전자물리특강-OLED Driving Method

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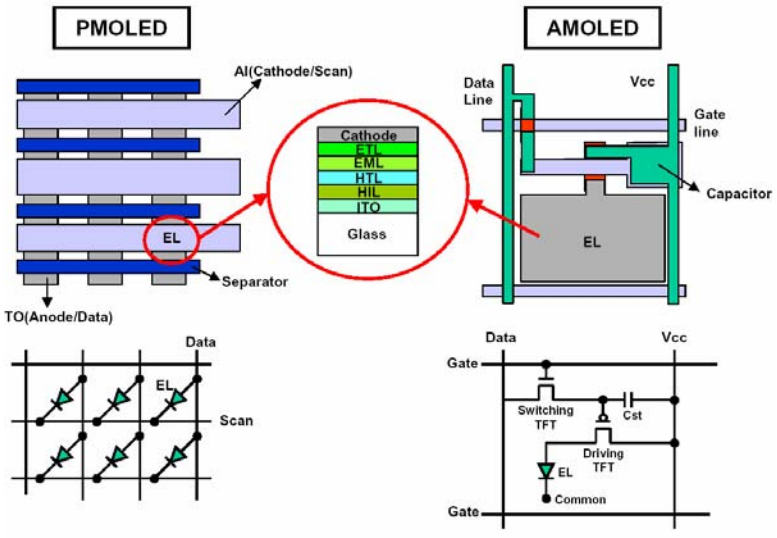
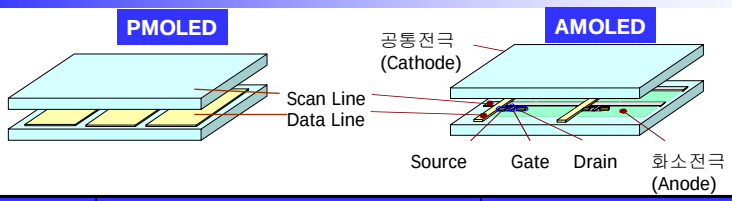
PMOLED and AMOLED



김기용박사 (엘리아텍)

PMOLED vs. AMOLED



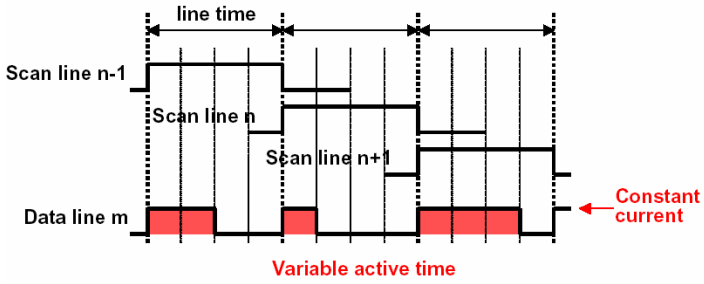
	Passive Matrix		Active Matrix	
구동법	Display during line time: Duty driving (Row line 선택시 점등)		Display during frame time Static driving	
고휘도 고정세화	△	Row line수 증가에 따라 **높은 순간 휘도 요구 → 수명,** 소비전력에 불리 Row line수의 한계(현재240)	◎	Row line 수에 관계없이 고휘도 실현가능, **고해상도 가능**
저소비 전력	△	순간휘도=Row line X 휘도 **고 전압 구동**	○	요구 휘도의 구동전압 구동 저 전압 구동
소형화	○	구동 IC 외장	◎	**구동회로 Panel 내부 내장**
소자구조 Cost	◎	Simple process Low cost Low initial investment	△	저온 poly Si TFT+유기 EL 복잡한 Process High Fab. Cost

권장혁박사 (삼성SDI)

Grey Scale Control: PWM

- ❑ Current density (amplitude) is fixed during whole time
  - ✓ Initially, the amplitude can be set by register value
- ❑ Active time is modulated by data value

