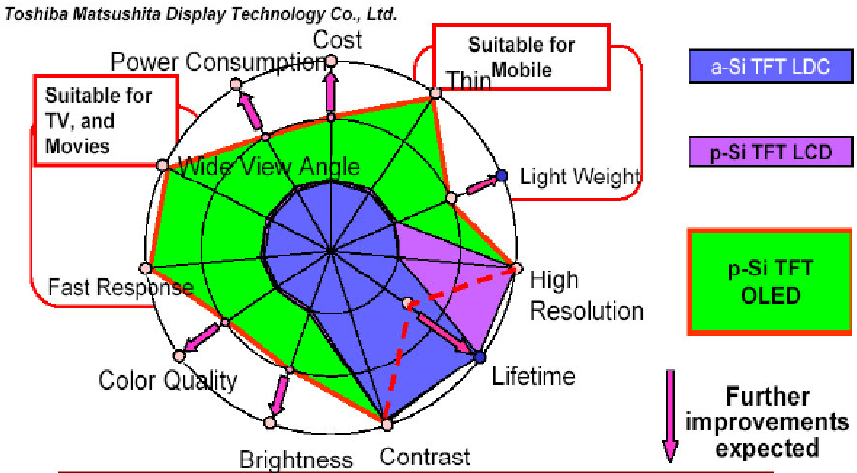
전자물리특강: OLED Panel Testing

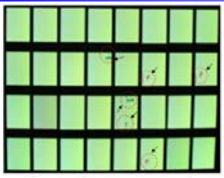
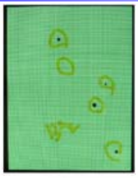
Changhee Lee
School of Electrical Engineering and Computer Science
Seoul National Univ.
chlee7@snu.ac.kr

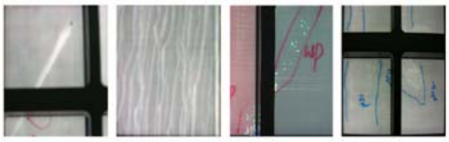
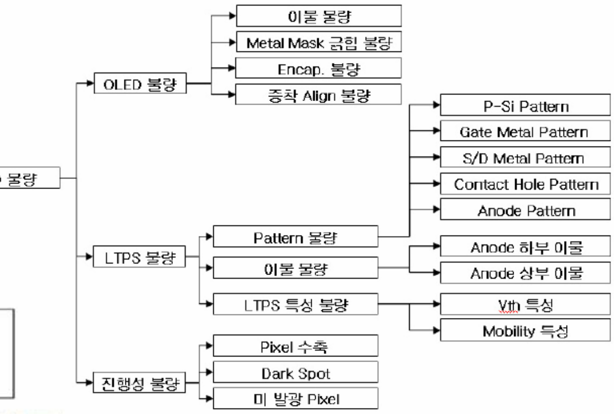
OLED Performance



OLEDs potentially provide high performance display

AMOLED 불량원인

양중환, 윤종근, 한국정보디스플레이학회지, 8 (5), 11 (2007)

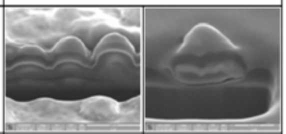
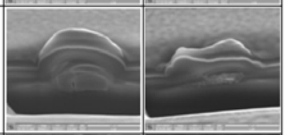
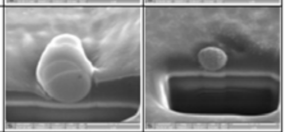
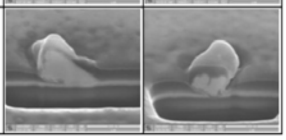
AMOLED 불량별 발생원인

불량 분류		발생 공정	검출 방법	신뢰성에 미치는 영향
OLED	공정 이물	유기물 성막	점등 검사	Dark spot, 암점
	Mask 긁힘	EML 증착	점등 검사	암점, 화소 수축
	Encap. 불량	Encapsulation	점등 검사	내충격성, 수명, 화소 수축
	Align 불량	EML 증착	점등 검사	색변화 (색재현율 감소)
LTPS	Pattern 불량	Photo	Pattern 검사	휘선, 암선
	발광부 이물		점등 검사	암점
	특성 불량		점등 검사	화질 uniformity (줄무늬)
진행성	화소 수축	Encapsulation	가속 실험	휘도 및 수명 저하
	Dark spot		가속 실험	발광면적 감소, 휘도 및 수명 저하, 암점
	미발광 화소	Photo, 증착	가속 실험	암점

암점(BP, black point) : 전극간 short에 의해 발광하지 않는 화소
암선(BL, black line) : 배선 전극 불량에 의해 scan, data line 전체가 발광하지 않는 불량
휘점(WP, white point) : TFT 또는 OLED 불량에 의해 항상 밝게 빛나는 화소
휘선(WL, white line) : 배선 전극 불량에 의해 scan, data line 전체가 항상 발광하는 불량
Pixel 수축 : 외부 산소, 수분 침투에 의한 pixel 발광면적 감소

양중환, 윤종근, 한국정보디스플레이학회지, 8 (5), 11 (2007)

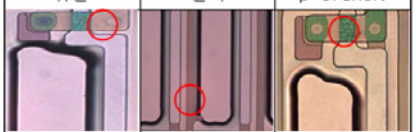
AMOLED 불량: LTPS 기판

LTPS성	불량 형상
ITO 하지막	
ITO하부 SUS성	
ITO 상부 metal성	
ITO성 이물	

LTPS 기판성 이물	발생 원인 및 영향	대책
ITO 하지막	▪ ITO 하부 layer에 나타나는 carbon성 이물에 의한 상부 morphology 불량 ▪ Anode - cathode 간 누설전류 증가 및 단락에 의한 발광불량의 원인	이물 관리
ITO 하부 SUS성	▪ ITO 하부 layer SUS 등의 metal 성 이물에 의한 상부 morphology 불량 ▪ Anode - cathode간 누설전류 증가 및 단락에 의한 발광 불량의 원인 ▪ Gate metal 공정시 발생	
ITO 상부 metal성	▪ ITO 이후 공정 중 metal layer 형성 공정에서 발생한 metal 잔류물 ▪ ITO 이후 공정의 부유성 이물 중 metal 성분 이물에 의한 것으로 short 유발	
ITO성 이물	▪ ITO 성막 중 발생된 ITO 이물 (poly ITO, 성막 중의 splash 등) ▪ Anode - cathode간 누설전류 증가 및 단락에 의한 발광 불량의 원인	

양중환, 윤종근, 한국정보디스플레이학회지, 8 (5), 11 (2007)

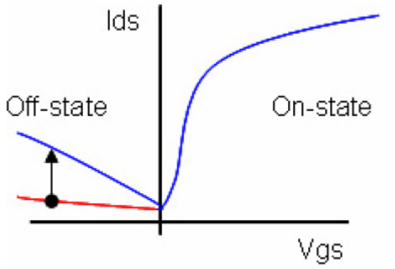
LTPS 기판의 Photo 공정의 불량

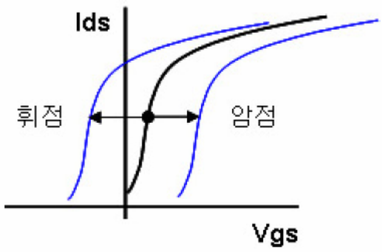
S/D metal 유실	S/D metal 잔막	Gate-active p-Si short
		
