature range; some salts superconducting
- 1977 – Heeger *et al.* – first conducting polymer

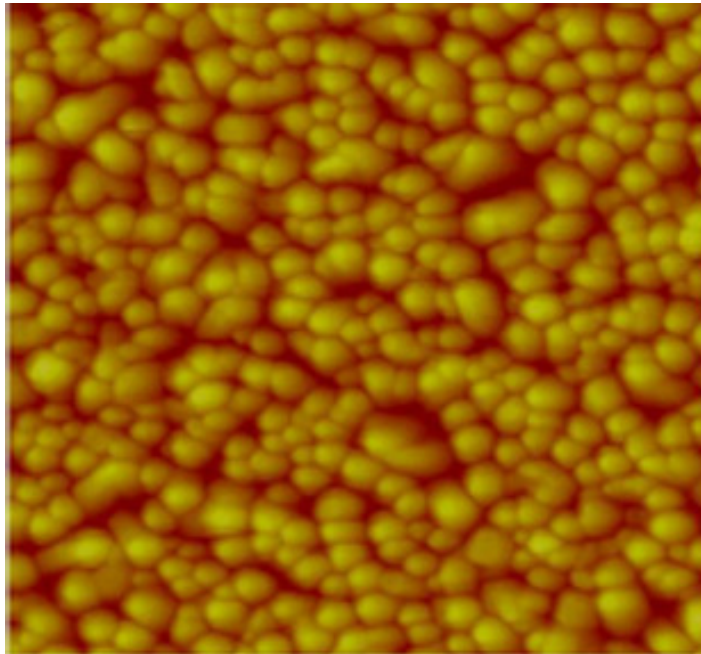
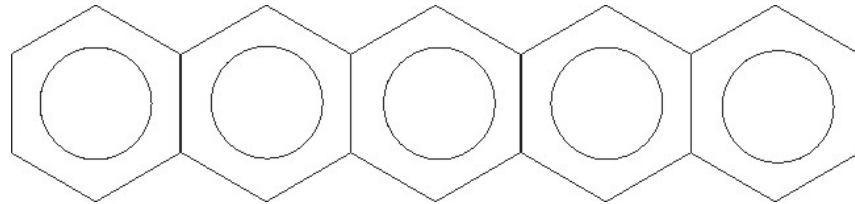
Electron Transport

- Organic solids tend to be insulators:
 - Highest Occupied Molecular Orbital completely filled; large energy difference to Lowest Unoccupied Molecular Orbital
 - No covalent bonds extending over macroscopic distances

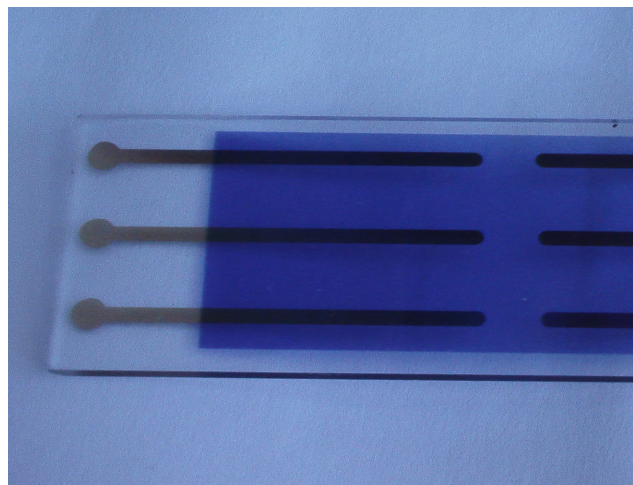
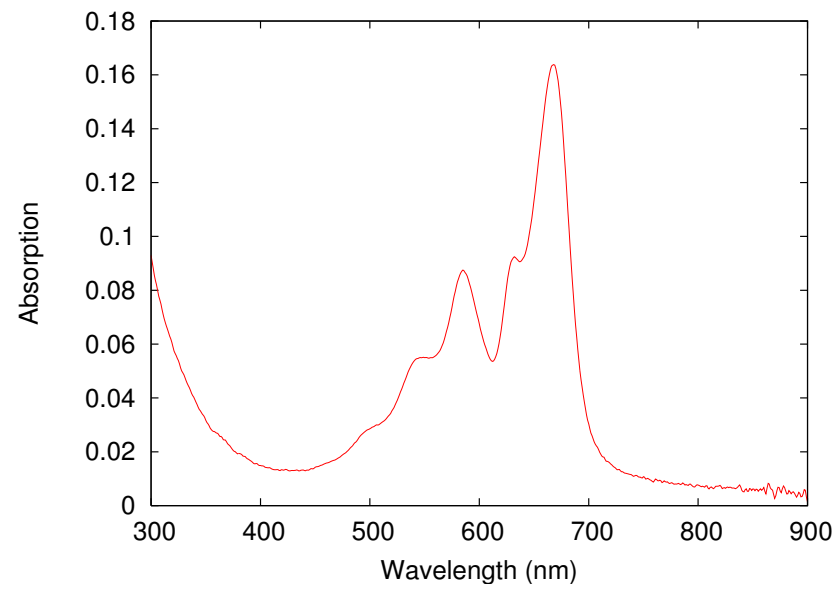
Increasing Conductivity