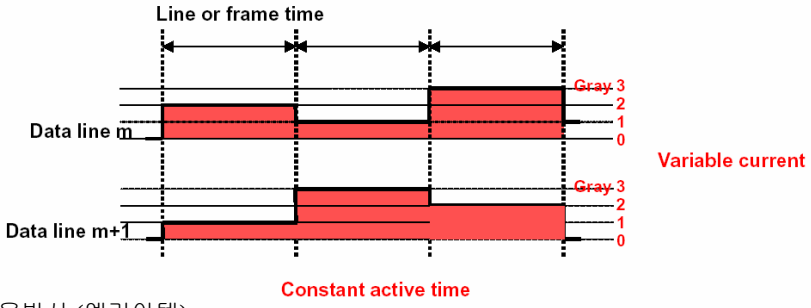
- ❑ Simple 4-gray example in PMOLED



김기용박사 (엘리아텍)

Grey Scale Control: PAM

- ❑ Current density (amplitude) is modulated by data value
- ❑ Active time is fixed
  - ✓ During line time in PMOLED
  - ✓ During frame time in AMOLED
- ❑ Simple 4-gray example

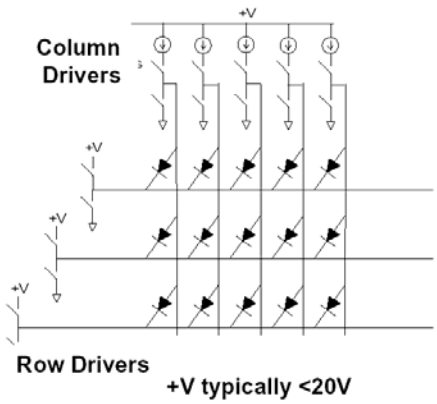


김기용박사 (엘리아텍)

PMOLED Driving

Drive Approach

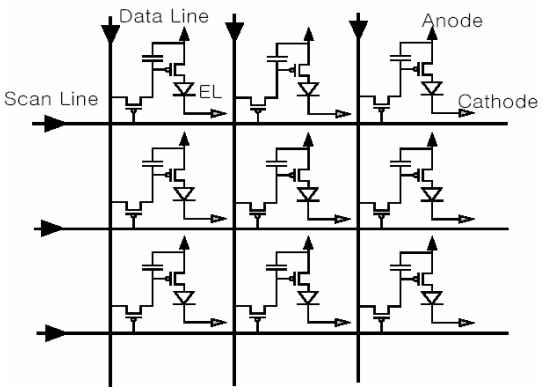
- Maintain constant current through the OLED
- Progressive row scan
- Row/OLED's duty cycle = 1/(# rows)
- High current for short time
- I^2R loss in lines results in high system power



김기용박사 (엘리아텍)

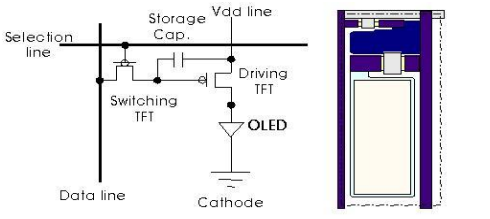
AMOLED : Panel Structure

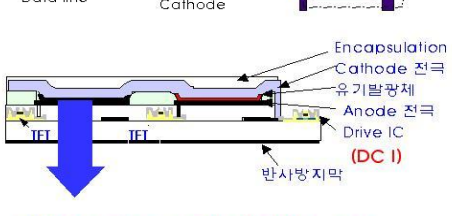
- Matrix 전극 사이에 switching TFT →OLED pixel의 독립 구동 가능
- Frame time 동안 emission 가능 → EL 구동주파수 감소
- High resolution, Large size panel 가능
- 해결과제: TFT 불균일성 및 전원 line 저항에 의한 voltage drop :



