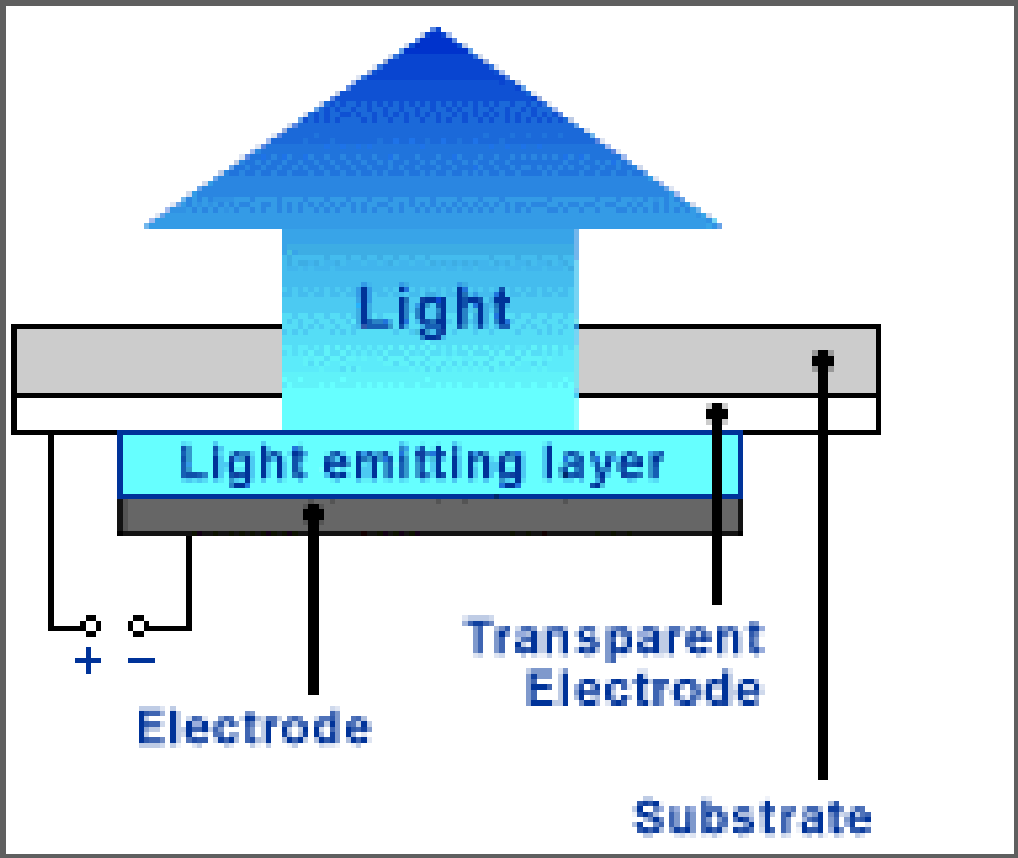
Fabrication of Organic Light Emitting Devices

Technology Overview

- Basic OLED structure



BasicPhysics

OLEDs produce light when current is passed through layer(s) of organic material. Electrons and holes become excited and recombine to form an exciton-particles at an excited state of energy. Light emission results when these excitons decay to the ground state.

Advantages of OLED Technology

- Low cost of production
- Low power consumption (2-10V)
- Very thin devices ~100nm thick
- Large viewing angle (160 degrees)
- High efficiency (40Lumens/Watt)
- Flexibility : substrate may be made of plastic or polymers

Organic materials

Small Molecule OLEDs

	Function	Thickness (Å)	Current (Amps)	Color
Alq_3	ETL	100-400		Green
Bu-PBD	ETL	100	13	Blue
Perilene	ETL/emitting	400*	9	Blue
CuPc	HTL	100-400	12	Blue
TPD	HTL	400	15	Blue
(α)NPB, (α)NPD	HTL	400	12	Blue
DPVBi	HTL/emitting	100-200	12	Blue
CBP	HTL/emitting	400	13	Blue
Aluminum	Anode	1000-3000	35-40	———
Al_2O_3	Buffer	20		———
CsF (or Cs Acetate)	Buffer	20	20	———
ITO	Cathode	1000	———	———

Organic materials contd...

