Auxiliary Anode on Large-Area Organic Light-Emitting Diode Lighting

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Outline

- Introduction
- Experiment
- Results and Discussion
  - 1. green OLED area of 3x3 cm^2
    - HIL(CuPc) material for large area OLED
  - 2. 6x6 cm^2 area of green OLED
    - Ag and Au auxiliary electrode
    - Luminance uniformity measurement
- Conclusions

Introduction(1)

- Features
  - Low drive voltage
  - Wide view angle
  - Large-area lighting source
  - Flexible
  - Thin and light-weight



Source : Samsung

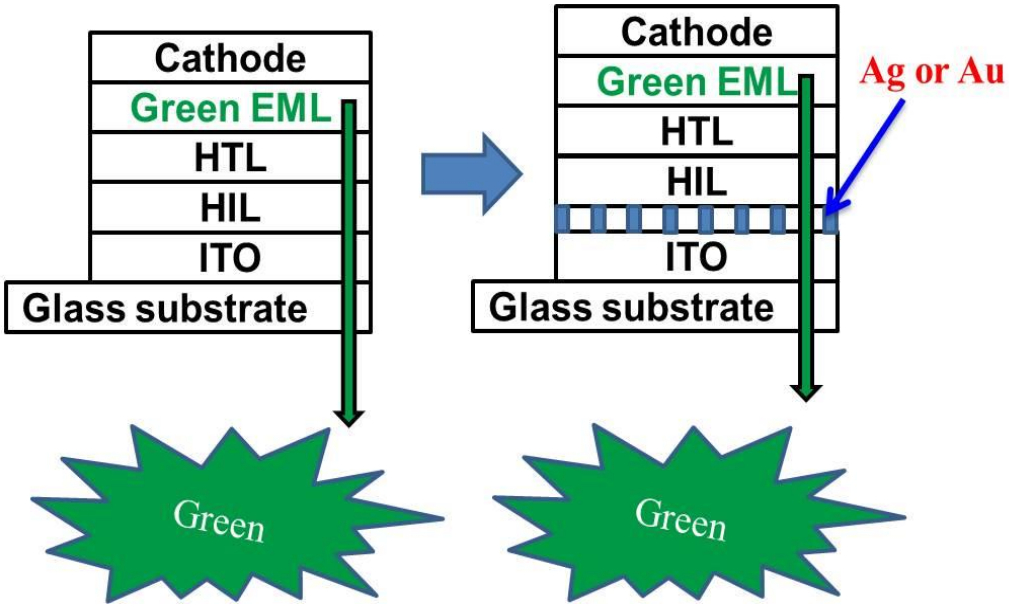


Source : Acuity Brands

- Applications
  - Electronic paper
  - Full-color OLED displays
  - Lighting

Introduction(2)