AMOLED vs. AMLCD

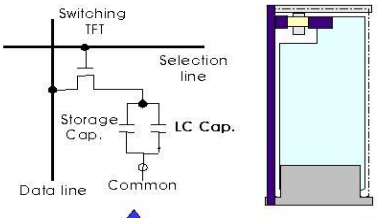
❑ AMOLED

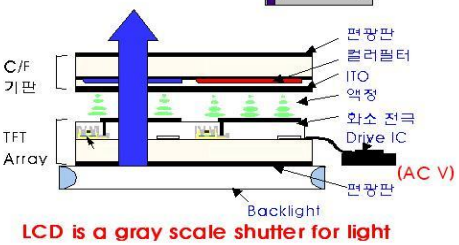




OLED is primary color light source

❑ AMLCD





LCD is a gray scale shutter for light

김기용박사 (엘리아텍)

AMOLED: Sony PDA – CLIE PEG-VZ90

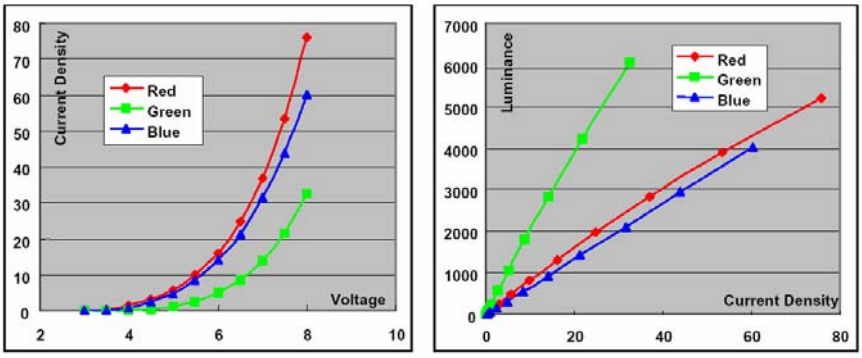
http://www.sony.net/SonyInfo/News/Press/200409/04-048E/

Sony PDA : OLED *vs* LCD

	Sony's OLED display	Reference : Sony's equal level LCD display (transmissive / reflective combined type)
Display Size	9.7cm (3.8-inch)	(same)
Number of Dots	480xRGBx320 (HVGA)	(same)
Dot Pitch	56μm×168μm	(same)
Number of colors	262,144 colors	(same)
Brightness	150cd per square meter	55cd per square meter
External Dimensions	94.7mm(horizontal) × 77.2mm(vertical) × 2.14mm(thickness) (thickness including the panel only and not including the protruding portions)	65.0mm(horizontal) × 96.5mm(vertical) × 3.49mm(thickness) (thickness includes the panel + backlight)
Response Time (at 25°C, ON)	~ 0.01 Mil. sec.	~ 16 Mil. sec.
Color Gamut (NTSC* Ratio)	Approx. 100%	Approx. 40%
Viewing Angle	Vertical: Approx. 180 degrees Horizontal:Approx.180degrees	Vertical: Approx. 130degrees Horizontal: Approx. 125 degrees
Contrast Ratio (in darkness)	Approx. 1000 : 1	Approx. 100 : 1