- Reduce HOMO-LUMO gap
 - Extensive π -bonding
 - Include heteroatoms with lone pair electrons
- This gives rise to semiconducting properties

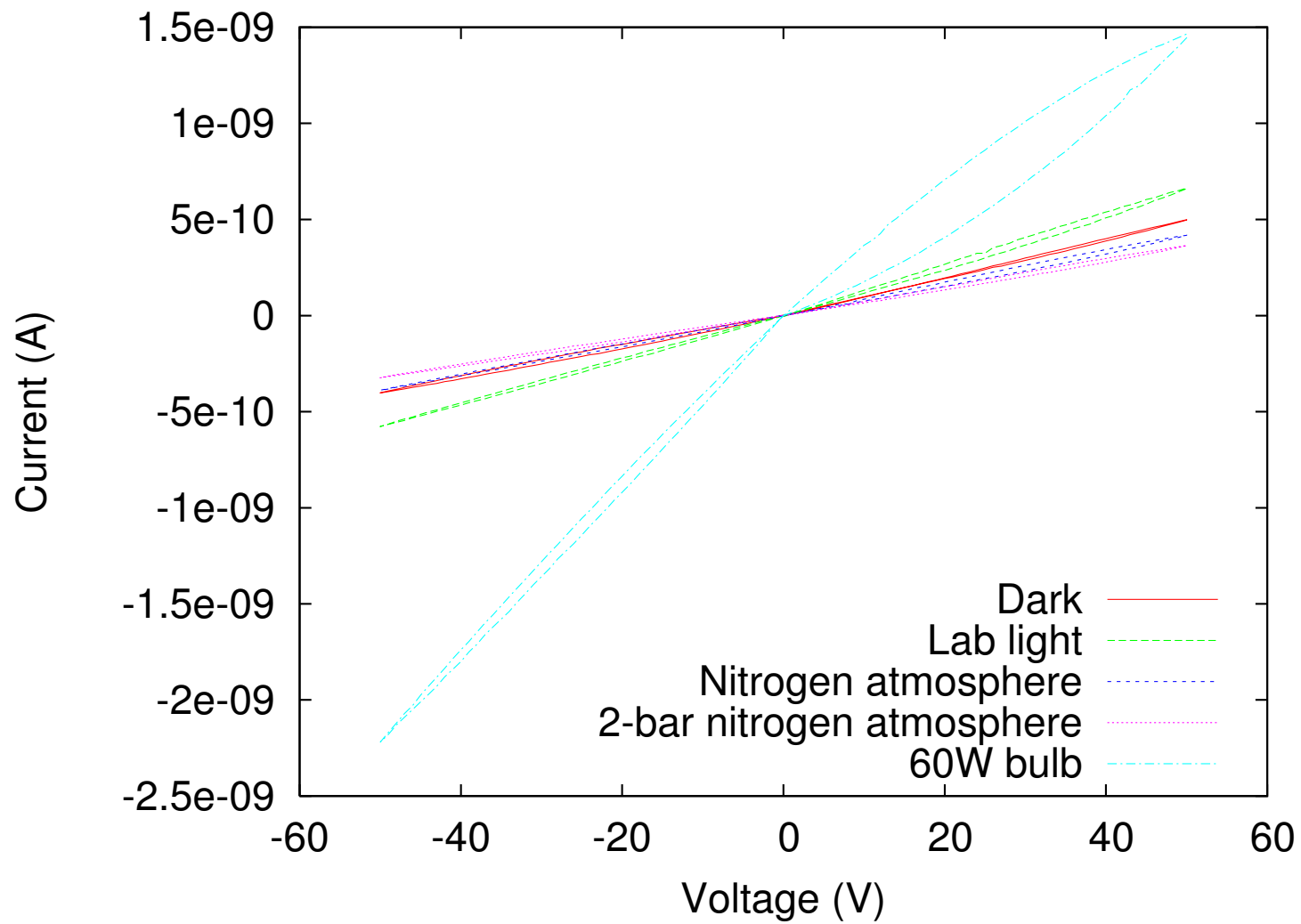
Pentacene