Device structure



Problems

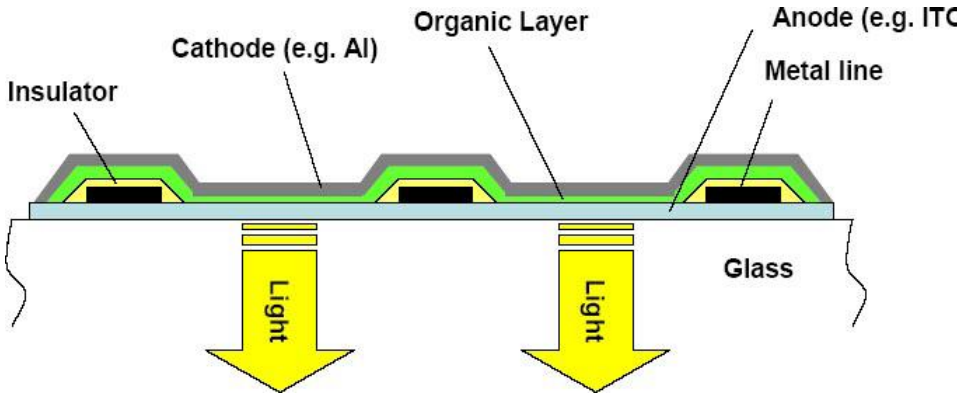
short circuit, hot spot, power loss

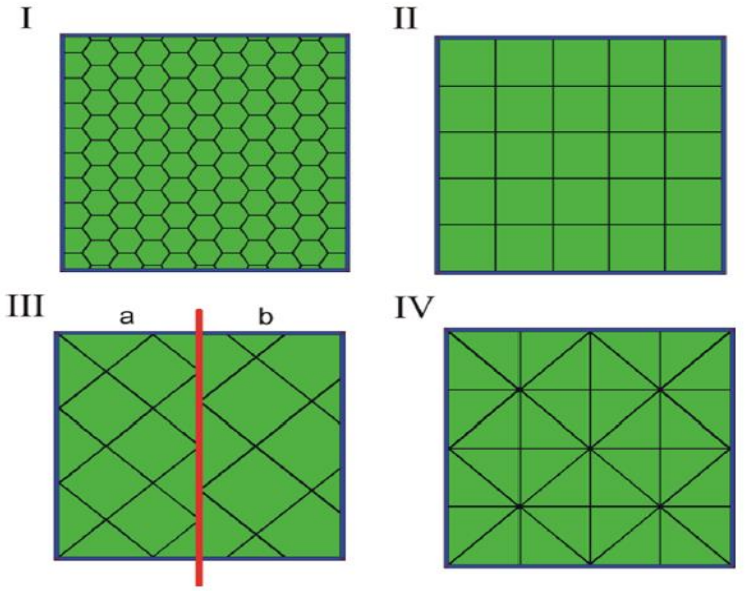
current injected from the panel edges reaches hardly its central region

inhomogeneous light emission and heat distributions

One possibility is to use metal support lines

Introduction(3)





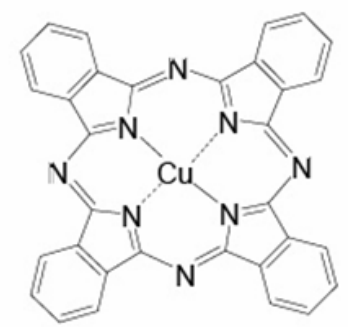
Metal support line integration reduces overall resistance and improves evenness of the light output

