OLEDs

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Introduction

- Made using an organic material in between an anode and a cathode
- Acts like semiconductor through de-localized pi bonds
  - Forms 2 Energy levels (HOMO and LUMO which are comparable to Conduction and Valence bands)
- Used mostly for displays
- Typically two types of systems to make devices:
  - Small Molecule
  - Polymers

OLEDs vs. LEDs

OLED Advantages

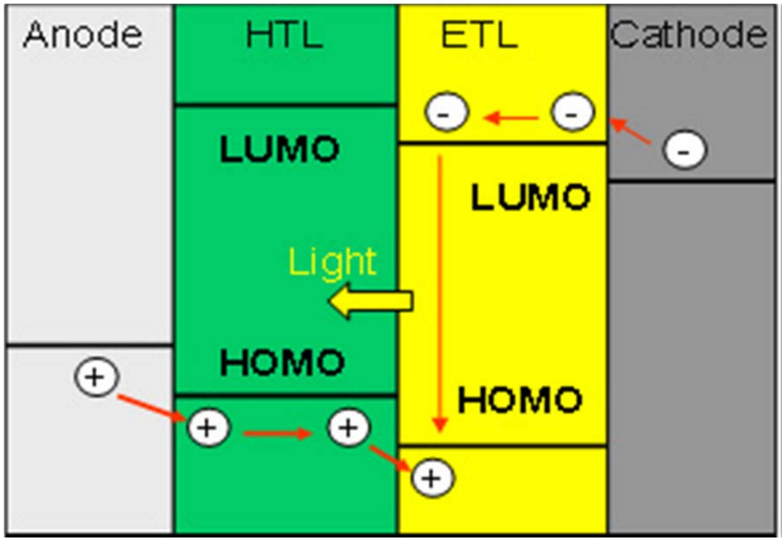
- Less power consumption at dark colors like black
- Flexible
- Thickness
- Better viewing angles

LED Advantages

- Less power consumption with bright colors like white
- Easier to manufacture
- Longer lifetime
- Better for Lighting

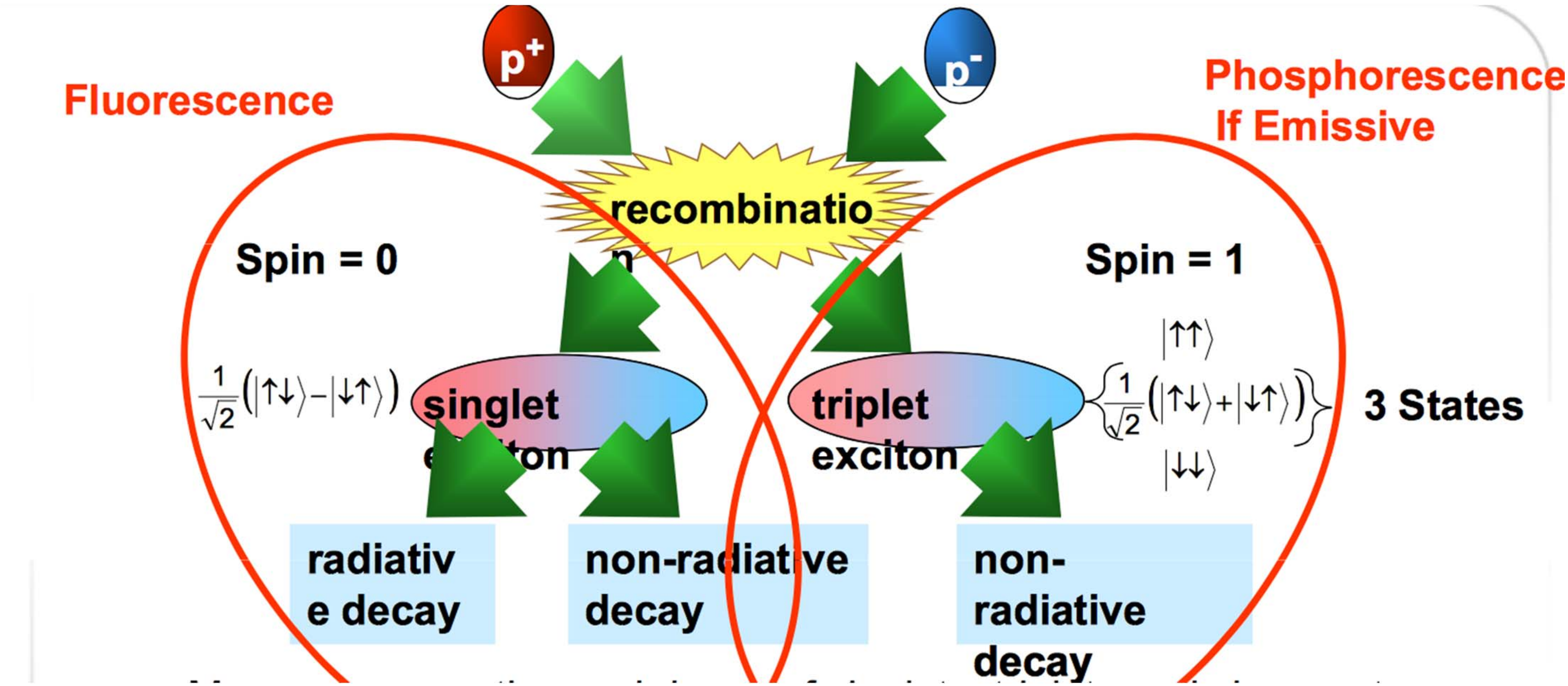
How Do OLEDs Work?

