Study report of OLED

Sheng-Horng Yen

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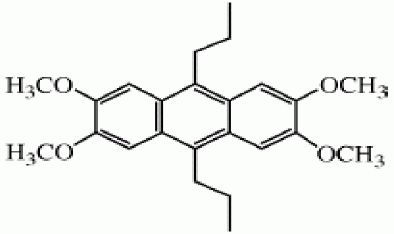
Outline

- Organic materials
- Operation steps of an OLED
- Conclusion

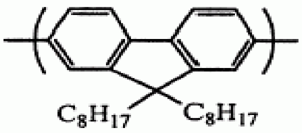
Molecule (left) and Polymer (right)

Blue

ANTH
$\lambda_{max} \sim 429$ nm
$\eta_f \sim 0.14$
(in solution in PMMA)

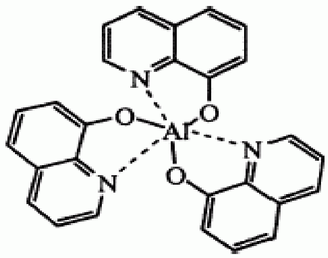


Poly(9,9'dihexylfluorene)
$\lambda_{max} \sim 450$ nm
$\eta_f \sim 0.155$

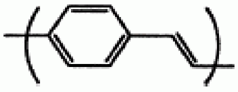


Green

Alq3
$\lambda_{max} \sim 550$ nm
$\eta_f \sim 0.25$

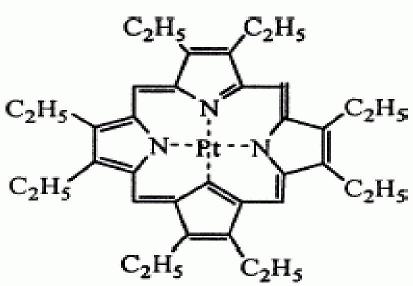


PPV
$\lambda_{max} \sim 515$ nm
$\eta_f \sim 0.27$

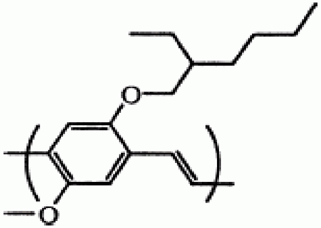


Red

PtOEP
$\lambda_{max} \sim 650$ nm
$\eta_{ph} \sim 0.5$



MEH-PPV
$\lambda_{max} \sim 610$ nm
$\eta_f \sim 0.15$



Different types of emitting materials

- Conjugated small molecule:

  1.Small, 0-D, weakly anisotropic.

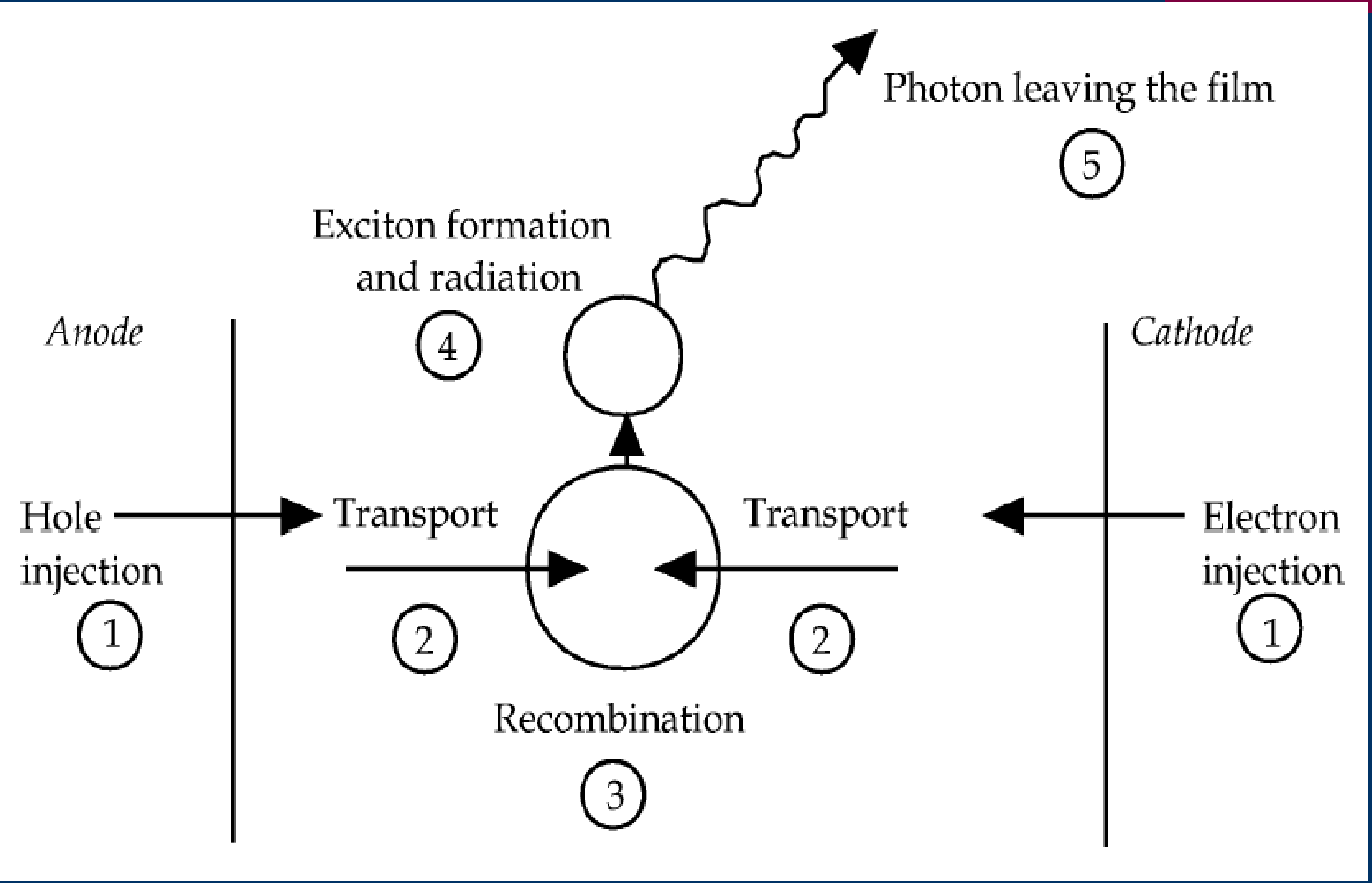
  2.Deposited by evaporate (熱蒸鍍), multilayers with sharp interfaces are easily prepared.