Cap short	Contact hole 불량	Gate metal 잔막
		

불량 유형	발생 원인	대책
S/D metal 유실	S/D metal patterning 중 etching에 의한 배선 open	이물 및 공정 관리
S/D metal 잔막	S/D metal patterning시 부분적인 etching 결여에 의한 이종 layer간 short	
Gate-active poly-Si short	Poly-Si 및 GI 형성 고정 이물에 의한 상부 gate metal과 하부 Tr. Ch. short	
Cap short	Capacitor 양 전극 사이에 이물	
Contact hole 불량	Under-etching에 의한 contact 불량 및 over-etching에 의한 short	
Gate metal 잔막	Gate metal patterning 공정의 부분적인 etching 결여에 의한 동종 layer간 short	

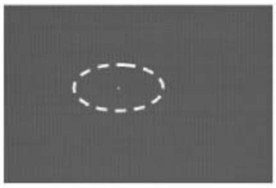
양중환, 윤종근, 한국정보디스플레이학회지, 8 (5), 11 (2007)

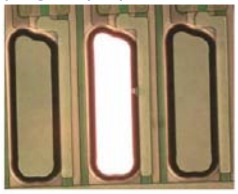
TFT 특성 불량



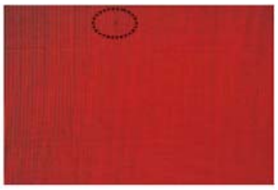


누설전류 증가에 의한 휘점 (bright spot)



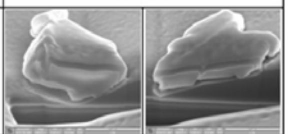
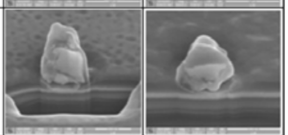
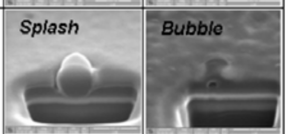
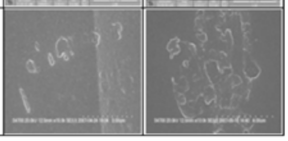


Vth shift에 의한 암점 (dark spot)

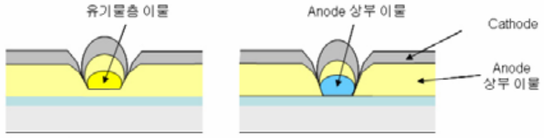


양중환, 윤종근, 한국정보디스플레이학회지, 8 (5), 11 (2007)

OLED 공정에서의 불량

OLED성	불량 형상
이물	
SUS성	
유기물 splash & bubble	
Scratch	

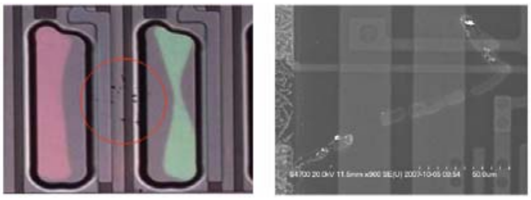
OLED성 불량	발생 원인 및 영향	대책
이물	▪ O, C 성분이 높게 검출되나 대부분 원인을 알 수 없는 particle임. ▪ Anode-cathode 간 누설전류 증가 및 단락 → 암점 발생 가능성 증가	이물 관리
SUS성	▪ OLED 공정 중 장비 및 mask에서 유래 ▪ Anode-cathode 간 누설전류 증가 및 단락	
유기물 splash & Bubble	▪ OLED 증착시 유기물 입자가 혼입되거나 cathode의 splash 발생 ▪ Anode-cathode 간 누설전류 증가 및 단락	
Scratch	▪ Mask- ITO 사이의 이물 또는 mask 표면의 돌기에 의한 긁힘 ▪ Anode-cathode 간 누설전류 증가 및 단락	
Cathode splash	▪ Cathode 증착 중의 splash ▪ Anode-cathode 간 누설전류 증가 및 단락	
Mask align 불량	▪ 고정세 EML shadow mask와 기판간의 align ▪ Color 불량 : 혼색 및 타색	



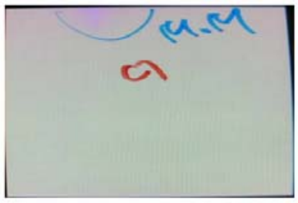
양중환, 윤종근, 한국정보디스플레이학회지, 8 (5), 11 (2007)

OLED 공정에서의 불량의 예

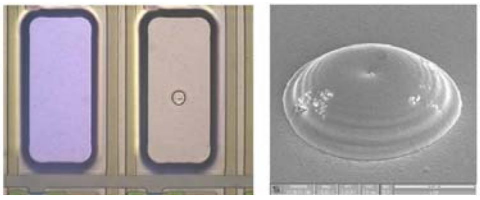
마스크 긁힘



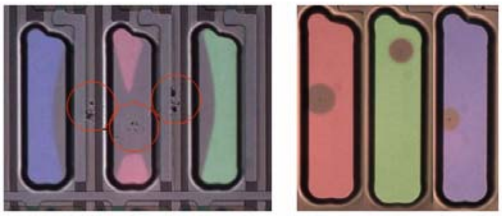
마스크 정렬 불량에 의한 국부적 색변질



Cathode metal splash



Cathode defect 및 이물에 의한 화소부 축소



양중환, 윤종근, 한국정보디스플레이학회지, 8 (5), 11 (2007)

OLED 공정에서의 불량의 예

평가 항목	평가 조건	사 양	비 고
Gray scale (gamma)	0~100% gray	1.8~2.8	화질을 고려한 γ 최적화
Luminance	Full white, 1 point	최소값 규정	TFT-LCD > 250nits
Luminance uniformity	Full white, 9 points	Min. 70%	OLED > 90%
White uniformity	Full white, 9 points	x, y ±0.05 이하	기준 white 중심 좌표 별도 제시
Crosstalk	0/20/100% gray, 4 points	5% 이하	
Color temperature	White	5,000K~10,000K	제품별 색온도 별도 제시
Color gamut	Red, Green, Blue	> 70%	TFT-LCD 65% 내외
Image sticking	Check box (5*5)	User 협의사항	제품별 상세기준 별도 설정
ACR (average CR)	White, black	> 200:1	OLED > 500:1
소비전력	W,R,G,B @40% ON	User 협의사항	TFT-LCD 250mW@250nits

양중환, 윤종근, 한국정보디스플레이학회지, 8 (5), 11 (2007)

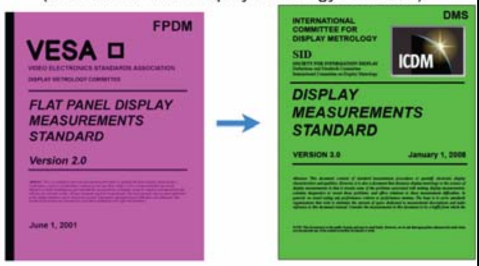
Display Metrology

Measure useful parameters: display ←→ vision

Make it reproducible (for millions of years, if necessary)
Make sure the metrics apply to all types
→ Standardize!
IEC, ISO, VESA, JEITA, KS, etc.