Hexagon I
Square II
Square 45°, fine III a
Square 45° III b
Triangle IV

Ref: M. Slawinski et al. Organic Electronics 14 (2013) 2387–2391

J. Park and J. Lee. JOURNAL OF DISPLAY TECHNOLOGY, VOL. 5, NO. 8, 2009

Materials

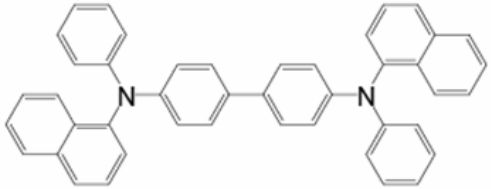


3.6eV

CuPc

5.24eV

Hole injection material

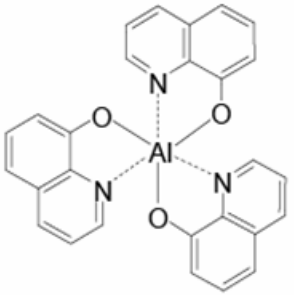


2.4eV

NPB

5.4eV

Hole transport material



3.0eV

Alq_3

5.7eV

Emitting material

Ag

4.3eV

Metal material

Au

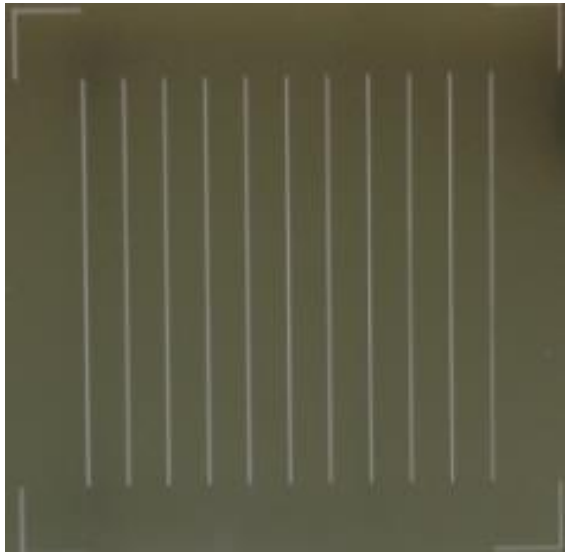
5.1eV

Metal material

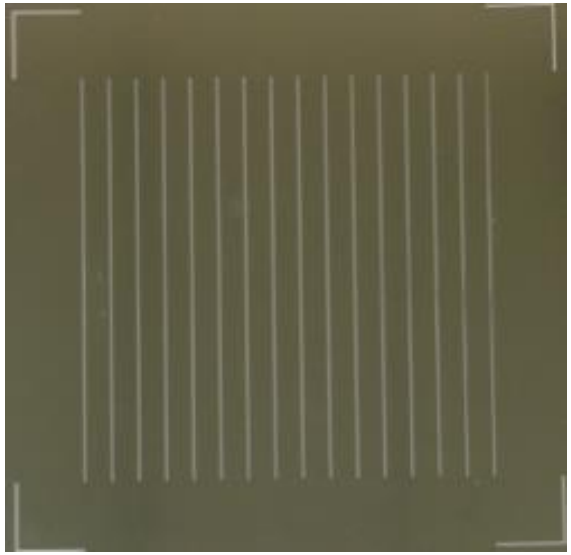
Experiment

Metal mask

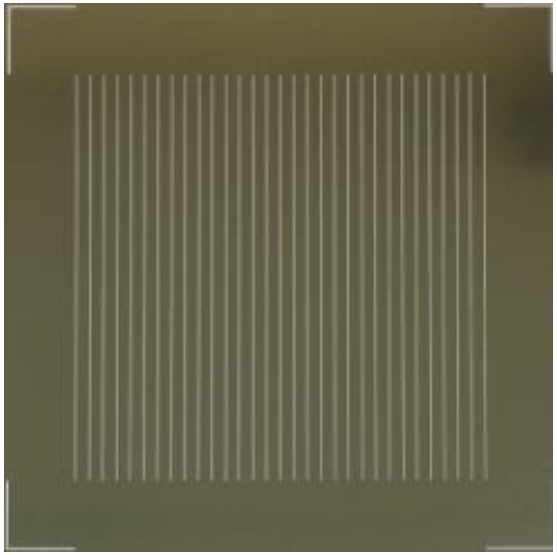
Line width : 1μm



8x8 cm^2, gap 6 mm



8x8 cm^2, gap 4 mm

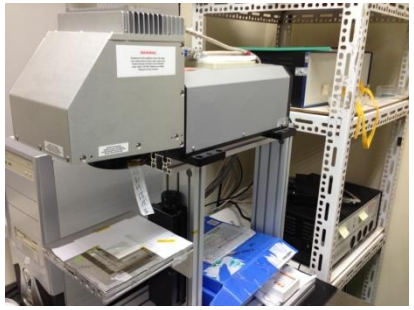


8x8 cm^2, gap 2 mm

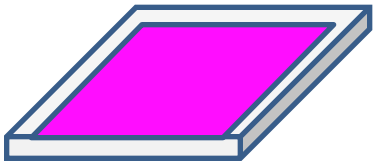
*Light emission area : 6x6 cm^2

Experiment

Laser ITO pattern



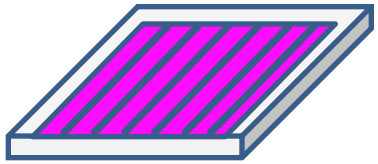
Clean substrate (acetone ➔ isopropyl alcohol ➔ DI Water)



