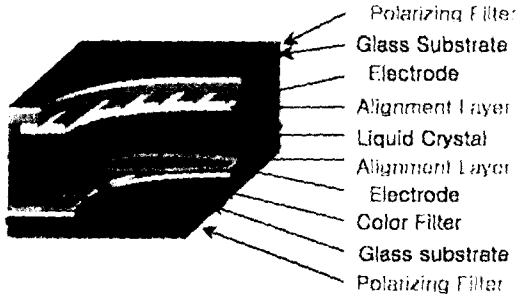
The Present Status and Future Prospects of Organic EL Display

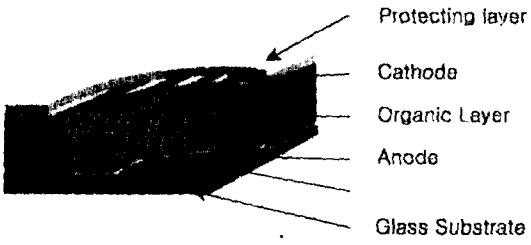
Young Kwan Kim
Center for Organic Materials and Information Devices(COMID)
Hongik University

OUTLINE

1. BASIC PRINCIPLE
2. PRESENT STATUS
3. PROGRESS OF PRODUCTS
4. KEY ISSUES TO BE SOLVED
5. FUTURE PROSPECTS

Characteristics of Organic ELD



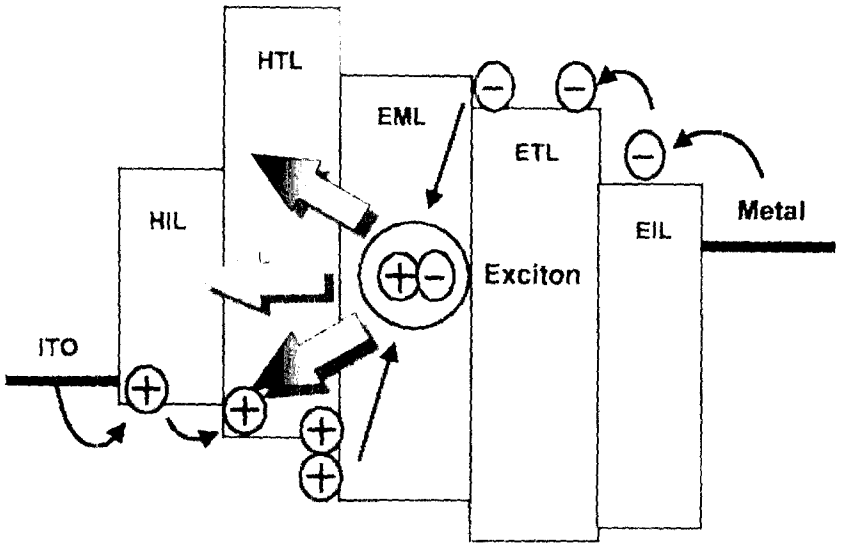


LCD **Organic EL**

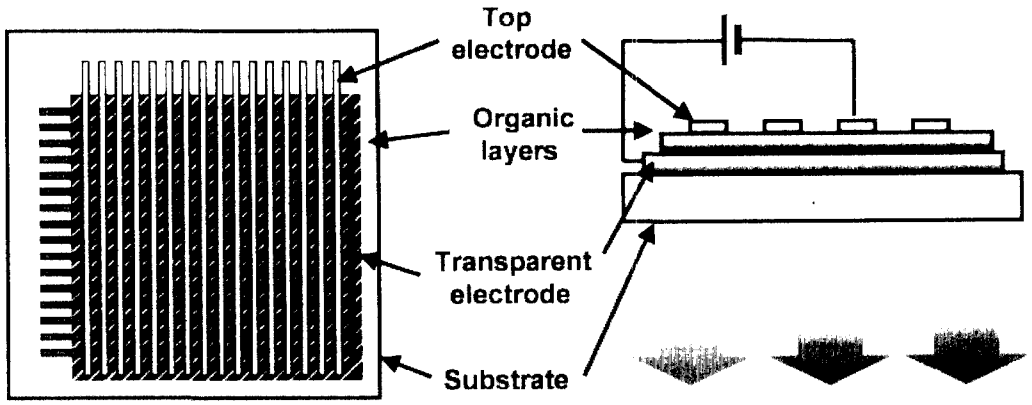
Advantages of OELD

- **Self light emitting characteristics**
- **Fast response, Large viewing angle, High contrast, Wide temp. range, Very thin**
  → PM OELD has superior than AM LCD up to 10"
- **Cost merit of OELD**