- **Metrics for emissive displays**
  - Luminance, uniformity
  - Dynamic response (Switching, warm-up, flicker)
  - Contrast ratio (plain field / window)
  - Specular reflections /
  - White chromaticity, colour reproduction / gamut
  - Resolution (analog / digital)
  - Power consumption
- **Additional for transmissive displays**
  - Viewing direction / angle range
  - Gray scale inversion
  - Cross-talk

(VESA Flat Panel Display Metrology Standard)



Radiometry and Photometry

Radiometry

Watt

W/nm

Photometry

Photopic vision eye sensitivity

$$\Phi_{\upsilon} = 683\,\mathrm{lm/W} \times \int \Phi_e\, V(\lambda)\, d\lambda$$

Luminous flux

W/nm

Wavelength (nm)

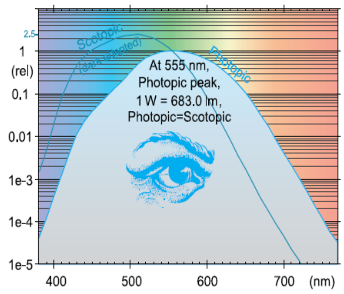
$$I_{\upsilon} = d\Phi_{\upsilon}/d\omega = 683\,\mathrm{lm/W} \times \int I_e\, V(\lambda)\, d\lambda$$

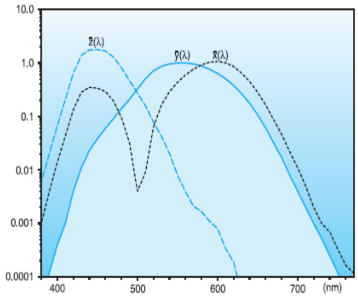
Luminous intensity
(Candela = lm/sr – SI unit)

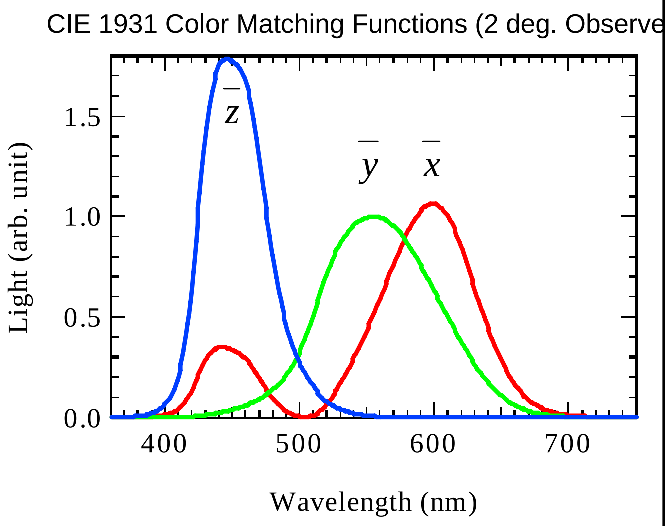
1/60 of the luminous intensity per square centimeter of a blackbody radiating at the temperature of 2,046 degrees Kelvin

Luminous efficiency: power into actuation of vision (lm/W)

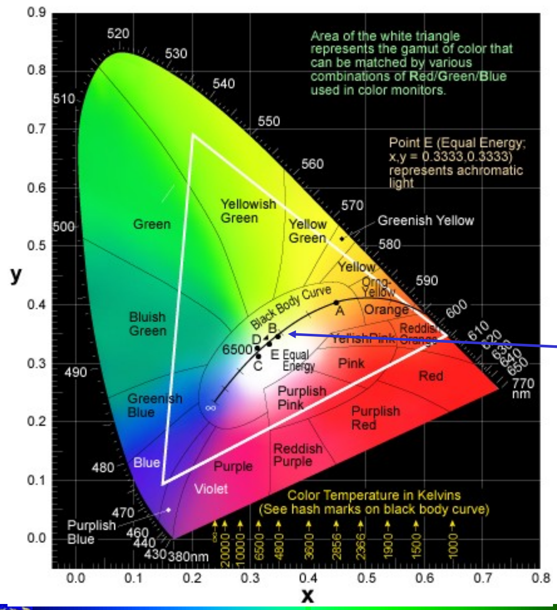
CIE 1931 Color Matching Functions







Chromaticity Coordinates & Color



$$X = K\int_{380}^{780} S(\lambda)\bar{x}\,d\lambda \qquad K = 683 \text{ lm/W}$$

$$Y = K\int_{380}^{780} S(\lambda)\bar{y}\,d\lambda$$

$$Z = K\int_{380}^{780} S(\lambda)\bar{y}\,d\lambda$$

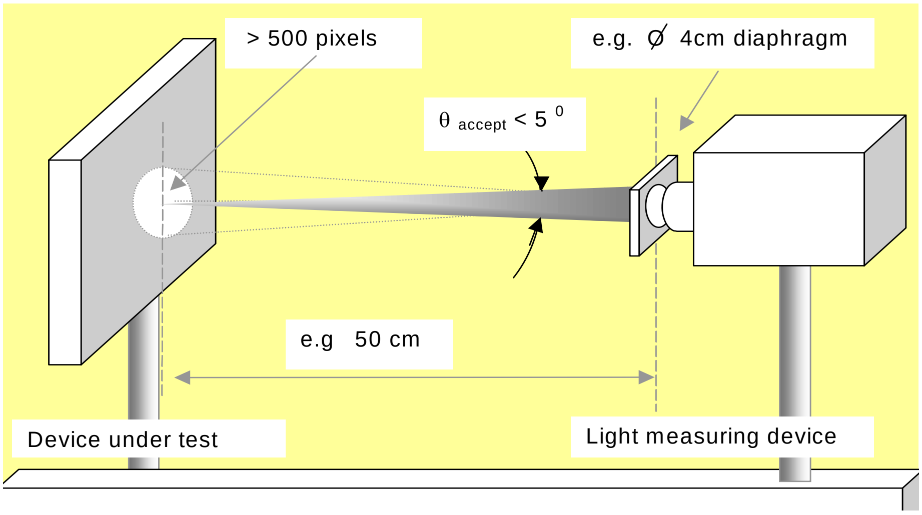
$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z}$$

$$x + y + z = 1$$

- A black body radiator (Planckian Source) glows with a color that is solely dependent on its temperature (in K).

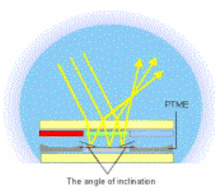
- Standard source
  D_{65} (daylight, 6500 K)
  $(x,y) = (0.312, 0.329)$
  E = Equal Energy point: (0.333, 0.333)