http://www.sony.net/SonyInfo/News/Press/200409/04-048E/

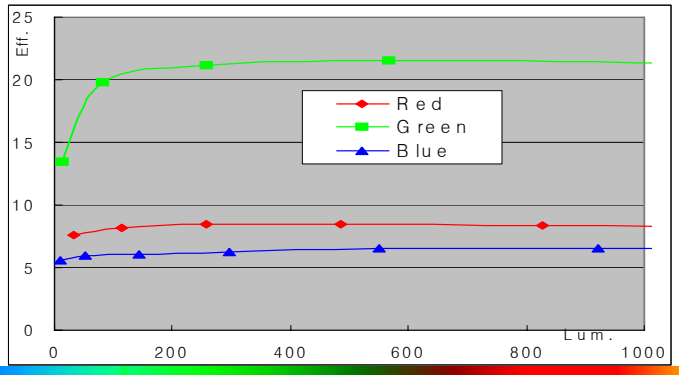
I-V-L characteristics of OLED



OLED I-V curve　　OLED I-L curve

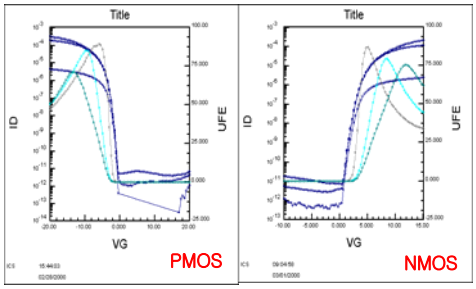
Driving Technologies for AMOLED

- **White Balance**
  - Different data swing range
  - Different size of driving TFT
  - Different illumination time of each colors
  - CCM (Color Changing Media)
- **Different efficiency to luminescence**

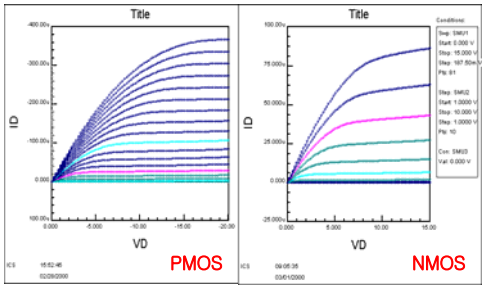


TFT Characteristics

❑ Transfer Curve



❑ Output Curve



- Ioff 영역 : V_g=0V
- Sub threshold 영역: 0V<V_g<V_{th}
- Ion 영역: V_g>V_{th}

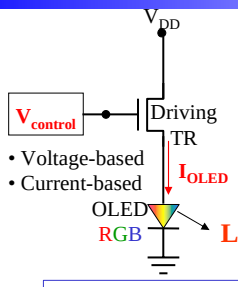
• Linear region

$$I_D = \frac{WC_{ox}}{L}\mu(V_G - V_T - \frac{V_D}{2})V_D$$

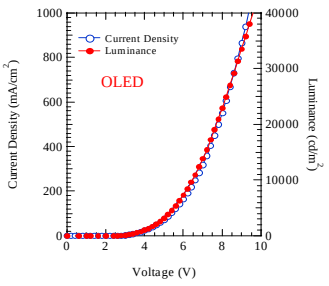
• Saturation region

$$I_D = \frac{WC_{ox}}{2L}\mu_{FET}(V_G - V_T)^2$$

AMOLED Driving

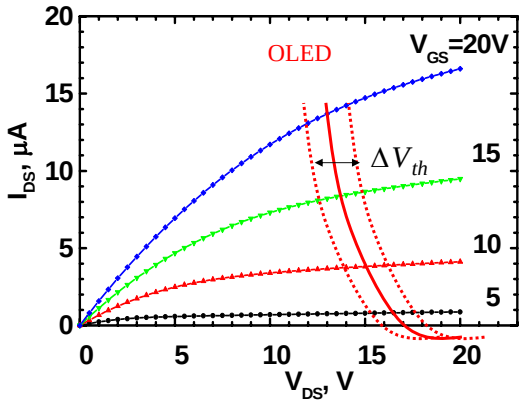


$Light \propto I_{OLED} \times Efficiency$



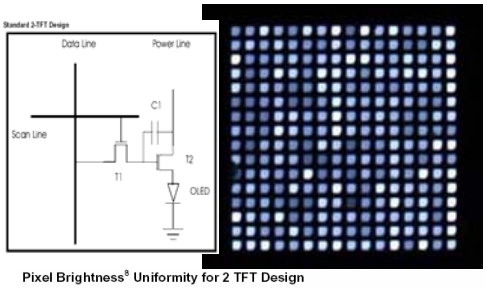
• Active-matrix 방식에서 각 화소마다 OLED 전류 공급원이 필요.
• 2 TFT + 1 Cap이 가장 단순한 구조