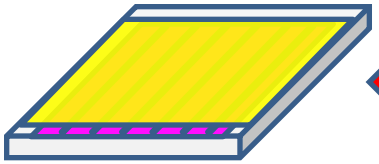
UV-ozone (Time : 300s)



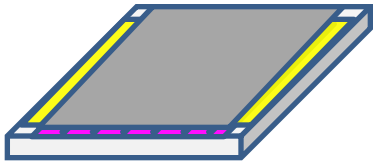
Auxiliary Metal Evaporation (Ag or Au)



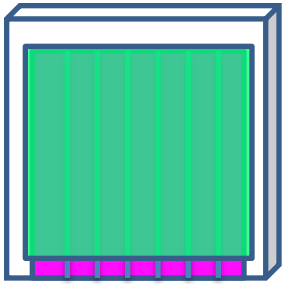
Organic Materials Evaporation (CuPc, Alq_3 , NPB)



Cathode Metal Evaporation (LiF, Al)



Measurement (I-V, Luminance)



Results and Discussion

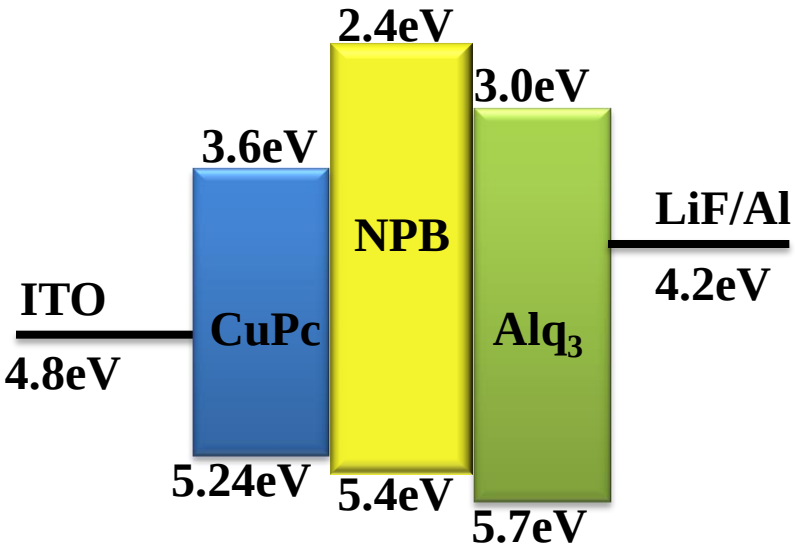
1. green OLED area of 3x3 cm^2

- HIL(CuPc) material for large area OLED

2. 6x6 cm^2 area of green OLED

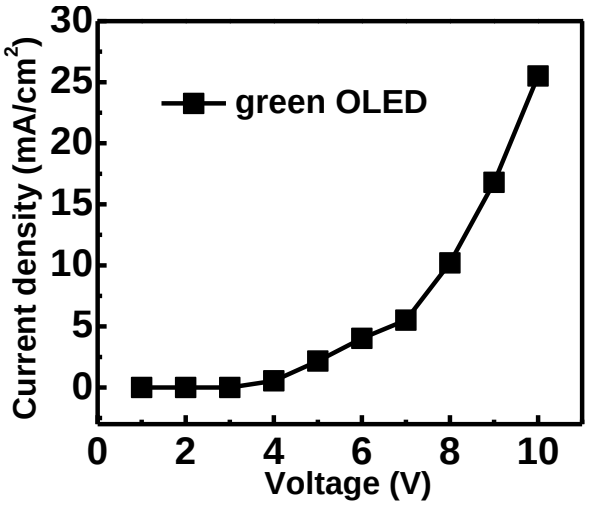
- Ag and Au auxiliary electrode

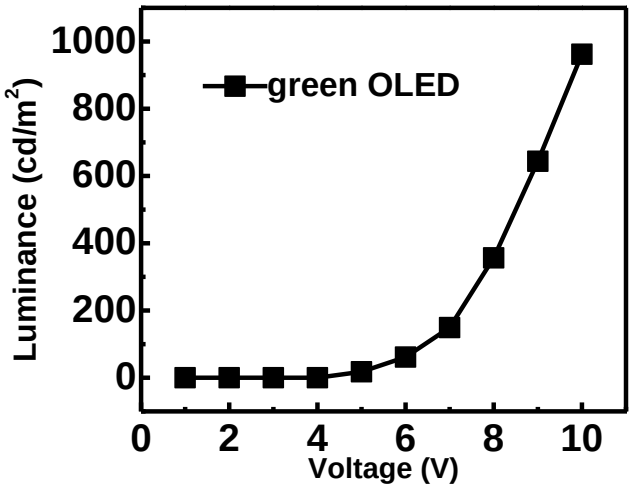
- Luminance uniformity measurement