Polymers

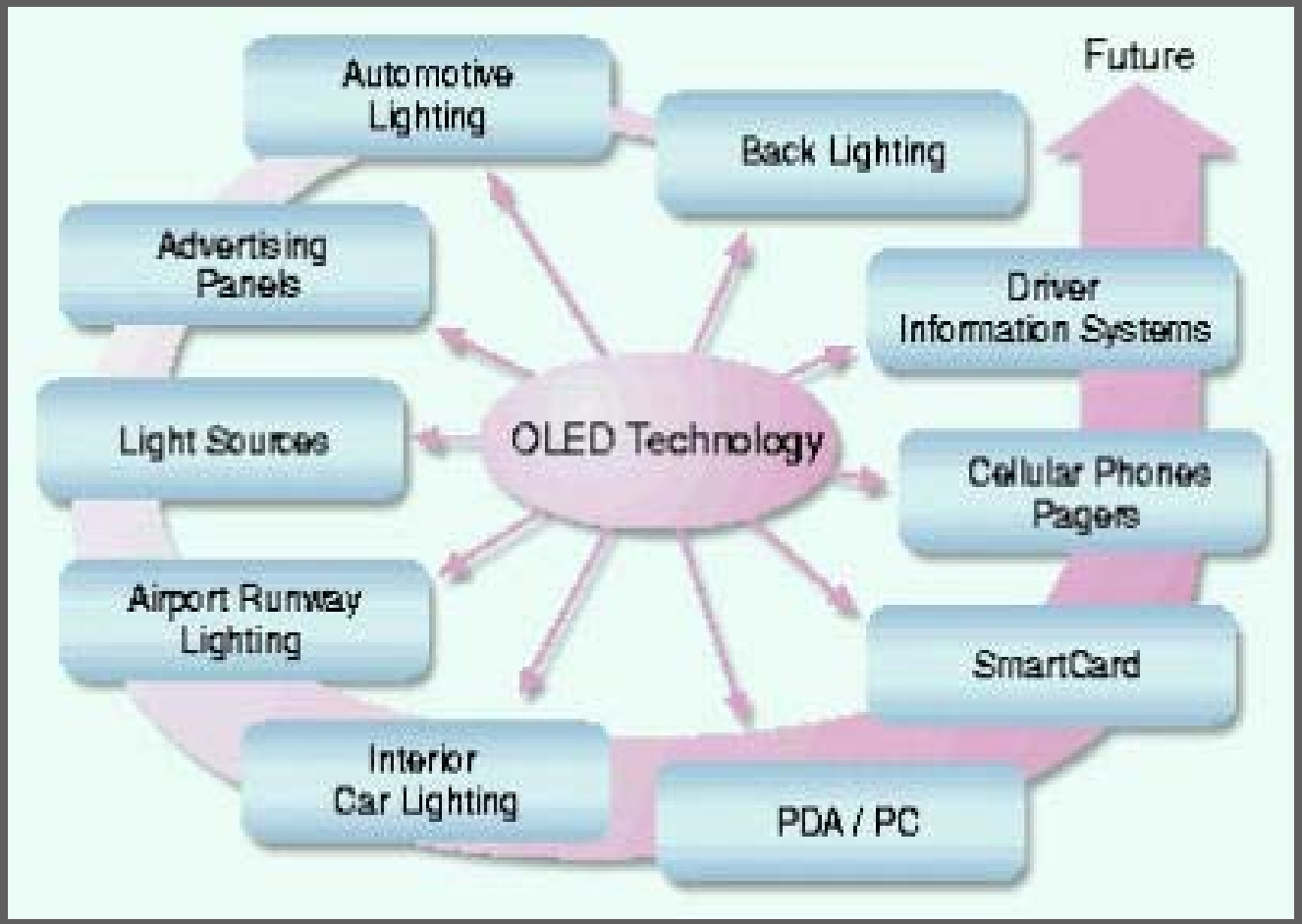
One layer of organic material is used

Materials

PPV: poly paraphenylene vinylene

Dendrimers

Applications of OLED Technology



Fabrication process basics

- Plastic, polymer, or glass substrate (must be clean)
- Deposition of Indium Tin Oxide via CVD
- Deposition of organic layer(s)
- Doping each layer with fluorescent molecules
- Deposition of metal with low work function for anode via sputtering or CVD methods
- Patterning the anode
- Encapsulate the device to prevent exposure to air and moisture

Challenges in fabrication

- Etching of the electrodes is difficult by photolithography costly methods needed because the organic material degrades in any cleaning solution.
- The organic layers must be planar. Uniformity in thickness is desired. Deposition methods have to be precise over a large area.
- Substrate must be very clean.

