OLED Research of Postgraduate Students in COSDAF, CityU, Hong Kong

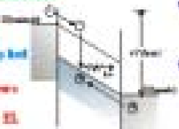
OLED Material design and development

I. Introduction

EL - Electroluminescence

The light emits from an activated media excited by an applied electric field.

Organic materials were used as the active materials in organic EL.



- There are several function materials in OLED: hole-transport material, electron-transport material, emitting-material (include host emitter and dopant emitter)
- Developing of function OLED materials are aimed at improving the color purity, energy efficiency and operation stability.

II. Better Blue OLED Dopant Material by Reduction of Aggregation (TBPe)

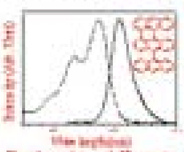
Perylene

TBPe

III. Pure color and high efficient green dopant material(pNNA)

pNNA Device AlQ NPB

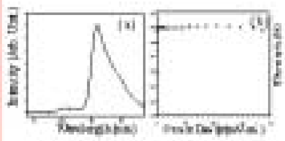
IV. Red dopant material(DpNA,pAAA)



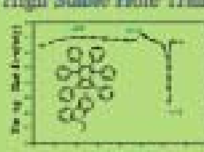
The absorption and PL spectra of pAAA in dilute solution

With the increasing of the driving voltage, the current efficiency almost keeps constant.

The EL efficiency is not very high for display application.



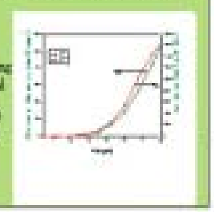
V. High Stable Hole Transport Material(HPCzI)



Hole mobility of HPCzI: up to half of that of NPB.

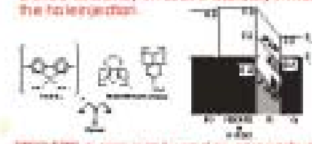
Thermal analysis by DSC (differential scanning calorimeter) shows that HPCzI is very thermal stable.

The device with a configuration of ITO (30 Ω) / HPCzI (60 nm) / AlQ (60 nm) / MgAg (200 nm) showed a green AlQ emission with a current efficiency of 3.5 cd/A, at a drive voltage of 8.8 V and a current density of 20

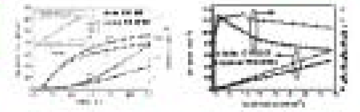


I. Anode Modification in PLEDs

- Ultraviolet Photoemission Spectroscopic study revealed that the low work function Ca led to no electron injection barrier at the PF (blue emitting polymer) interface.
- Device efficiency in PLEDs is basically limited by the hole injection.



- PEDOT:PSS is commonly used as an anode in PLEDs and it has a conductivity of 10 S/cm.
- We found that its conductivity can be increased by 6 times to ~ 20 S/cm upon glycerol incorporation.
- The incorporation of glycerol into the PEDOT:PSS (G-PEDOT) has no observable side effect on the overall electronic structures.
- PLEDs with the configuration of ITO/G-PEDOT/PF/Ca/Al were fabricated so as to study the performance of the G-PEDOT buffer layer.



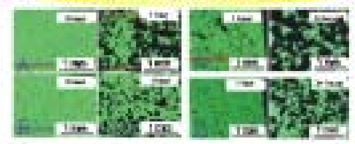
- At a driving voltage of 6 V, the current density in the glycerol-doped device is double that in the undoped device. The brightness of the doped device is more than doubled that of the undoped device.
- At a current density of 20 mA/cm², the doped device shows much higher power and current efficiencies than those of the undoped device.
- The inset of left figure shows the resistance of the ITO/G-PEDOT/Au is about 5 times lower than that of the ITO/PEDOT:PSS/Au device. These results suggest that adding glycerol can increase the conductivity of the PEDOT:PSS layer and the corresponding hole current in the devices.
- It is believed that the device configuration using G-PEDOT as an anode facilitates hole transport, which leads to better balance in the electron and hole currents and improved efficiency.

II. Cathode Modification in SMOLEDs

- Mg:Ag is often used as a cathode in SMOLEDs.
- Practical applications using OLEDs are feasible only if the devices have sufficiently long life time.
- Reaction between cathode and water/oxygen species, i.e. cathode oxidation is one of the causes for formation and growth of dark spots.
- Therefore protection against oxygen and moisture is necessary. Here, a simple method to inhibit the growth of dark spots is proposed by deposition of a metal (a higher E.O.P) on the cathode, e.g. Ca

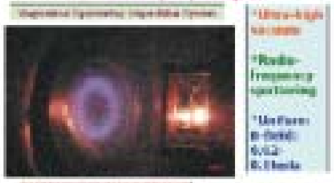
NPB AlQ

Electroluminescent images of type A (w/o Ca) and B (w/Ca) devices at humidity of 95% (left) and 60% (right)



- Radial growth rate α t indicates a diffusion-controlled process.
- Devices with Ca can retard the growth rate of dark spots.
- Since Ca has a electronegative of -2.87 (Mg -2.34 and Ag 0.8 V), Ca preferably corrodes when galvanically couples to the Mg.
- Ca is a sacrificial metal and oxidation was accelerated when Ca was completely consumed.
- The dark spot growth could not be inhibited when other metals were used instead of Ca. Ca not in contact is less effective and the protective function of Ca involved in redox reaction is more significant.

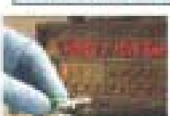
Low Temperature Deposition of Transparent Conductive Oxide (TCO) on plastic substrate and fabrication of Flexible Organic Light-emitting Diode



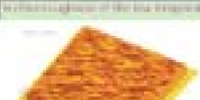
*Ultra-high vacuum

*Radio-frequency sputtering

*Uniform B-field



Optical performance

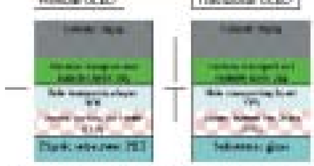


AFM image of ITO on PET (deposited by RT)

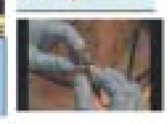
AFM image of ITO on PET (deposited by RT)

Configuration of FOLED and traditional OLED

Flexible OLED | Traditional OLED



Organic and metal layers are deposited on the top of the ITO layer by thermal evaporation.



Advantage of FOLED:

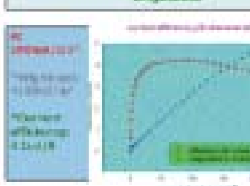
*Very low drive voltage

*Light

*Not fragile

Electroluminescence Performance of FOLED

Current Density Vs Voltage Vs Brightness



Current Efficiency Vs Current Density Vs Brightness

Surface and Interface Studies on Organic Electroluminescent Devices by High Resolution Electron Energy Loss Spectroscopy

HREELS Instrument

Working principle of HREELS

HREELS results on OLED study