$$I_{OLED} = \frac{1}{2}\mu C_{ox}\frac{W}{L}(V_{Data} - V_{th})^2$$

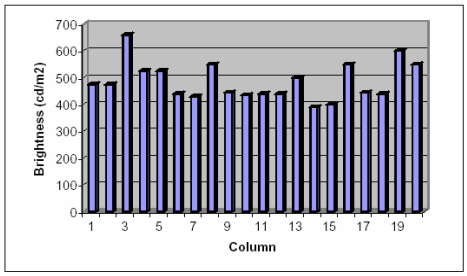


Brightness Nonuniformity

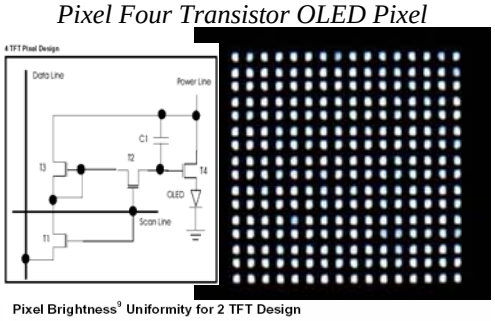
Standard Two Transistor OLED



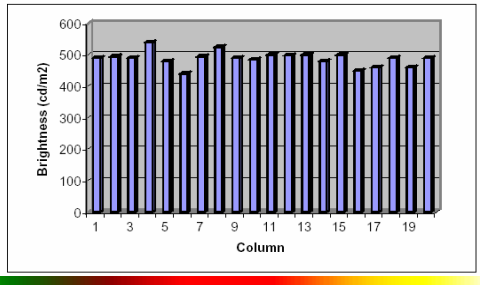
Pixel Brightness[8] Uniformity for 2 TFT Design



Pixel Four Transistor OLED Pixel

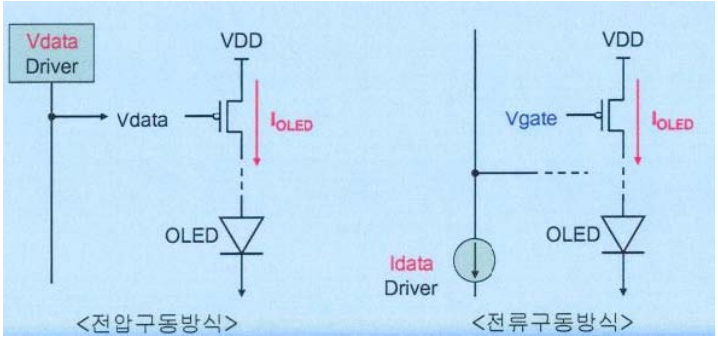


Pixel Brightness[9] Uniformity for 2 TFT Design



AMOLED Pixel Circuit

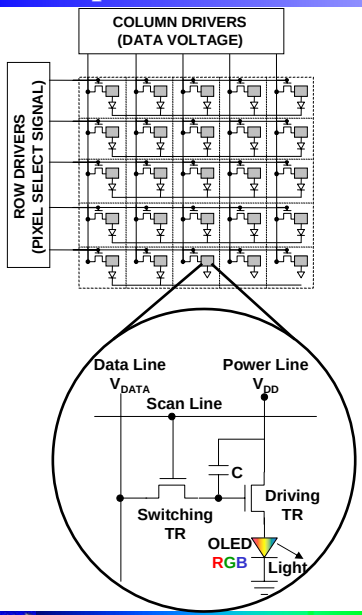
- Equivalent OLED Current (I_{OLED}) by the same V_{data} regardless of TFT
- 전압구동방식: 인가된 V_{data} 에 의해 I_{OLED}가 결정됨
- 전류구동방식: 인가된 I_{data} 에 의해 I_{OLED}가 결정됨 (인가된 I_{data} 에 의해 적절한 V_{gate} 값이 정해짐)