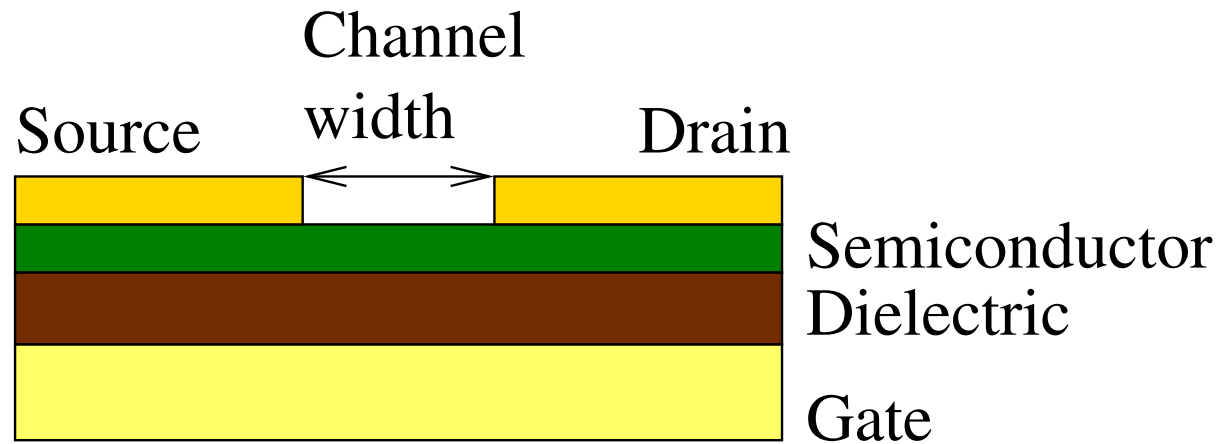
Pentacene



Pentacene



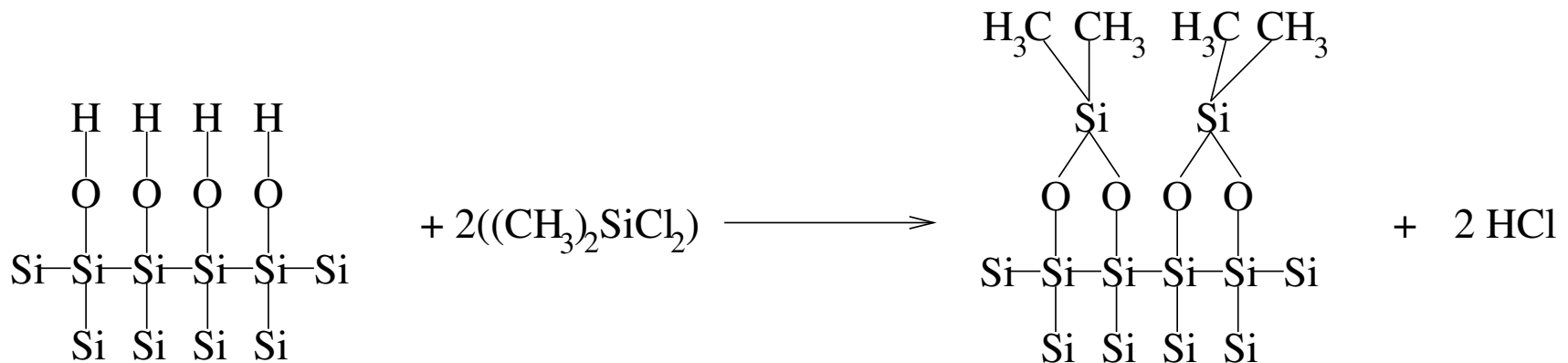
Transistors



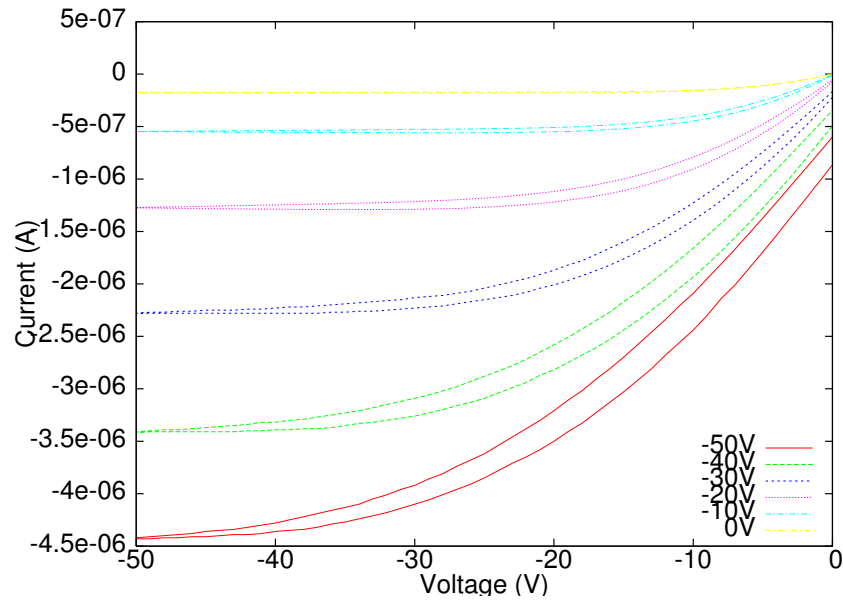
- 30nm Gold
- 20-40nm Pentacene