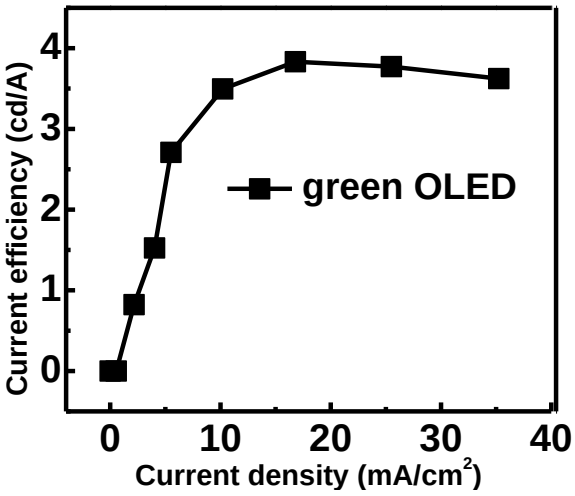


Area (3x3cm^2) *Unit：nm*

Device	HIL (CuPc)	HTL (NPB)	EML (Alq_3)	EIL (LiF)	Cathode (Al)
C-1	10	100	60	0.8	150







@20mA/cm² **Area (3x3 cm²)**

Device	Voltage (V)	Luminance (cd/m²)	Yield (cd/A)
A	10.5	418	2.09

Using this structure：

ITO / CuPc(10nm) / NPB(100nm) / Alq_3(60nm) / LiF(0.8nm) / Al(150nm)

- **Driving Voltage： 10.5 V** ***@100 cd/m²***
- **Luminance： 418 cd/m²** ***@20m A/cm²***
- **Yield： 2.09 cd/A** ***@20m A/cm²***

Results and Discussion

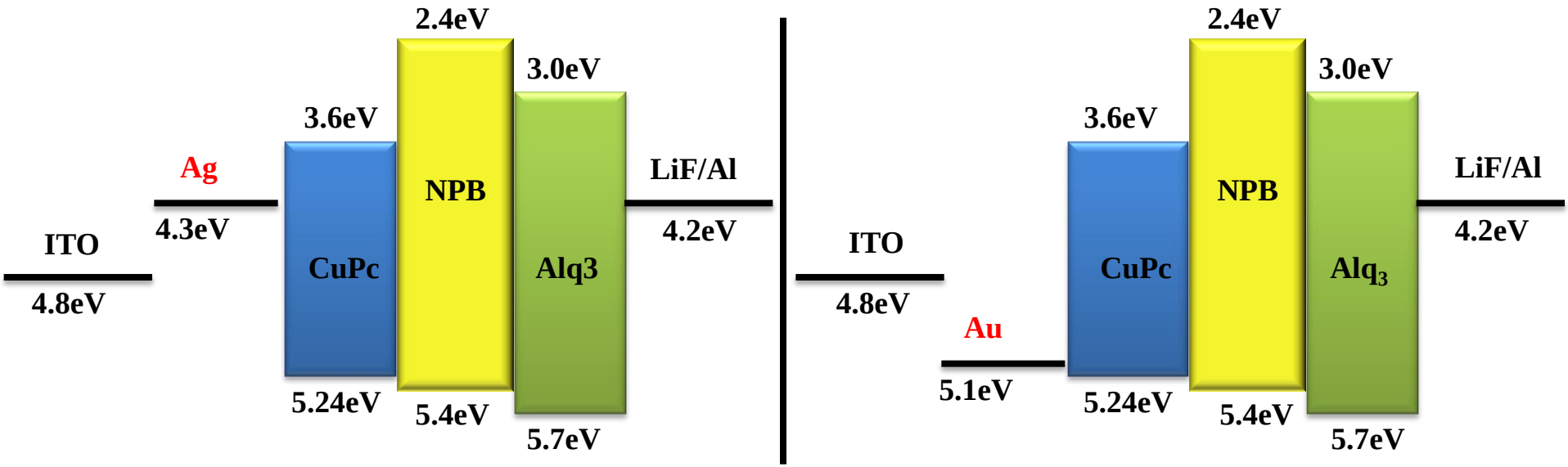
1. green OLED area of 3x3 cm^2
   - HIL(CuPc) material for large area OLED