Small Molecule OLED

Deposition of organic layers

And patterning of electrodes

Deposition Techniques

Two methods used:

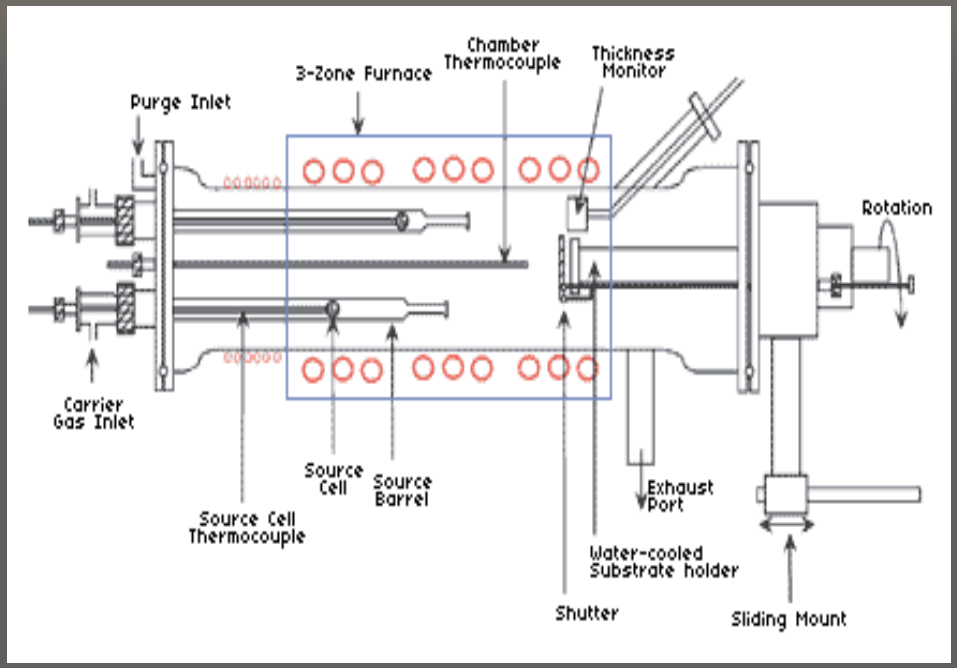
Ultra High VTE (Vacuum Thermal Evaporation)
Organic Vapor Deposition

Ultra High Vacuum Thermal Evaporation:

This method results in a high degree of purity and structural control. However, control of film thickness uniformity and dopant thickness over large areas is difficult

OPVD

The OVPD production process utilizes a carrier gas stream in a hot walled reactor at very low pressure to precisely and Uniformly deposit the thin layers of organic materials.



The Organic compounds are evaporated into this carrier stream prior to deposition. Gas diffusivity is increased at low pressure therefore increasing rates of mass transfer between component streams andto substrate.

Patterning Techniques

Methods of etching the electrodes

Stamping
Shadow masks (Organic layers are deposited through)
Other non-optical lithography methods (costly)

Stamping

produces feature size as small as 12 microns. Pre-patterned metal coated stamp is stamped unto electrode. Metal is then lifted off leaving a pattern. Based on cold welding process. High pressure deforms cathode layer.

The anode may be patterned using chemical solutions and photoresist.

Polymer OLED

Deposition techniques

Polymers may be spin coated onto the ITO surface. Cheap method

Disadvantages:

Short lifetime. Quality degrades.

Changing the chemistry of the polymer can tune the color of an OLED. However, even such simple chemical substitutions can change the device efficiency and reliability in an unpredictable manner.

Conclusion

Questions?