- 120nm SiO₂
- Aluminium gate
- 50-70 μm channel

Surface treatments

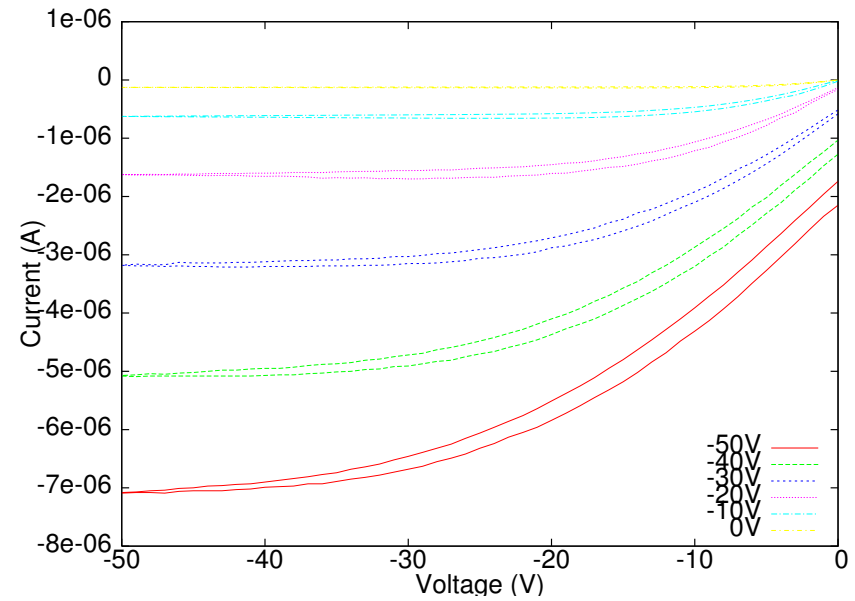
- Modifies oxide surface; results in increased electron mobilities
- Using DMDS