2. 6x6 cm^2 area of green OLED

- Ag and Au auxiliary electrode

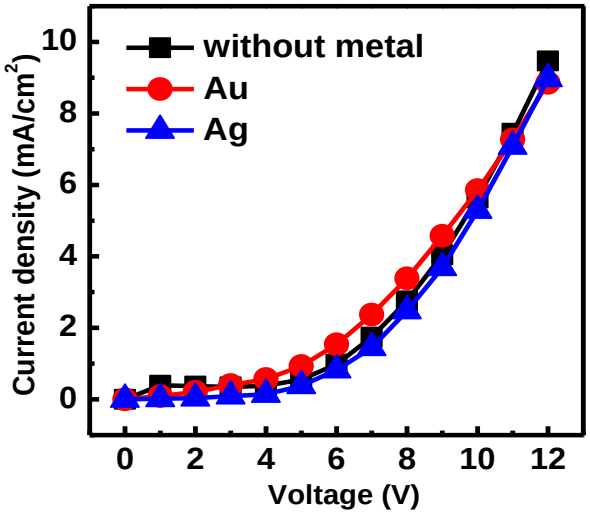
- Luminance uniformity measurement

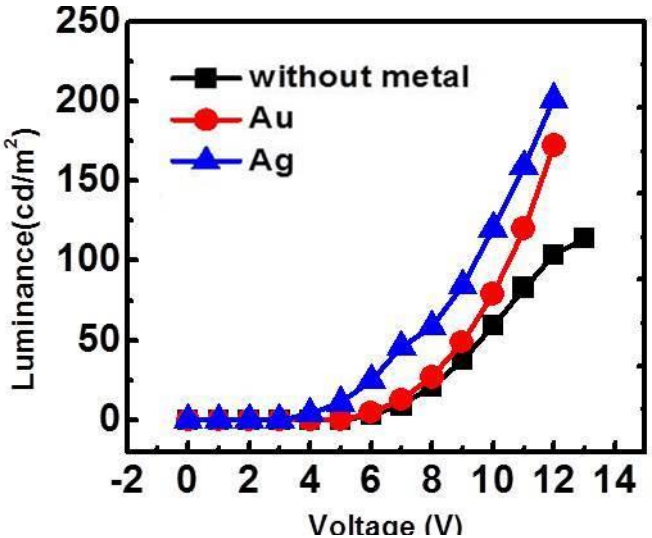
Ag and Au auxiliary electrode

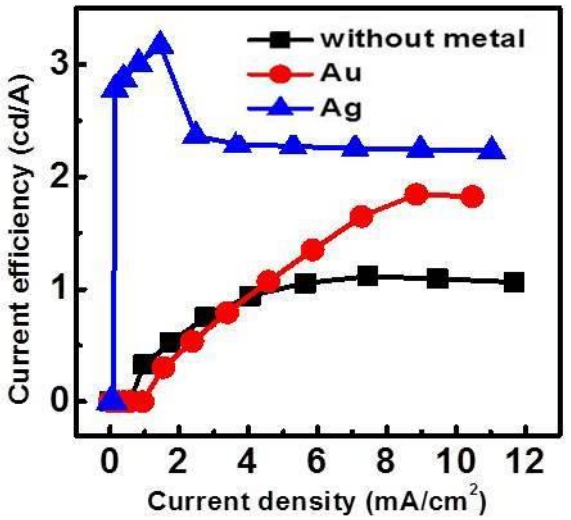


Area (6x6 cm^2) *Unit：nm*

Aus.anode (15nm)	Gap	HIL (CuPc)	HTL (NPB)	EML (Alq_3)	EIL (LiF)	Cathode (Al)
X	6 mm	10	100	60	0.8	150
Au						
Ag						





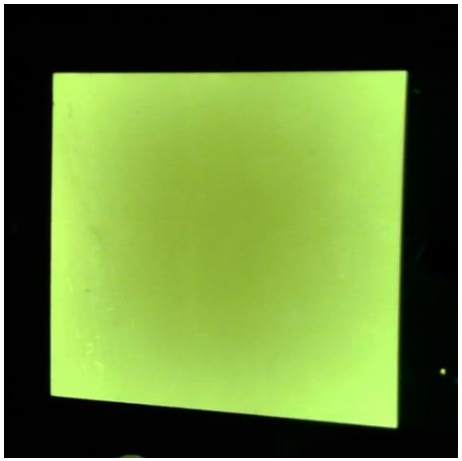


Area (6x6cm²) *@10 mA/cm²*

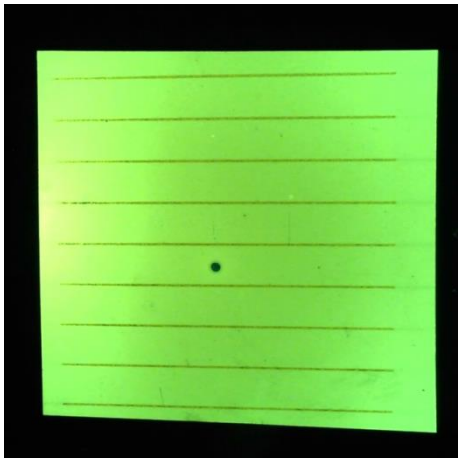