- There are two major layers to make the OLED, an emissive polymer and a conducting polymer
  - Emissive Layer: Typically where the electrons are injected in from the cathode (Electron Transmission Layer)
  - Conducting Layer: Typically where the holes are injected in from the anode (Hole Transmission Layer)
- Electrons and holes combine and light is the byproduct



How OLEDs Emit Light

- 2 types of excitation
  - Singlet
    - The spin of the electron and hole pair together
  - Triplet
    - The spin of the electron and hole do not pair together
- The singlet will occur once for every 3 triplets (statistically)
- In order to use the triplet excitons, phosphorescent materials are required to allow illumination
  - Phosphorescent materials are not necessary for singlet excitons


Fluorescence
Phosphorescence
If Emissive
p+
p-
recombination
Spin = 0
Spin = 1
$\frac{1}{\sqrt{2}}\left(|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle\right)$
singlet exciton
triplet exciton
$|\uparrow\uparrow\rangle$
$\frac{1}{\sqrt{2}}\left(|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle\right)$
$|\downarrow\downarrow\rangle$
3 States
radiative decay
non-radiative decay
non-radiative decay

Things to Consider

- Carrier transport is relatively slow compared to inorganic semiconductors
  - This means that the layers are incredibly thin (.1 microns)
- Dopants are used to make different colors in Small Molecule
- Blue is the hardest color to have (requires the most energetic electrons)
  - Typically use Phosphorescent materials for most colors (not used for blue)