Transistor surface treatment

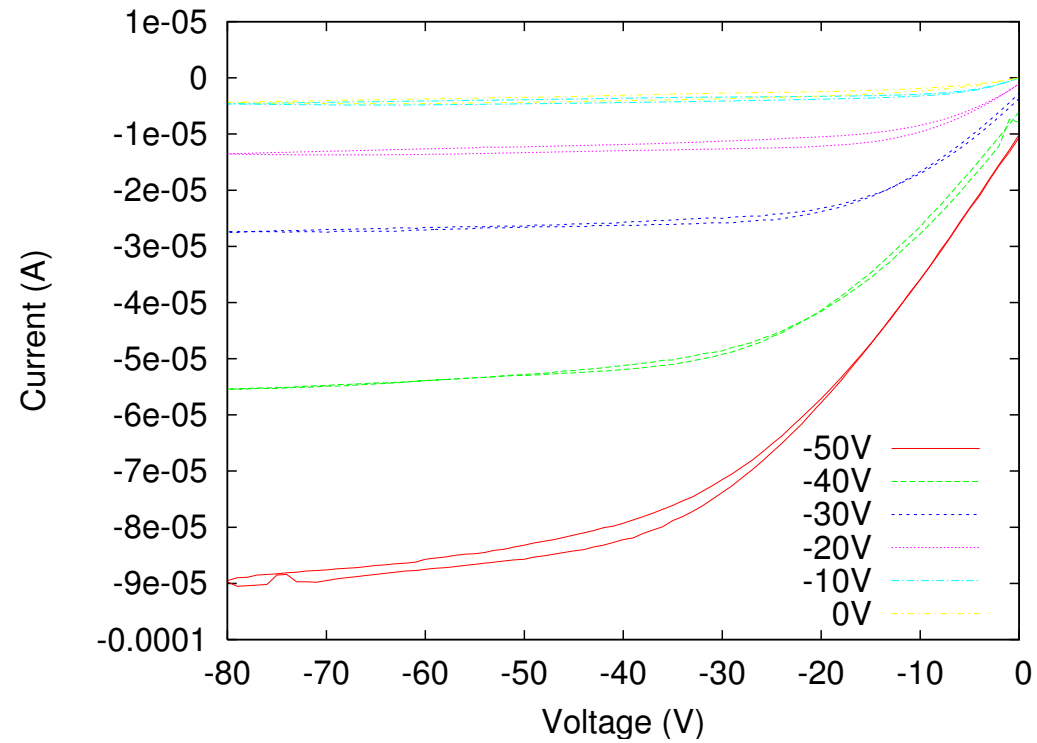


$1.8 \times 10^{-3} \text{ cm}^2/\text{Vs}$



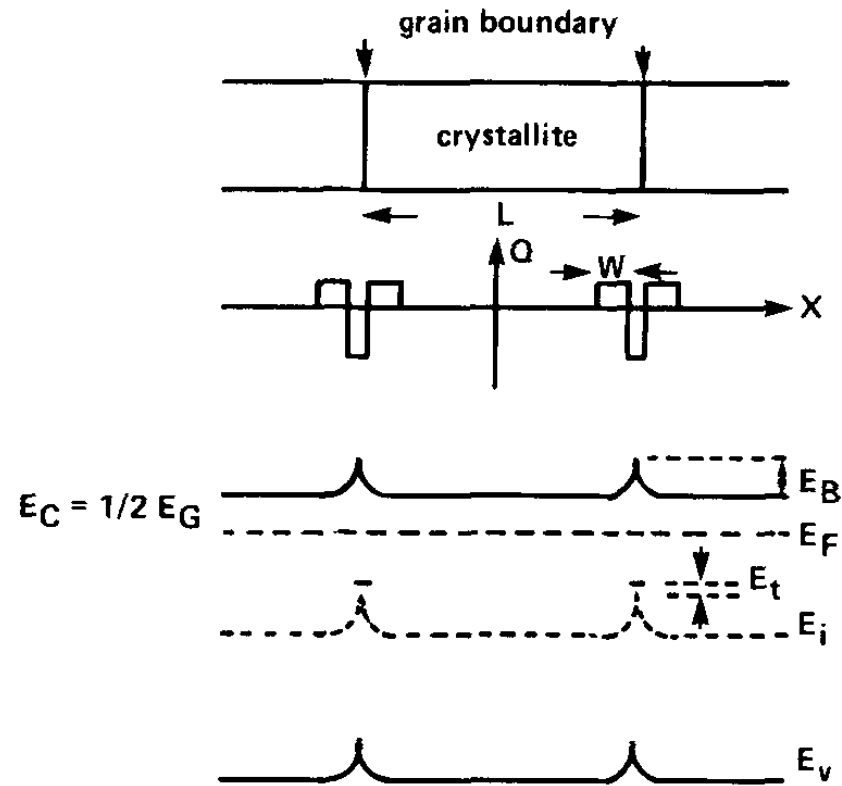
$3.3 \times 10^{-3} \text{ cm}^2/\text{Vs}$