- Conjugated polymer chains:

  1.large, 1-D, amorphous, highly anisotropic.

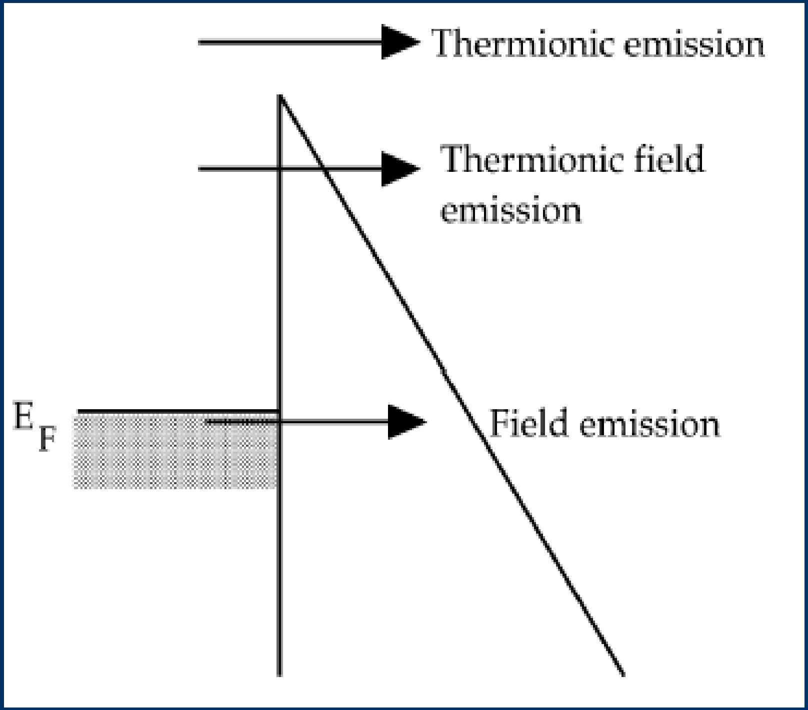
  2.Large area homogeneous polymer thin films are easily deposited by spin-coating (旋轉塗佈).

Operation steps of an OLED



Injection

- Thermoionic emission
- Tunneling
- Combination



Tailored interface

- Attaching substituent to the organic materials.
- Inserting a dipolar layer at the interface.
- Insertion at the interface of insulating barriers thin enough to allow tunneling.

Carrier transport

- Mobility (μ):

  In low μ case, dispersive transport is observed. (different current transient sharps)

- Fast increase of μ with electric field:

  Particularly in polymer, μ will start to increase rapidly at very large fields

  >1 MV/cm. (This property can be used to produce laser light)

Langevin-type recombination

- Capture distance: $$r_{\mathrm{c}} = \frac{e^2}{4\pi\varepsilon e_0 kT}$$
- Recombination rate: $$\gamma_{\mathrm{r}} = \frac{e(\mu^+ + \mu^-)}{\varepsilon\varepsilon_0}$$
- The capture results from a process of diffusion in a field treated by Langevin.