Energy Band Diagram of Organic ELD



Typical Structure of Passive Matrix Organic EL Display



Top view

Side view

Manufacturing Process of Organic ELD

Image Process
- ITO electrode
- Supplementary electrode
- Cathode separator

↓

Film Formation Process
- Organic films for RGB
- Top metal electrode

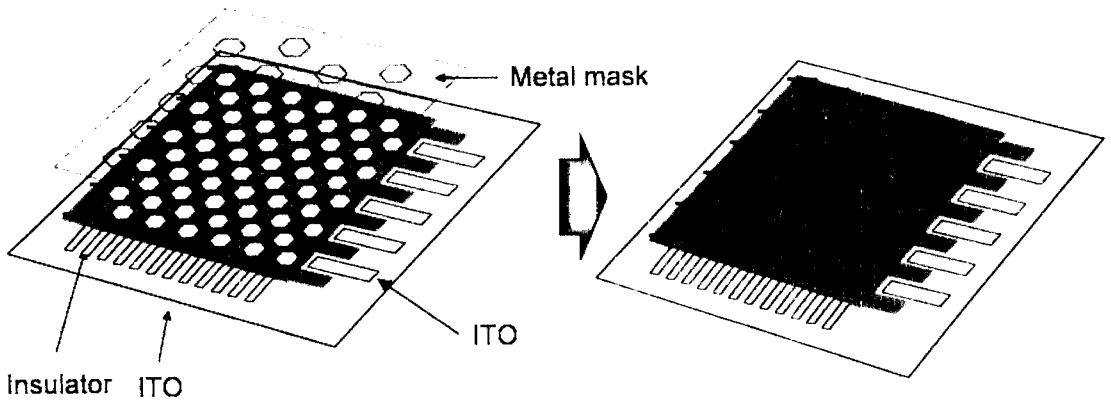
↓

Encapsulation Process
- Sealant coating
- Metal can
- UV curing of sealant

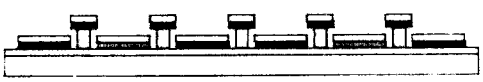
↓

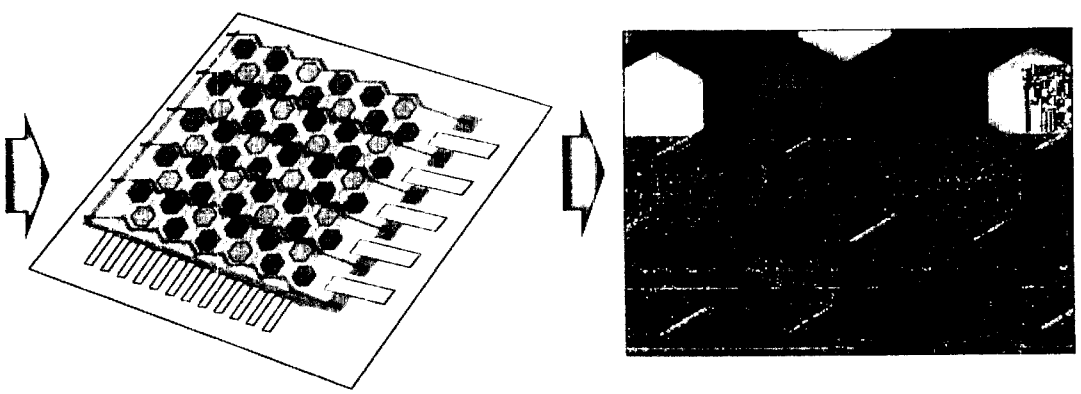
Module Process
- Attaching driving circuit