AMOLED : Programming Technologies

입력 data	보상 방법		Company or Inst.	장점	단점
Analog	Driving TFT 직접 보상	전압	Sarnoff	Vth특성 변화 보상	Vth 이외 특성변화 보상 안됨
		전류	Sarnoff, Philips, NEC, Epson…	Ideal TFT 특성변화 보상	Programming Time 문제
	Pair TFT 로 보상	전압	Epson, SNU, HYU	Vth특성 변화 보상	특성 mismatch Vth 이외 특성변화 보상 안됨
		전류	NEC, Sony	Large size가능	특성 mismatch
Digital	Area		Epson	간단히 구현 가능	Resolution Size Power
	Time		Epson, SEL		

Backplanes for OLEDs

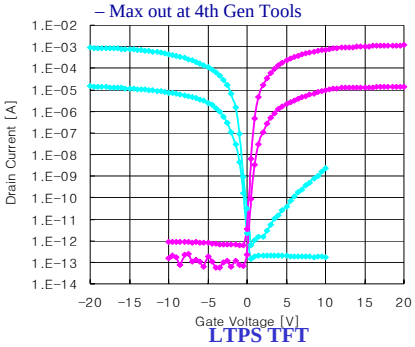


	Poly-Si TFT	a-Si TFT	OTFT
Type	CMOS	NMOS	PMOS
Performance :			
Mobility	Very good	OK for PHOLED	OK?
Leakage	OK	Very good	OK
Stability	Good	OK	Issue
Uniformity	Issue		Issue
Manufacturability	Maturing	Excellent	N/A
# of Interconnercs	Data?	scan +data	scan +data
Cost	>Medium	Medium	Low
Plastic compatibility	Under development	Good	Excellent

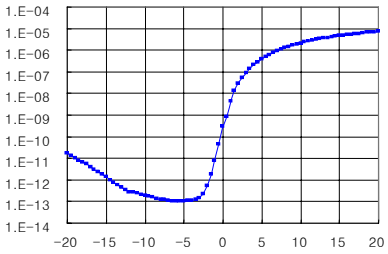
M. Hack, IMID'03

LTPS vs a-Si TFTs

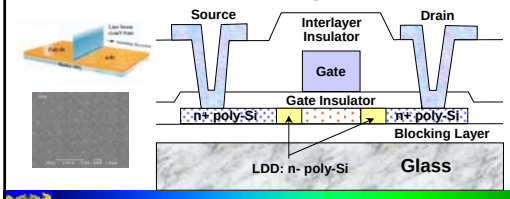
LTPS –TFT (ELA)
– Expensive process (~2 x a-Si TFT)
– Poor Uniformity
– Max out at 4th Gen Tools



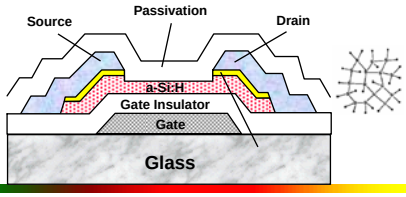
a-Si –TFT
– Low mobility (< 1 cm2/Vs)
– Operational instability (V_{th} shift)