Space-Charge Limited (SCL) condition

- High EL yields require:

  1.Efficient recombination

  2.Reach SCL conditions (no trapping carrier)

  In non SCL condition requires large applied voltage, hence smaller energetic yields (the factor $h\nu$/eV decrease).

Photo emission

- Electroluminescence quantum yield is proportional to $\frac{\eta_\mathrm{s}+3\eta_\mathrm{t}}{4}$.
- η_s: Singlet emission, fluorescence.
- η_t: Triplet emission, phosphorescence.
- Currently favored materials in OLED have $\eta_s \approx$ 0.15-0.6; $\eta_t \approx 0$.

Photo extraction

- The probability P_0, that the photons are emitted outside the device is small.
- Improvement:

  1.Reflecting mirrors

  2.Microcavity

Multilayer diodes (I)

- Organic material should have:

1. Large electron affinity

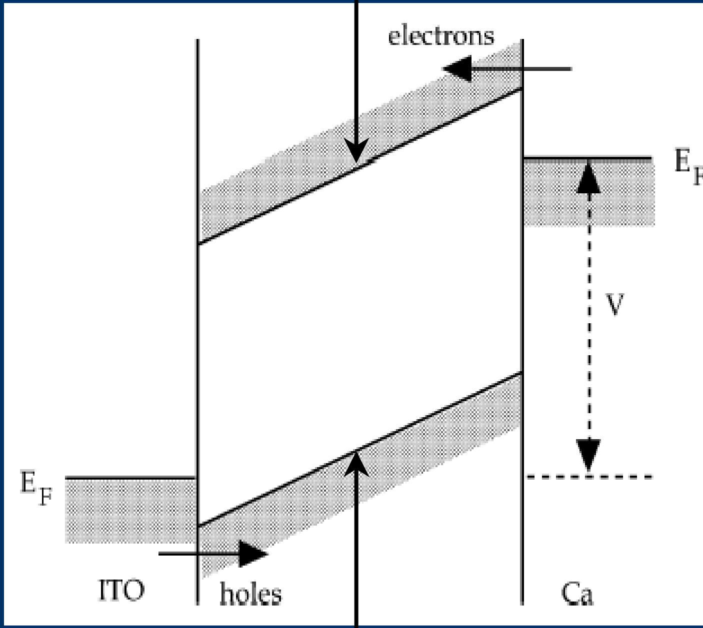
   A_c (Lumo) $\geq$ 3 eV.

2. Small ionization potential

   I_c (Homo) < 5 eV.

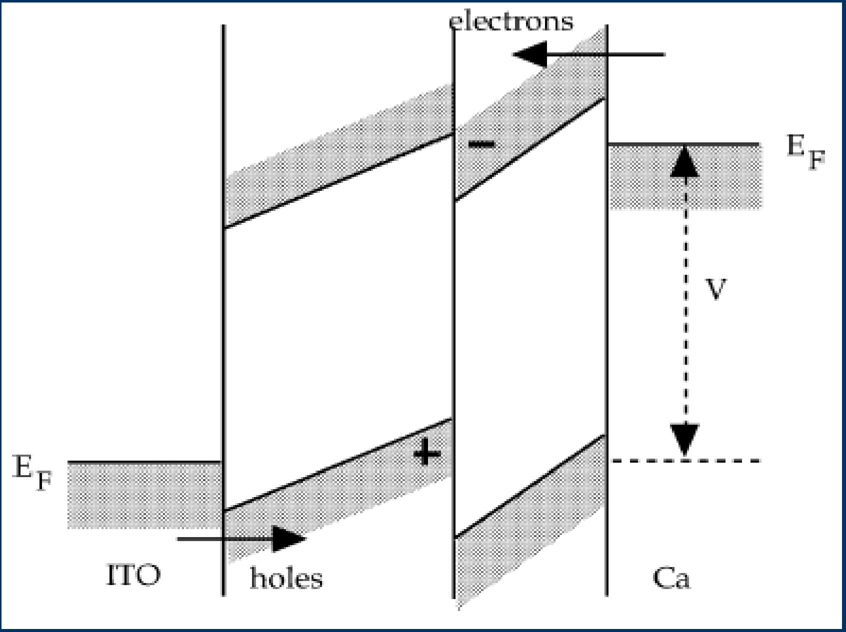
   $E_g = I_c - A_c$

Lowest unoccupied molecule orbital (Lumo)



Highest occupied molecule orbital (Homo)

Multilayer diodes (II)



- The device would increase yield and shift the wavelength.

Conclusion

- Much work remains to be done on physical problems:

  1.Understanding interfaces and injection.

  2.High voltage/high current operation.

- Optimization depends on improved materials.