Typical Sub-Pixel Patterning Process of Organic EL Display



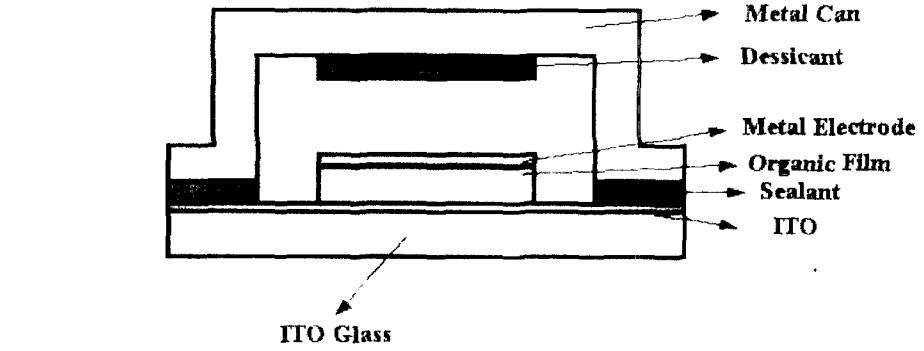
Typical Metal Patterning Process of Organic EL Display

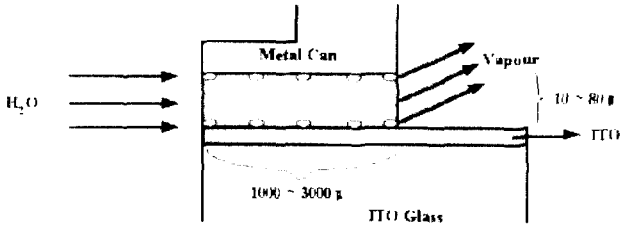




Ref. LG 전자 발표자료

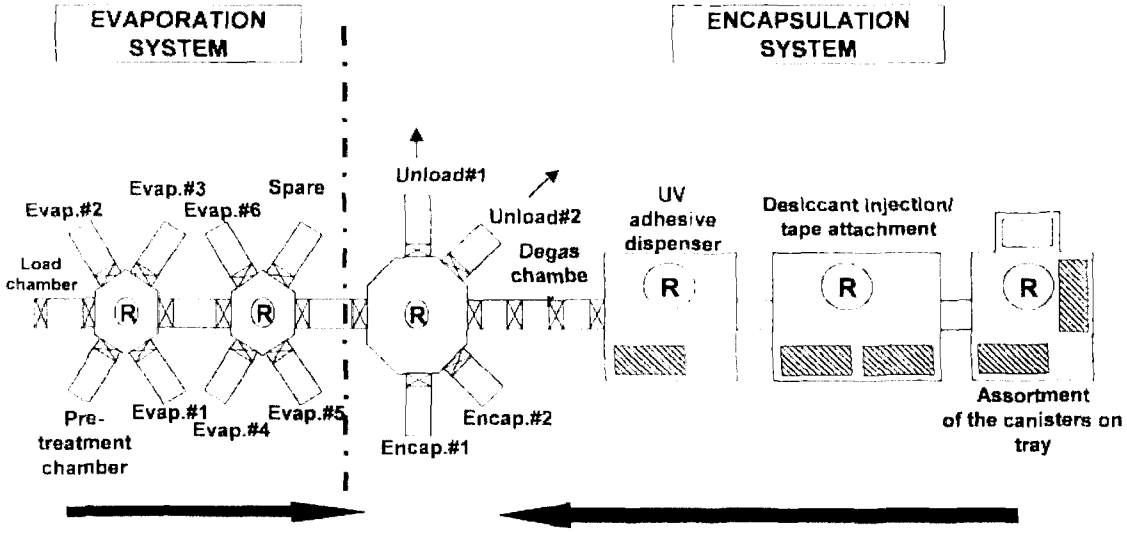
Current Encapsulation Method for OELD





- **Coating uniformity**
- **Lower shrinkability**
- **Low H_2O permeability**
- **Adhesion to metal**
- **Rapid low temp. curing**