Higher Mobility Transistor

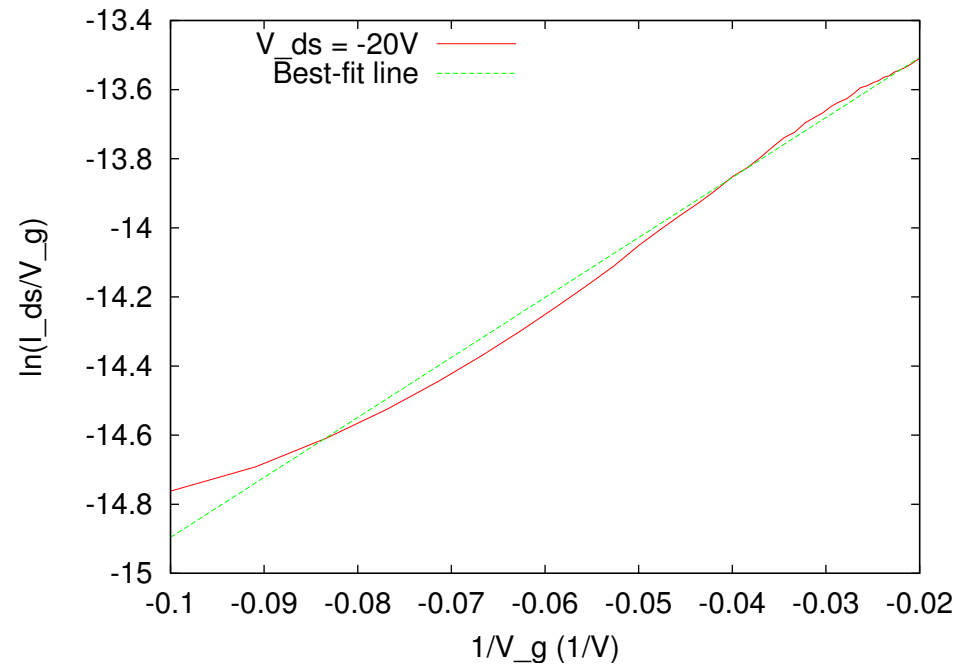


0.032 cm²/Vs

Grain-boundary trapping model



'Levinson' plot



For -50V gate voltage:

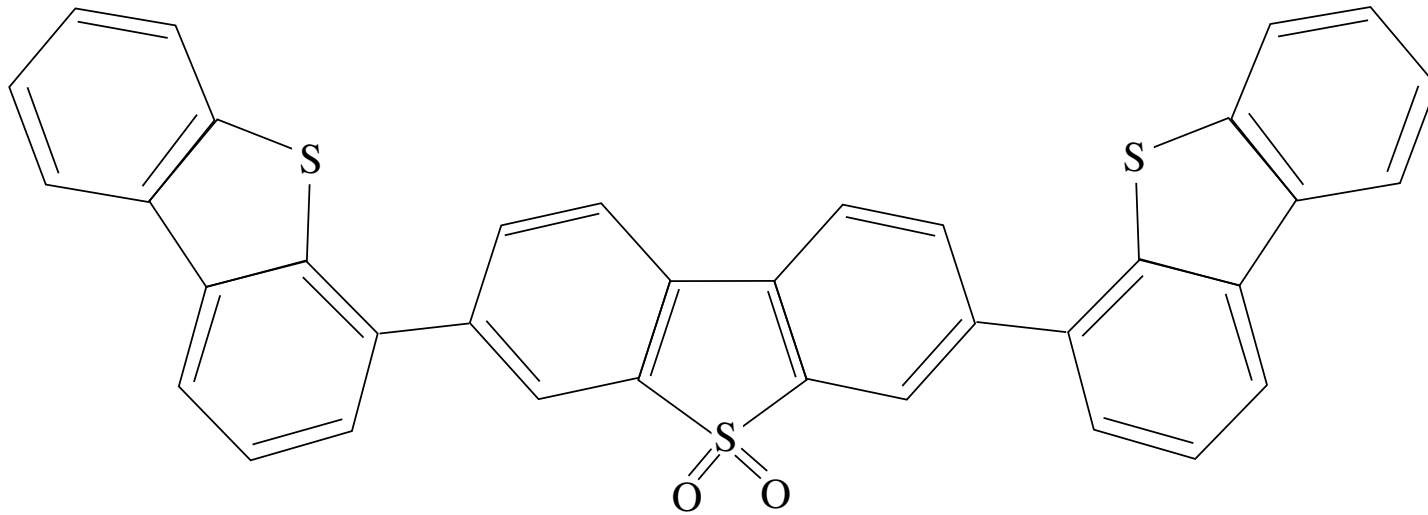
- Potential barrier height – 9meV
- Trap-free mobility – 0.045 cm²/Vs