LTPS TFT

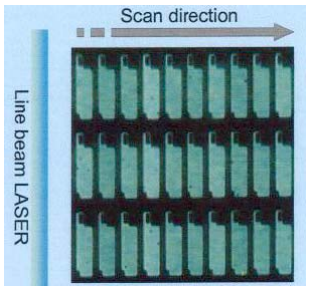


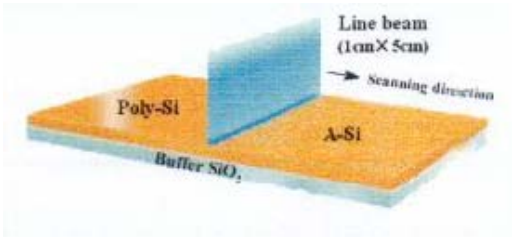
a-Si TFT



LTPS non-uniformity

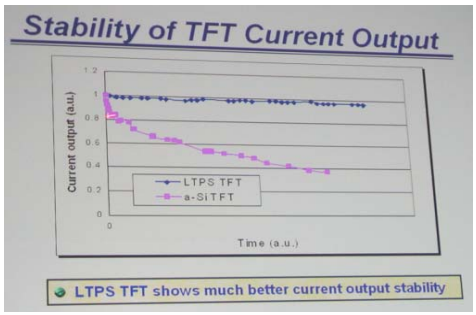
Non-uniformity problem of ELA (Excimer Laser Annealed) Poly-Si TFT
• XeXl (λ=308 nm) ELA: 가장 일반적인 Si 박막 결정화 방법
• Laser energy fluctuation
→ non-uniform crystallization
→ non-uniform V_{TH} and μ of poly-Si TFTs → non-uniform brightness

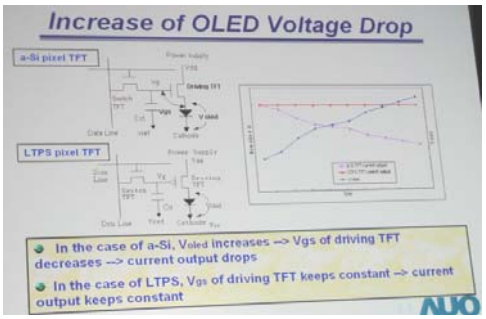




Possibility of a-Si TFT

- **Required Compensation of Vth Shifting**
- **Small Size High Resolution is very difficult (Low Mobility)**
- **Temp. Stability ?**



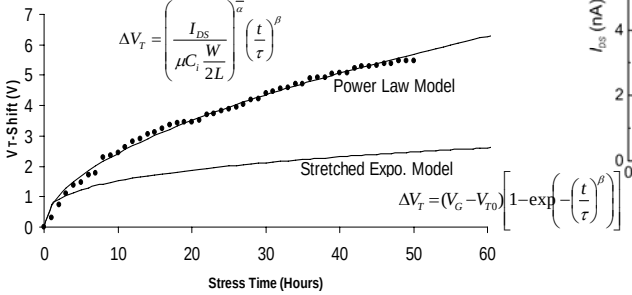


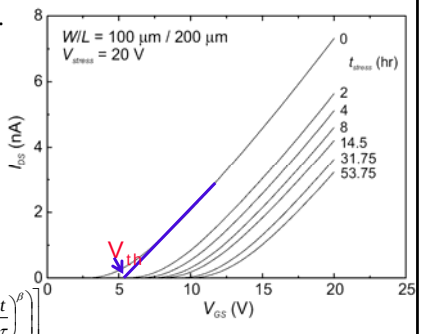
Threshold voltage shift of a-Si TFT

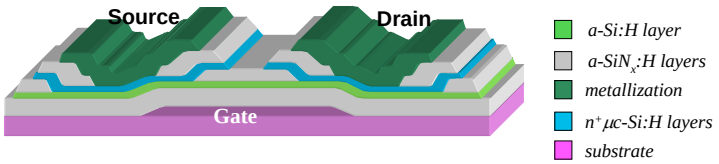
- Long term bias stress leads to threshold voltage shift (ΔV_{th}).

$$I_{OLED} = \frac{\mu_{eff}}{\alpha} C_i^{\alpha-1} \frac{W}{L} (V_{GS} - V_T)^{\alpha}$$

$$\Delta V_T = \left(\frac{I_{DS}}{\mu C_i \frac{W}{2L}} \right)^{\frac{1}{\alpha}} \left(\frac{t}{\tau} \right)^{\beta}$$







- *a-Si:H layer*
- *a-SiN$_x$:H layers*
- *metallization*
- *n$^+$μc-Si:H layers*
- *substrate*

A. Nathan, IMID'05