Current OELD Mass Production System



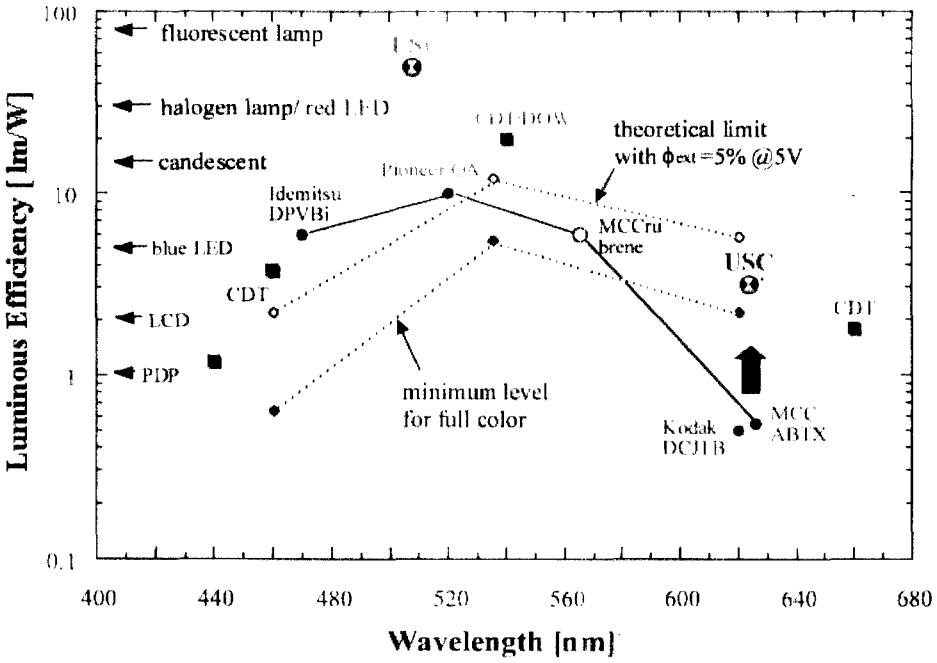
Current Status of Organic EL Display

Issues	Target	Current Status	Future Trends
Efficiency	Blue: 1 [lm/W] Green: 6 Red: 3	6 (Idemitsu) 22 (CDT / COVION) 1.8 (CDT)	small molecule vs. polymer red: efficiency, color purity low voltage operation
Stability	lifetime >10,000 hours @100cd/m²	B: 20,000 (Idemitsu) G: 50,000 (Kodak) R: 20,000 (Kodak) Y: 20,000 (Sanyo) W: 50,000 (TDK)	thermal stability (>100°C) high duty operation efficient white interface control ITO substrate
Full Color	patterning method	blue/CCM (Idemitsu) white/CF(Mitsubishi, TDK) RGB side by side (Pioneer, NEC)	ink jet printing photobleaching
Driving Scheme	passive matrix	product by Pioneer (Green, Multi) 5"-QVGA full color (Idemitsu, Pioneer, NEC)	gray scale control dynamic operation-low voltage effect of negative bias
	active matrix	5"-QVGA (TDK; HT poly-Si) 2.4" (Sanyo; LT poly-Si)	low temperature poly-Si: cost constant-current operation
Fabrication Process	cathode patterning encapsulation vacuum deposition	cathode separator drying agent multi-chamber system	improved encapsulation in-line system repairing technology