Further work

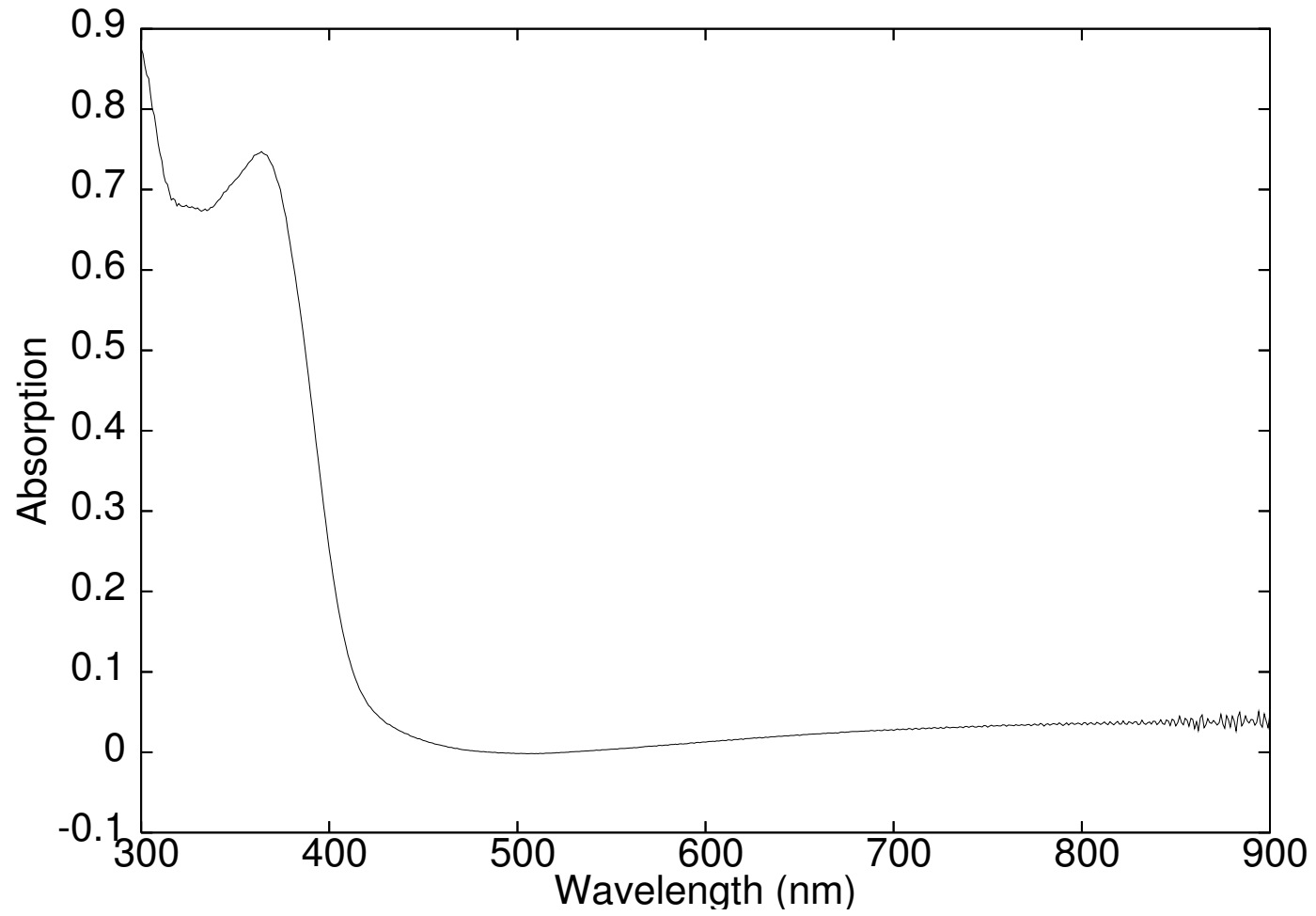
- Alternate substrates
 - ITO-coated glass
 - Flexible substrate
- Reduce leakage currents
- Flash memory
- Circuits
- Alternate semiconductors

IR-35F

- May be an *n*-type semiconductor



IR-35F



Summary

- Measured electrical and optical characteristics of pentacene
- Fabricated transistors with reasonable mobilities
- Started to look at new semiconductor material