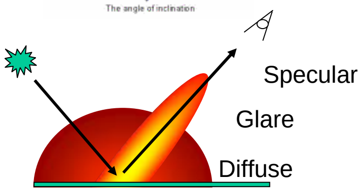
Measurement system setup

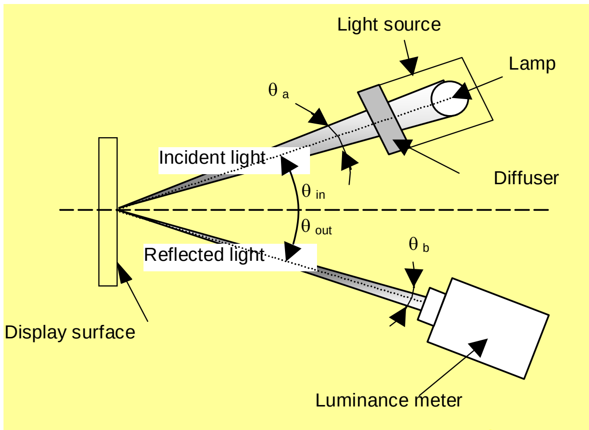


Standardized measurement equipment

Specular reflection



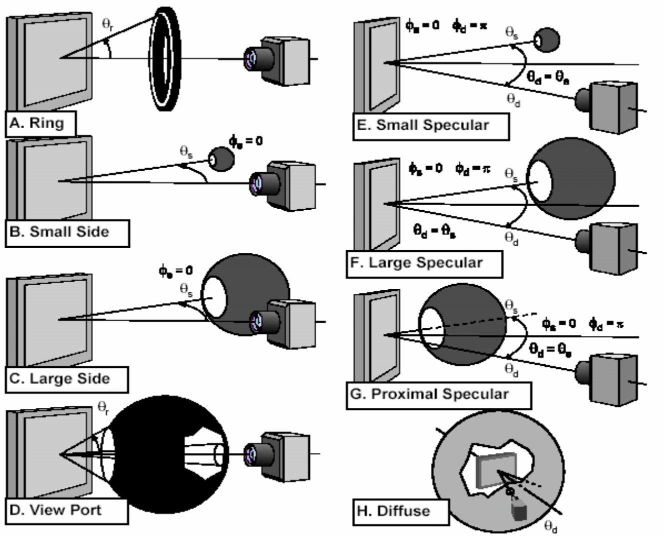




Standard illuminants
CIE – A (2856 K)
CIE – B (abandoned)
CIE – C (6750 K)
CIE – D65 (6500 K)

* Light source determines measurement result

Standardized measurement equipment



Apparently, anyone is free to choose the method that suits the display best.

This makes it very difficult to make a fair comparison.

Source: Edward F. Kelley, NIST

Standard environment

- Not really defined.. → Nist: Measuring device
- The real environment is full of reflections!!
- Usually measured in the DARK!: Reproducible, but there is no good relation to real use!

example:

brightness	= 500 Cd/m2
Contrast ratio	= 500:1 (brightness dark state = 1 Cd/m2)
Environment	= 500 Cd/m2 (diffuse)
Front screen reflection	= 3% (15 Cd/m2)
Resulting contrast	= 500 / (15+1) = **31:1**

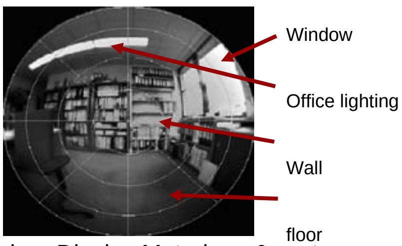
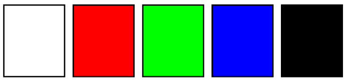


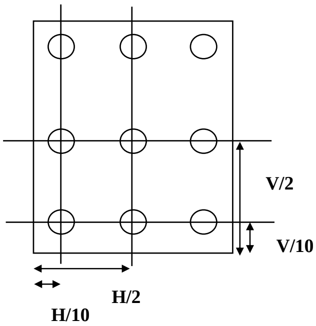
Photo: courtesy M. Becker, Display Metrology & systems

Luminance

❑ **Pattern**



❑ **Measure Positions**



❑ **Calculation**

: Average of 9 points

❑ **Others**

➢ **Long Range Non-uniformity**

: (Lmax – Lmin)/Lmax (%)

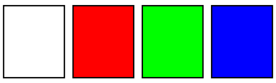
➢ **Contrast Ratio(Dark room)**

: $L_{\_white}$ / $L_{\_black}$

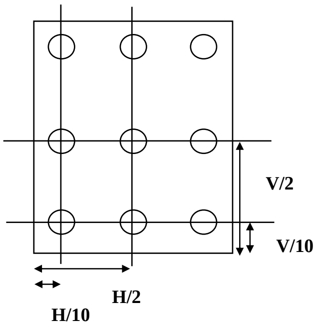
자료: 이정노 박사 (삼성SDI)

Color

❑ **Pattern**



❑ **Measure Positions**



❑ **Calculation**

: Average of 9 points

❑ **Others**

➢ **Correlated Color Temperature(CCT)**

: T = 437*n^3 + 3601*n^2 + 6831*n + 5517

(n=(xw-0.332)/(0.1858-yw))

➢ **Gamut Area**

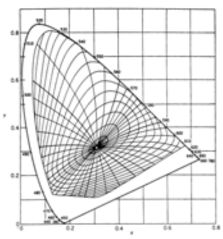
: Area ratio to NTSC

- in CIE1931 (x, y)

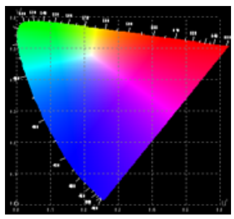
- in CIE1976 (u’, v’)

➢ **Color Non-uniformity**

: longest distance in CIE1976



CIE 1931



CIE 1976

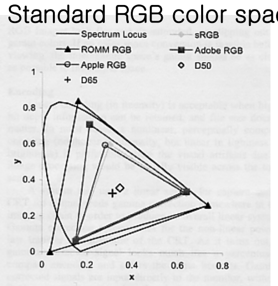
자료: 이정노 박사 (삼성SDI)

RGB Color Coordinates

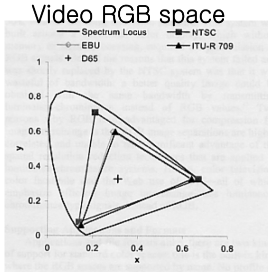
Color space	Rendered	Encoding	Gamut	White point	Primaries
ISO RGB	X	8-bit nonlinear	Limited	Floating	Floating (ISO 17321)
Extended ISO RGB	X	10~16 bit nonlinear	Unlimited	Floating	Floating
sRGB (IEC 61966-2-1)	O	8-bit nonlinear	CRT	D65	R(0.64, 0.33) G(0.30, 0.60) B(0.15, 0.06)
ROMM RGB	O	8-bit nonlinear (12-16 bit)	Wide	D50	R(0.7347, 0.2653) G(0.1596, 0.08404) B(0.0366, 0.0001)
Adobe RGB 98	O	8-bit nonlinear	Extended CRT	D65	R(0.64, 0.34) G(0.21, 0.71) B(0.15, 0.06)
Apple RGB	O	8-bit nonlinear	CRT	D65	R(0.625, 0.34) G(0.28, 0.595) B(0.155, 0.070)
NTSC RGB	O	Nonlinear	CRT	C	R(0.67, 0.33) G(0.21, 0.71) B(0.14, 0.08)
EBU RGB (CCIR 601)	O	Nonlinear	CRT	D65	R(0.64, 0.33) G(0.29, 0.60) B(0.15, 0.06)
ITU-R BT.709	O	Nonlinear	CRT	D65	R(0.64, 0.33) G(0.30, 0.60) B(0.15, 0.06)

* ROMM(Reference Output Medium Metric/Kodak)

Standard RGB color spac



Video RGB space

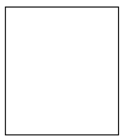


Power Consumption

- **Measure**
  - 전류, 전압 측정
- **Calculation**
  - : **Power(30) = 전류*전압 * 0.3**
- **Issue on screen power consumption**

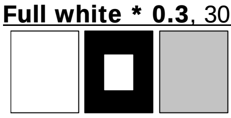
Pattern

Full White

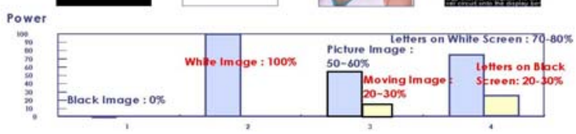


휘도 : **150 cd/m2**

- **Pattern : Full white * 0.3**, 30 % Area, 30% gray, Pixel 격자, others?