Aus. anode (15nm)	Voltage (V)	Luminance (cd/m²)	Yield (cd/A)
without metal	11.9	103	1.03
Au	10.6	172	1.72
Ag	9.5	223	2.23

- ◆Driving Voltage : 11.9V ➔ 9.5V
- ◆*@100 cd/m²*
- ◆ Yield：1.03cd/A ➔ 2.23 cd/A *@20 mA/cm²*

※Ag ➔ Yield increase
➔ drive voltage decrease



(a) ITO



(b) Au Grid



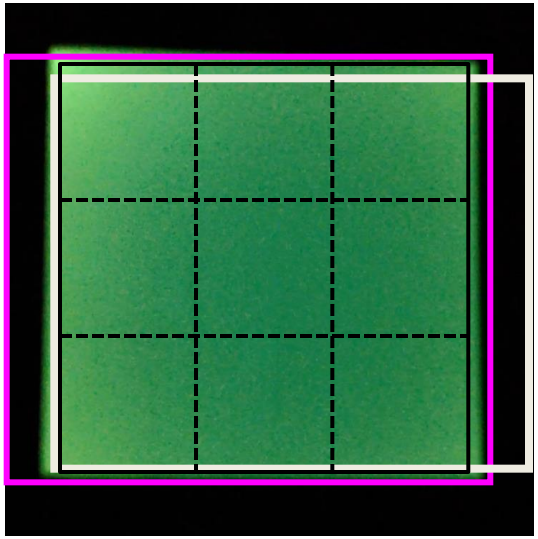
(c) Ag Grid

Results and Discussion

1. green OLED area of 3x3 cm^2
   - HIL(CuPc) material for large area OLED

2. 6x6 cm^2 area of green OLED
   - Ag and Au auxiliary electrode
   - **Luminance uniformity measurement**