Small Molecules *vs* Polymers

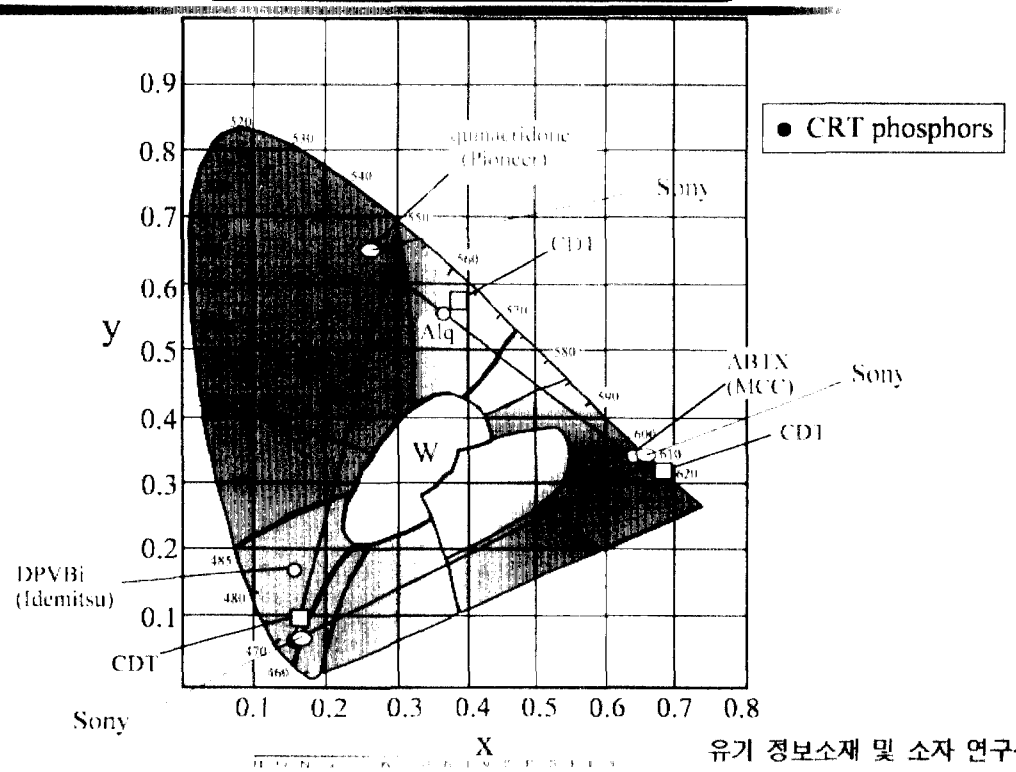
Issues		Small Molecule	Polymer
efficiency	B	3.9[cd/A] (Pioneer); 6 [lm/W] (Idemitsu)	1.5[cd/A] (Philips); 1[lm/W] (CDT/Dow)
	G	16[cd/A]; 10 [lm/W] (Pioneer) 28[cd/A]; 19 [lm/W] (Princeton Univ.)	[illegible]
	R	2.6[cd/A] (Pioneer); 0.6 [lm/W] (MCC)	1.8 [lm/W] (CDT/Dow); 0.5 [cd/A] (Philips)
	W	4 [lm/W] (TDK); 2.9 [lm/W] (MCC)	1.7 [lm/W] (CDT/Dow)
voltage		4V @100cd/m² -->3V (Yamagata Univ.)	2.6V @100cd/m²
stability		- lifetime : >10,000 H (except for B) - thermal: 85°C; voltage rise ? - degradation: crystallization, interdiffusion	- lifetime : >10,000 H (except for B and W) - thermal: 70-80°C; small voltage increase - degradation: photo-oxidation (PPV); PF?
full color		White/CF, Blue/CCM, shadow mask	White/CF, ink jet printing
area multi color		shadow mask	broad EL/filter, printing?
driving scheme		passive, active matrix	
panel process		cathode separator/shadow mask	cathode separator/shadow mask *interconnect?
application		automobile->mobile phone->AV, PDA	mobile phone, segmented
future		in-line deposition, cost	control of impurity, capping terminal group

Comparison of Organic ELD Efficiency



유기 정보소재 및 소자 연구센터

CIE Chromaticity of OLED



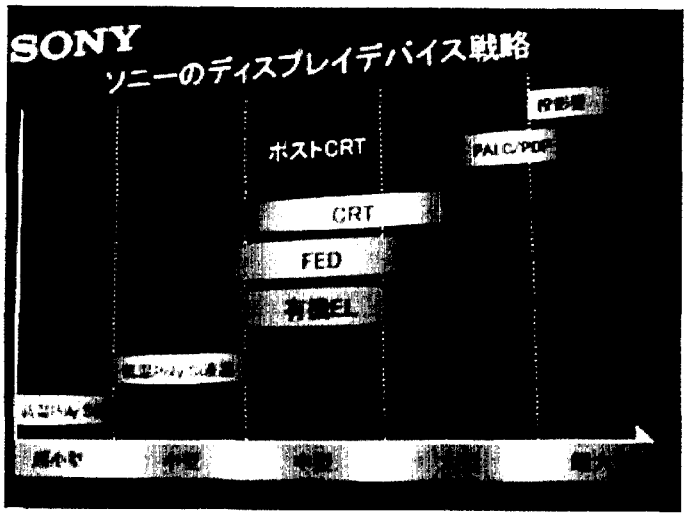
유기 정보소재 및 소자 연구센터

Sony Develops World's Largest Full Color Organic EL Display(13" diagonal)

Feb. 7, 2001

유기 정보소재 및 소자 연구센터

Post CRT is Organic EL Display?