측정 예	Full White	30% Area	30% 휘도
Power Ratio	100%	29%	32%

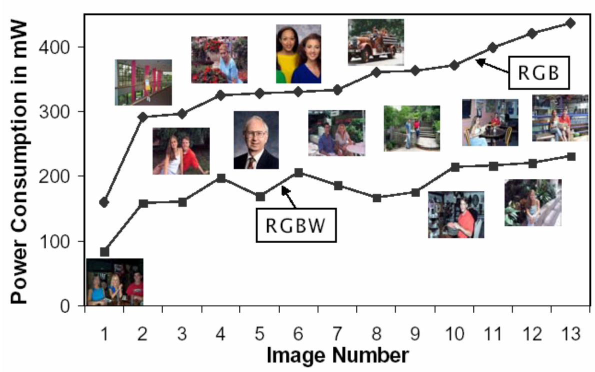


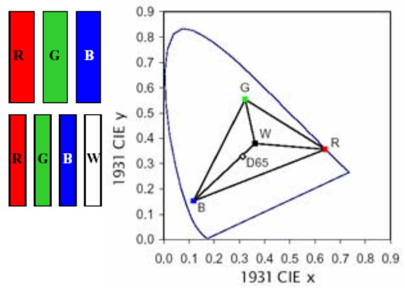
자료: 이정노 박사 (삼성SDI)

Power consumption: RGBW method

	R	G	B	W
CIE x	0.641	0.323	0.119	0.361
CIE y	0.357	0.554	0.153	0.380
cd/A	2.63	6.60	1.14	12.48

RGB saturated color를 표현하는 경우 비슷한 power를 소모하지만, White가 들어가는 일반적인 화면을 표시하는 경우 RGBW가 약 ½ 수준의 전력을 소모함.

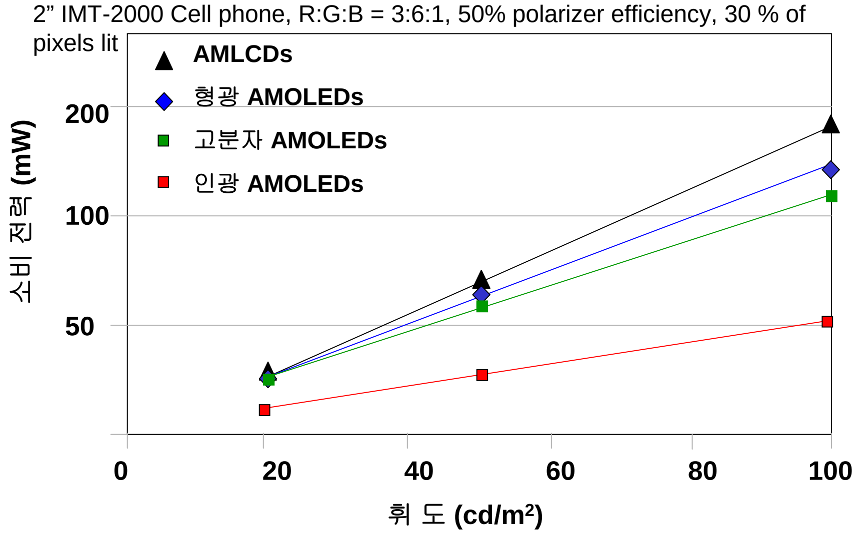




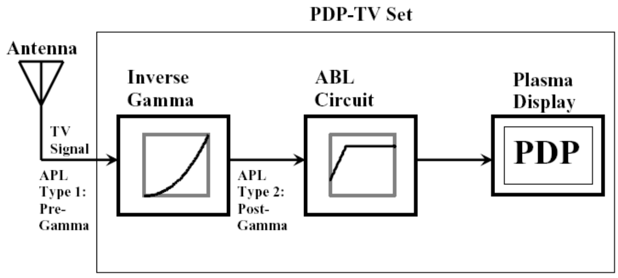
D. Arnold, T.K. Hatwar, P.J. Kane, M.V. Hettel, M.E. Miller, M.J. Murdoch, J.P. Spindler, S.A. Van Slyke, K. Mameno, R. Nishikawa, T. Omura, S. Matsumoto, IMID'04 Digest 25-2 (2004)

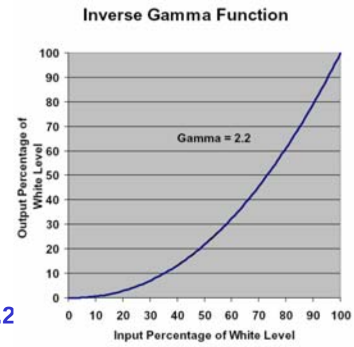
Cell Phone Power Consumption Comparison

2" IMT-2000 Cell phone, R:G:B = 3:6:1, 50% polarizer efficiency, 30 % of pixels lit



Average Picture Level (APL)





Output = 100 x (Input / 100) $^{2.2}$: Gamma=2.2

Average Picture Level (APL)

APL Type 1 (Pre-Gamma) Definition:

APL is the time average of the video signal input voltage to the TV set, which is usually expressed as a percentage of the *full white signal level voltage*.

APL Type 2 (Post-Gamma) Definition:

APL is the time average of the average luminance of all pixels in the TV set, which is usually expressed as a percentage of the *peak white luminance level*.

Ref. Dr. Larry F. Weber, 2005. 5. 8 IEC Meeting

Average Picture Level (APL)

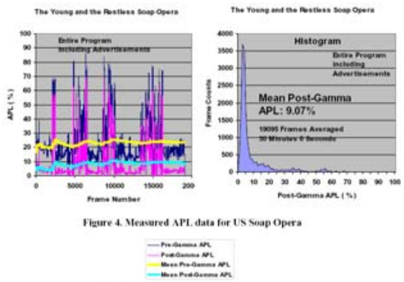


Figure 4. Measured APL data for US Soap Opera

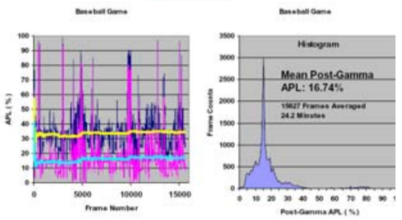
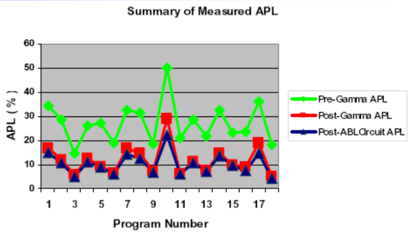