Area (6x6 cm²) at 8 V

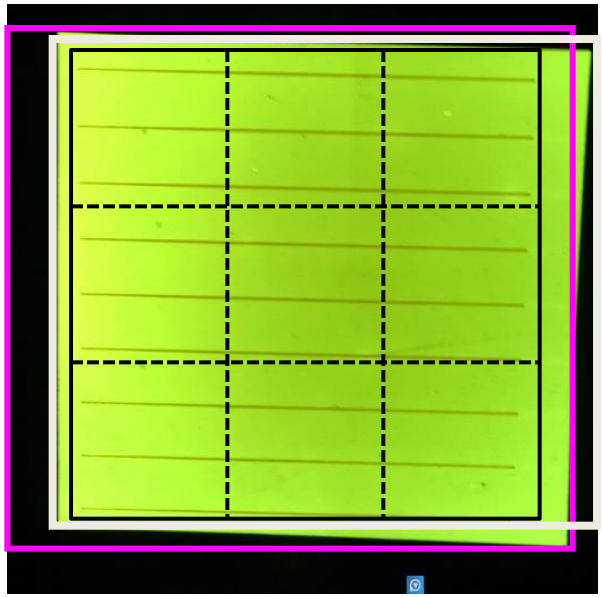


ITO

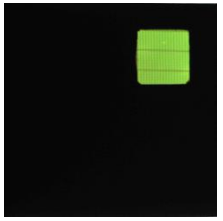
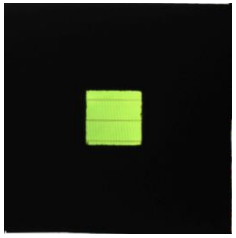
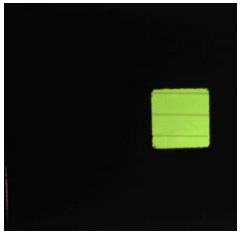
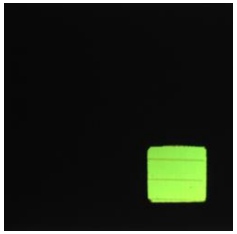
100% 70cd/m²	72.9% 51cd/m²	90% 63cd/m²
94.3% 65cd/m²	75.7% 53cd/m²	84.3% 59cd/m²
97.1% 68cd/m²	93.9% 61cd/m²	85.7% 61cd/m²

※ **Highest luminance : 100%**
※ **Lowest luminance : 72.9%**
※ **Average luminance: 87.5%**

Area (6x6 cm²) at 12 V



Ag gap 6 mm

87%  202cd/m²	90.9%  211cd/m²	84.5%  196cd/m²
89.7%  208cd/m²	87.5%  203cd/m²	85.8%  199cd/m²
100%  232cd/m²	94%  218cd/m²	88.8%  206cd/m²

※ **Highest luminance : 100%**
※ **Lowest luminance : 84.5%**
※ **Average luminance: 94.1%**

Conclusions

Fabrication large-area green OLED

Using this structure：area (6x6cm^2)
ITO/Ag(15nm)gap(6mm)/CuPc(10nm)/NPB(100nm)/Alq_3(60nm)/LiF(0.8nm)/Al(150nm)

- Optimize gap 6 mm ➔ Ag
- Driving voltage : 11.9V ➔ 9.5V *@100 cd/m^2*
- Yield：1.03cd/A ➔ 2.23 cd/A *@20 mA/cm^2*

Luminance uniformity measurement : area (6x6 cm^2)

- ITO average luminance ➔ 87.5%
- ITO/Ag 6 mm average luminance ➔ 94.1%
- Increased everage luminance ➔ 6.6%

- An optimized auxiliary metal is Ag with separation distance of 6 mm
- The low sheet resistance and high transparency of the ITO/Ag lines electrode
- Higher luminance homogeneity caused by a higher conductivity of the metal lines structures as a consequence of a larger cross section area

Thanks for

your attention ~