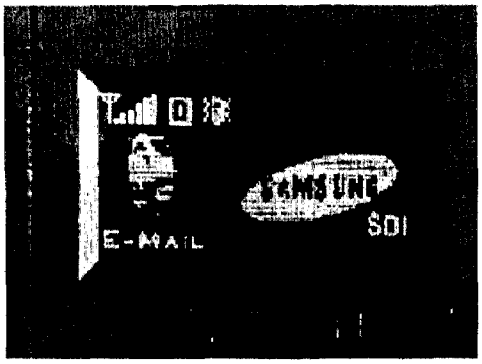


- **poly-Si TFT LCD: Mobile Phone & PDA**
- **Organic ELD : Medium, Large devices**

유기 정보소재 및 소자 연구센터

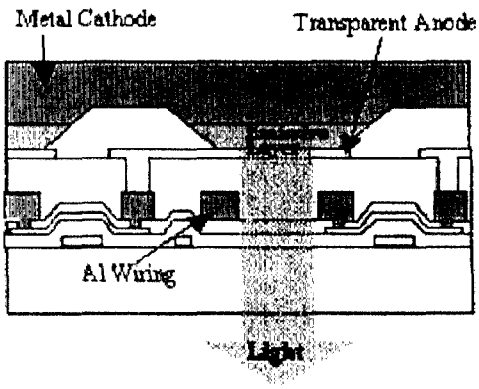
Recent Progress of OELD in Samsung SDI

- Material: Small molecules
- Driving scheme: Passive matrix
- Size: 5.7"
- Resolution: QVGA
- Colors: Full color
- Grey: 64
- developed at 09/'99

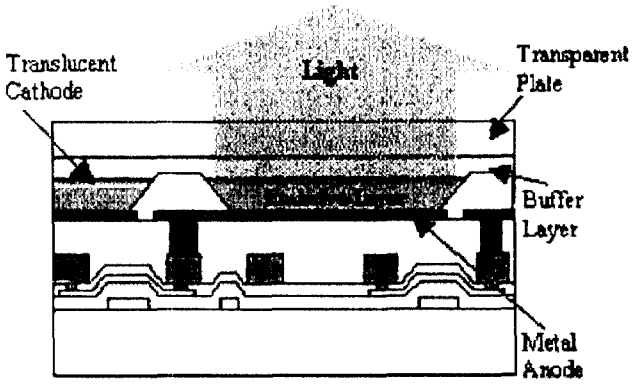


- Material: Small molecules
- Driving scheme: Passive matrix
- Size: 1.6"
- Resolution: 128*76
- Colors: 2colors
- Grey: 64
- Commercially available at 07/'01