Figure 9. Measured Post-Gamma APL data for baseball game



	Program Title	Type	Pre-Gamma APL	Post-Gamma APL	Post-ABL APL	Minutes	Frames
1	Baseball	Sports	34.30	16.74	15.01	24.2	15627
2	Charlie's Angels 2000	Movie	28.51	12.02	10.81	97.8	55725
3	Deadwood (Drama Western)	Movie	14.49	5.78	5.13	53.5	33184
4	Educating Miss Bunny	Adult	26.00	12.34	10.97	30.0	10400
5	Finding Nemo	Animation Movie	27.00	9.44	9.09	100.3	56554
6	Jay Leno	Talk Show	19.03	6.51	6.05	11.5	6500
7	Life Stories: Families in Crisis (Docu Drama)	Movie	32.62	16.85	14.26	45.0	10700
8	Noon News	News	31.40	14.54	12.60	29.0	18528
9	Real Time with Bill Maher	Comedy Talk Show	18.56	7.12	6.77	60.0	29368
10	Rug Rats	Budget Animation	50.17	29.09	21.99	24.0	15604
11	Shakespeare in Love	Movie	20.93	6.09	6.08	123.0	66975
12	Sports Highlights on Sports Network	Sports	28.56	11.48	10.66	28.9	19040
13	The Dreamers (Drama)	Movie	21.79	7.64	7.09	115.0	44854
14	The Price is Right	Game Show	32.60	14.62	13.62	25.0	15868
15	The Winslow Boy (Historical Drama)	Movie	23.24	10.00	9.80	105.0	26543
16	The Young and the Restless Entire Program	Soap Opera	23.50	9.07	7.34	30.0	19095
17	The Young and the Restless Ads Only	Soap Opera	35.93	18.97	14.62	9.4	5572
18	The Young and the Restless Opera Only	Soap Opera	18.37	4.99	4.34	20.6	13524

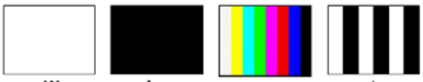
Figure 13. Summary of APL data measured in this study

Ref. Dr. Larry F. Weber, 2005. 5. 8 IEC Meeting

Measuring Method of Power Consumption

JEITA Measuring Method Proposal

Method of measuring annual energy consumption of LCD-TVs and PDP-TVs



w b c t

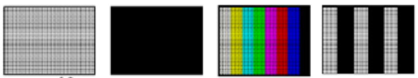
Po = 0.167 x Pw + 0.167 x Pb + 0.333 x Pc + 0.333 x Pt

where:

Po is the output power value that is used for the final power calculations,
Pw is the measured power of the 100% white pattern,
Pb is the measured power of the full black pattern,
Pc is the measured power of the color bar pattern,
Pt is the measured power of the white and black bar pattern.

Test Pattern	Label	Pre-Gamma APL	Post-Gamma APL	Constant Backlight LCD Power Calculation	Dynamic Backlight LCD Power Calculation
JEITA Test Patterns					
100% Intensity Full White Pattern	w	100.00	100.00	100	100
All Black	b	0.00	0.00	100	0
50% Color Bar	c	50.00	34.40	100	100
100% Intensity Vertical Bar Pattern	t	50.00	50.00	100	100
			Po =	100	83.3
Alternate Test Patterns					
40% Luminance Full White Pattern	w40	65.94	40.00	100	40
All Black	b	0.00	0.00	100	0
40% Color Bar	c40	30.70	20.00	100	40
40% Luminance Vertical Bar Pattern	t40	32.97	20.00	100	40
			Po =	100	33.3

Other Measuring Method Proposal



w40 b c40 t40

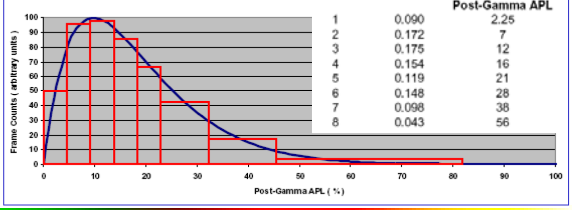
Ref. Measuring Annual Energy Consumption of LCD-TVs and PDP-TVs
By
Dr. Larry F. Weber
2005. 5. 8 IEC Meeting

Dr. Weber's Proposal of New Test Method

Po = W1 x P1 +W2 x P2 + W3 x P3 + W4 x P4 + …….. + Wn x Pn (3)

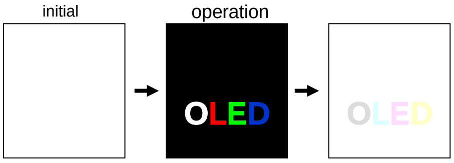
Where:

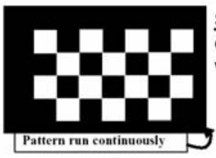
Po is the output power value that is used for the final power calculations,
P1, P2, P3,…, Pn are the powers that are measured with the various test images,



Term	W	Test Image Post-Gamma APL
1	0.090	2.25
2	0.172	7
3	0.175	12
4	0.154	16
5	0.119	21
6	0.148	28
7	0.098	38
8	0.043	56

Image Sticking





Simulation showing effects of differential aging assuming white, fixed format squares were run continuously.

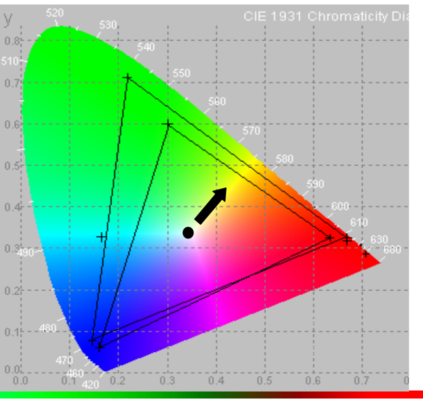
- At 10% intensity decrease, the fixed format characters can be observed.
- At 30% and 50%, the video image is significantly degraded.

www.planar.com

Slide courtesy of Eric Forsythe, ARL

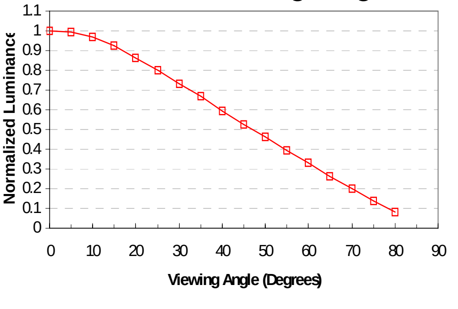
Differential Aging

- Image Burning
  - Improvement of OLED Lifetime
  - Development of Avoiding Driving Tech.
- White Balance Shift : Yellowish Problem
  - ⇨ Required the Same Lifetime of RGB

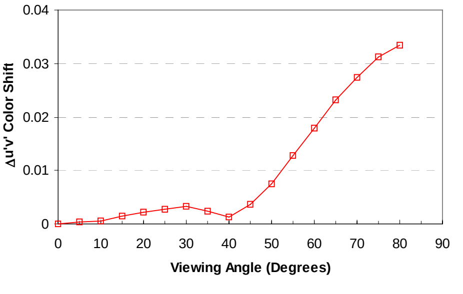


Viewing Angle

Normalized White Luminance with Viewing Angle



White Color Shift with Viewing Angle



Viewing angle based on luminance to be defined at X% luminance drop.

Viewing angle based on color shift be defined at 0.01 or 0.02 Δu'v' shift.