Small Molecule vs. Polymer

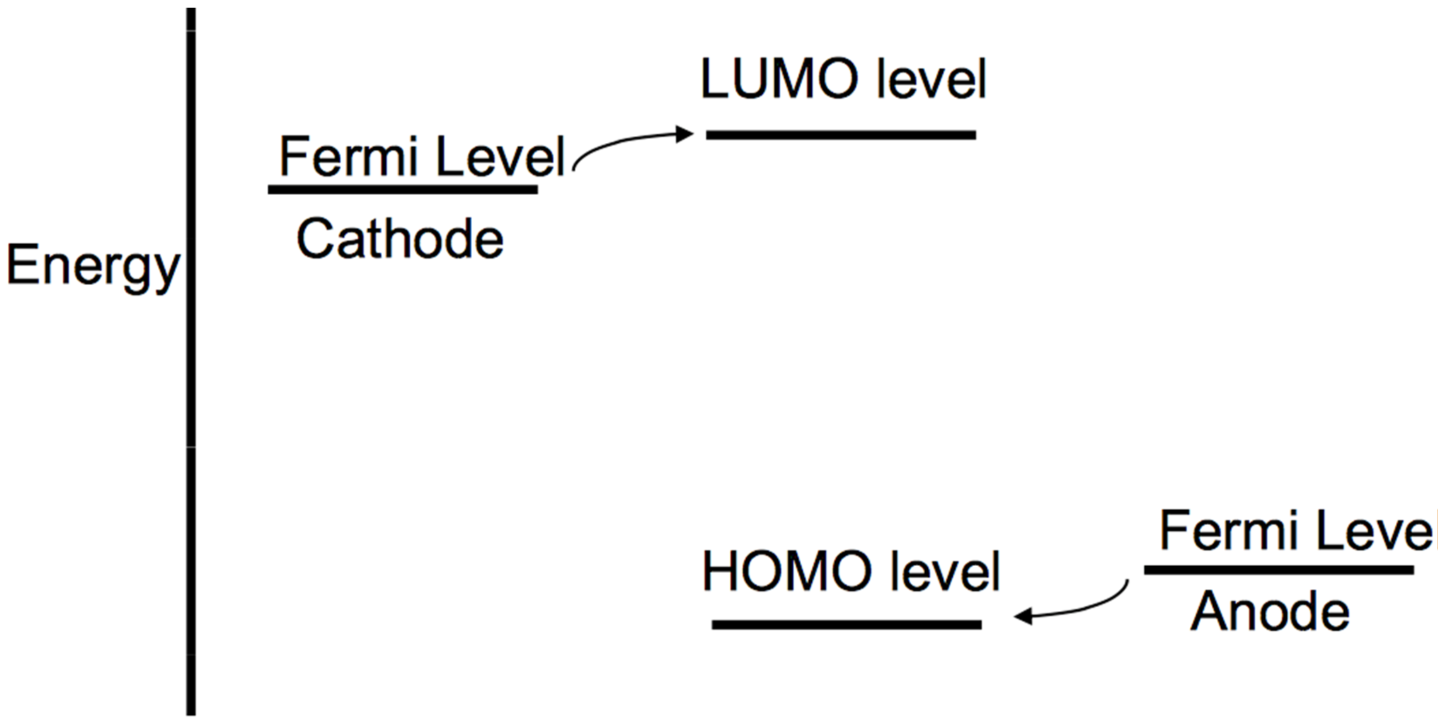
- Small Molecule Structure requires an additional layer for emission unlike Polymer
- Small Molecule has better performance than the Polymer design
- Polymers are easier to print (inkjet process can be used)
- Polymers can have different colors through chaining
  - Small Molecules need to have different dopants
- Small Molecule needs to be deposited onto a Glass Substrate but Polymers can be deposited onto other substrates
  - Polymers can be used for flexible devices because they can be grown on plastics

Organic Materials Used

- SM Electron Transport Layer: Alq3 (Tris(8-hydroxyquinolinato)aluminium)
- SM Hole Transport Layer: *N*,*N*-di(naphthalene-1-yl)-*N*,*N*-diphenyl-benzidene (NPB)
- Polymer Electron Transmission Layer: Polyphenylenevinylene (R-PPV), Polyflourene (PF)
- Polymer Hole Transmission Layer: Polyaniline (PANI:PSS), Polyethylenedioxythiophene (PDOT:PSS)

Other Materials

- Cathode: Low work function metal like LiF, or Al
  - Ensures that the Fermi Energies will be continuous
- Anode: ITO (Indium Tin Oxide)



Future of OLEDs

- Improvements in efficiency and lifespan of blue OLEDs are required for the future
- More companies are investing in technology
- Improvements for OLEDs in Solid State Lighting

QUESTIONS?

Bibliography

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