Top Emissive Structure of World Largest Full Color Organic EL Display

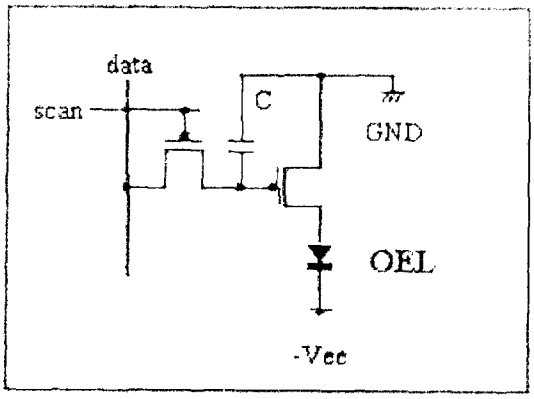


Conventional Structure

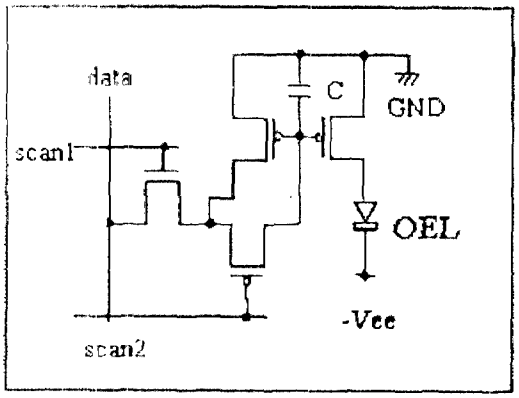


Top Emission Structure

Driver Circuit of World Largest Full Color Organic EL Display

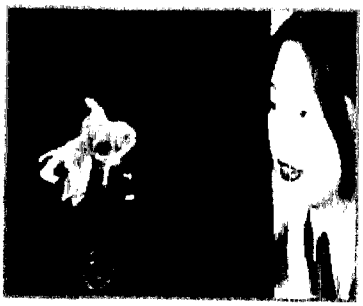


Conventional Voltage-Writing Driver Circuit

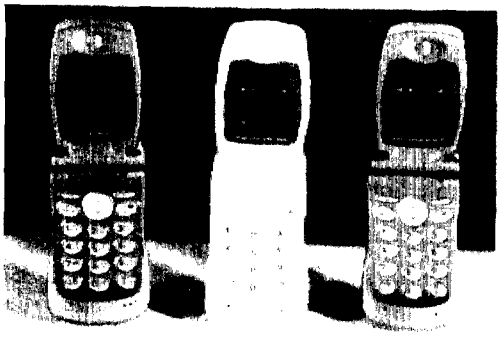


Current Mode Programmed Pixel-Driver Circuit

Recent Progress of OELD in LG Elec.



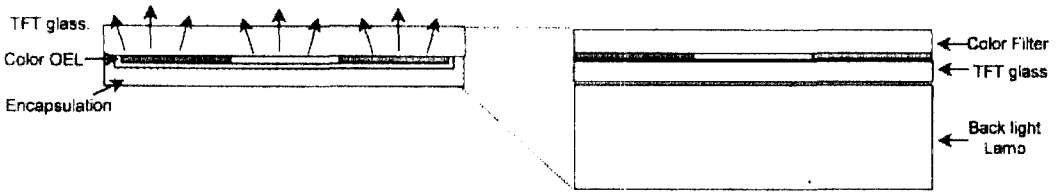
- Mat.: Small Molecules
- Driving scheme: PM
- Size: 8”
- Resolution: QVGA
- Colors: Full color
- Developed at 10/’99



- Mat.: Small Molecules
- Driving scheme: PM
- Size: 1.6”
- Developed at 8/’20

Comparison Between TFT-OELD and TFT-LCD

TFT-OLED(Self Emitting Type) **TFT-LCD(Transmissive Type)**



Performance Comparison

	Color	*Weight*	*Thickness*	*Bright-ness*	*Viewing angle*	*Response time*	*Power consumption*
TFT- OLED	○	◎	◎	○	○	◎	○
TFT- LCD	○	○	○	○	△	○	○

LG Philips LCD

How To Improve The Efficiency of OELD?

- **Power Efficiency, Full Colorization/High Resolution, and Lifetime must be improved!**

Power Efficiency: ↑ ⟷ **Lifetime : ↑**

- **Several ways to improve efficiency:**
  - **Using Phosphorescence**
  - **Lowering Injection Barriers**
  - **Other Methods**

More Technical Issues in OELD

- **CVD type Process may be required**
  - **thermal evaporation process is not adequate for large area mass production**
- **Thin film encapsulation technique is required**
  - **metal can encapsulation technique is too primitive and expensive**
- **Si-based TFT may be replaced by Organic TFT**
  - **Si TFT process is too expensive**

OELD Roadmap

Item	1999	2000	2001	2002	2003	2004
Material	developing full color materials					
		triplet device - 50 lm/W				
Device	ink jet printing technology					
Panel	multi color passive matrix		mass production		full color active matrix	
				low temperature poly-Si		
Market	automobile/mobilephone			audio-visual		lighting

Mitsubishi