자료: John Penczek (DuPont Displays)

Moving Edge Blur

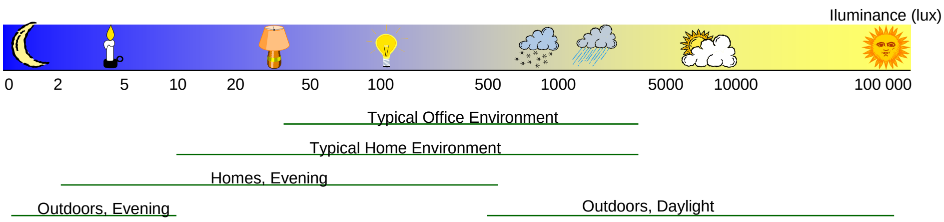
- Material response of OLEDs is very fast compared to LCDs
- Lesson from the LCD world: material response time is not a sufficient metric for moving image quality
- Possible artifacts in OLEDs arising from driving schemes
  - Edge blur by spatio-temporal retinal averaging
  - Dynamic false contours (grey scale by subfield modulation)
  - Flashes during saccades (passive matrix OLED)
  - Spatial high-pass filtering (ringing signal)

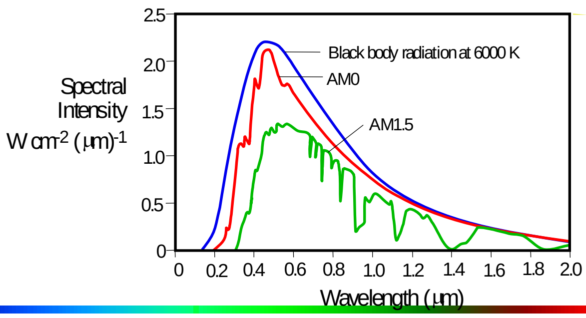
How can we objectively measure and characterise these artifacts to fairly compare image quality with other technologies?

자료: John Penczek (DuPont Displays)

Daylight Contrast

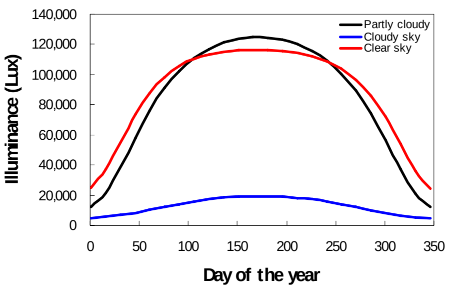
Daylight Illumination Levels

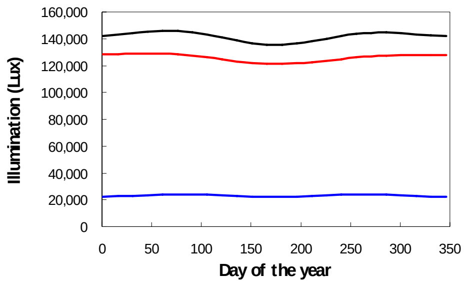




Daylight Contrast

Illuminance by Region/Season





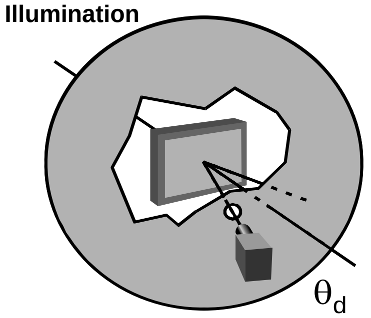
Source: The IESNA Lighting handbook, 9th edition, chapter 8

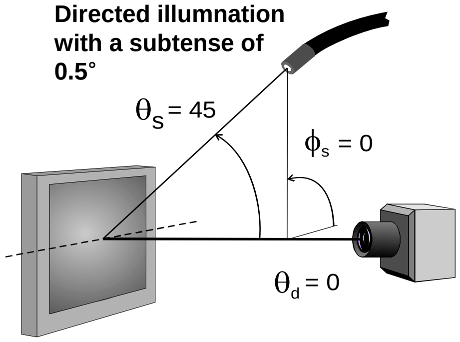
High display illuminance levels are required for daylight readability measurements,
or scale reflection measurements.

Data from J. Bergquist (Nokia), IDW 2003

Daylight Contrast

Proposed Illumination Geometry





Diffuse measurement
(θ_d = 8° to 10°)

Isolated source measurement

Example of sunlight readability testing configurations where two separate measurements are made at reduced illumination, numerically scaled to daylight levels, and combined.
(E. Kelley, M. Lindfors & J. Penczek, ADEAC 2005)

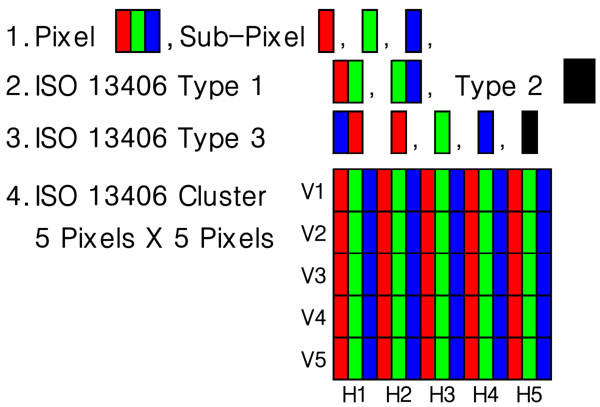
❑ Definition of Pixel Faults

Fault type	Description
Type 1 fault	Pixel in stuck high state (when system command = minimum luminance) (L> 0,75 L_X + 0,25 L_N)
Type 2 fault	Pixel in stuck low state (when system command = maximum luminance) (L< 0,75 L_N + 0,25 L_X)
Type 3 fault	Pixel or subpixel is abnormal, but not type 1 or 2. For example, a stuck subpixel or intermittent fault.
Fault cluster	Two or more pixels or subpixels with faults within a 5×5 block of pixels.

L is the measured luminance of the pixel.
L_X is the average pixel response to a maximum luminance command (e.g. white).
L_N is the average pixel response to a minimum luminance command (e.g. black).

ISO 13406-2

❑ Types of Pixel Faults



ISO 13406-2

❑ Definition of Fault Classes, *Class*$_{pixel}$

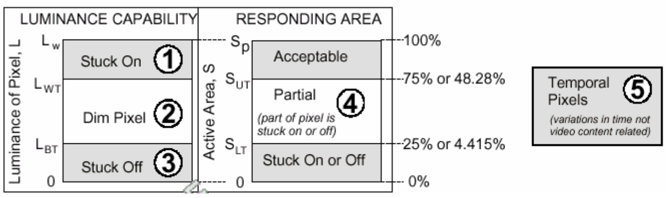
Maximum number of faults per type per *million* pixels					
Class	Type 1	Type 2	Type 3	Cluster with more than one type 1 or type 2 faults	Cluster of type 3 faults
I	0	0	0	0	0
II	2	2	5	0	2
III	5	15	50	0	5
IV	50	150	500	5	50

VESA FPDM2, Jun 1, 2001

303-6A Defective Pixel Characterization and Measurement

Thresholds of Observability			
Threshold Criterion	Required Luminance Thresholds, L_{WT}, L_{BT}	Lightness Perceived by Eye, L^*/L^*_w	Partial Pixel Areas† S_{UT}, S_{LT}
25 % Luminance (L)	25 %: $L_{BT} = 0.25L_w$	57.1 %	25 %: $S_{LT} = 0.25S_p$
75 % Luminance (L)	75 %: $L_{WT} = 0.75L_w$	89.4 %	75 %: $S_{UT} = 0.75S_p$
25 % Lightness (L^*)	4.415 %: $L_{BT} = 0.04415L_w$	25 %	4.415 %: $S_{LT} = 0.04415S_p$
75 % Lightness (L^*)	48.28 %: $L_{WT} = 0.4828L_w$	75 %	48.28 %: $S_{UT} = 0.4828S_p$

† S_p is the total area of the light-producing part of the pixel, e.g., the total subpixel area.



Pixel Faults

VESA FPDM2, Jun 1, 2001

303-6A Defective Pixel Characterization and Measurement

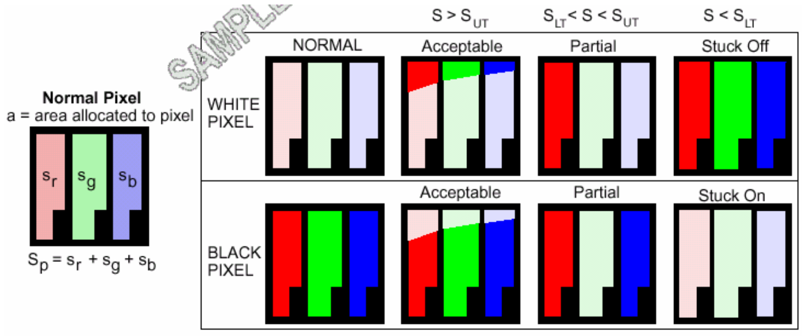


Fig. 1. Example of a hypothetical TFT LCD subpixel configuration.

Mura Defects

VESA FPDM2, Jun 1, 2001

303-8 Mura Defects

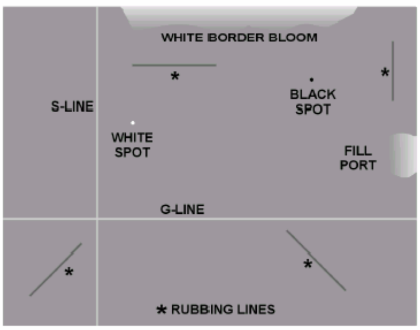


Fig. 1. Example of S-line, G-line, black and white spot, bright border bloom, rubbing lines and fill-port defect.

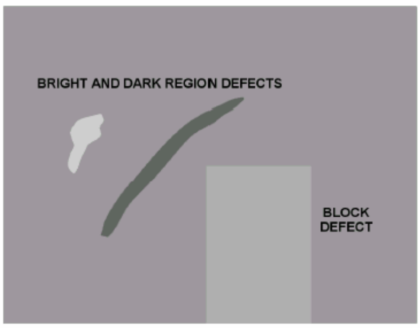


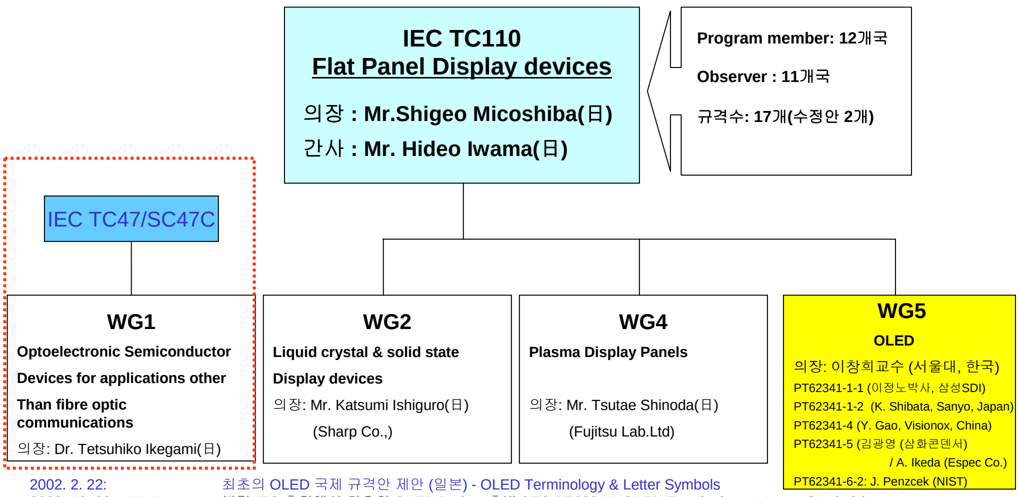
Fig. 2. Example of block defect, bright region and dark region defects

Mura Defects

Table 1. Defect detection phases and defect classes

Phase	Class	Class description	Examples of physical LCD defect types
1	1	column line	signal line
2	2	row line	gate line
3	3	random thin line pattern	straw pattern, irregular thin dark streaks
4	4-1	white interior spot	bright pixel, bright pixel cluster, bright spot
4	4-2	white corner bloom	bright corner
4	4-3	white border bloom	bright panel edge
5	5-1	black interior spot	dark pixel, dark pixel cluster, dark spot
5	5-2	black corner bloom	dark corner
5	5-3	black border bloom	dark panel edge
6	6	thin horizontal line	thin rubbing line
7	7	thin vertical line	thin rubbing line
8	8	thin positive slope diagonal line	thin rubbing line
9	9	thin negative slope diagonal line	thin rubbing line
10	10-1	bright region	elliptical region, wide rubbing line, bright streak, bright arc
10	10-2	bright region collection	bright ring, bright streaks, bright arcs
11	11-1	dark region	elliptical region, wide rubbing line, dark streak, dark arc
11	11-2	dark region collection	Newton ring, vertical periodic lines, dark streaks, dark arcs
12	12	wide horizontal line	panel driver block, lithography misalignment
13	13	wide vertical line	panel driver block, lithography misalignment
14	14-1	bright region non-uniformity	brightness non-uniformity of panel or backlight
14	14-2	bright border non-uniformity	fill port
15	15-1	dark region non-uniformity	darkness non-uniformity of panel or backlight
15	15-2	dark border non-uniformity	fill port

IEC TC110: Flat Panel Display Devices



2002. 2. 22: 최초의 OLED 국제 규격안 제안 (일본) - OLED Terminology & Letter Symbols
2002. 10. 28 ~ 11. 1 북경 IEC 총회에서 최초의 OLED Project 출범 (IEC PT62341: OLED Terminology & Letter Symbols), 한국 SC47C→TCxx로의 승격 및 OLED WG 신설 제안
2003. 6. IEC SMB 승인: IEC TC47/SC47C → TC110
2003. 12. 1 ~ 2: IEC TC110 Meeting, Fukuoka ; 이창희교수 OLED Area Manager로 임명
2006. 2. 8: WG5 (OLED) 신설

Progress of the IEC/TC110 OLED

Project	2002	2003	2004	2005	2006	2007	2008	2009	2010
IEC 62341-1-2 **Terminology and letter symbols** **(K. Shibata)**	47C/272/NP 2002. 2. 22		110/20/CD 2004. 4.23	110/68/CD 2005. 6.10 CDIS 2005. 10					
IEC 62341-1-1 **Generic Specifications** **(J. N. Lee)**	47C/291/NP 2002. 12. 20		110/38/CD 2004. 12. 3	110/68/CD 2005. 12. 2	CDIS 2006. 10				
IEC 62341-6-1 **Meas. Methods of Optical and Optoelectrical Parameters** **(L. Wang)**		47C/290/NP 2003. 12. 20		110/55/CD 2005. 5.20	CDIS 2006. 10				
IEC 62341-5 **Environmental and mechanical endurance test methods** **(K. Y. Kim)**				110/57/NP 2005.1.8	1st CD 2006. 11	CDV 2007.11	FDIS 2008.11		
PWI IEC 62341-6-2 **Meas. Methods of Visual Quality** **(J. Penczek)**					PWI 2006.1.20	1st CD 2007. 10			FDIS 2010.6