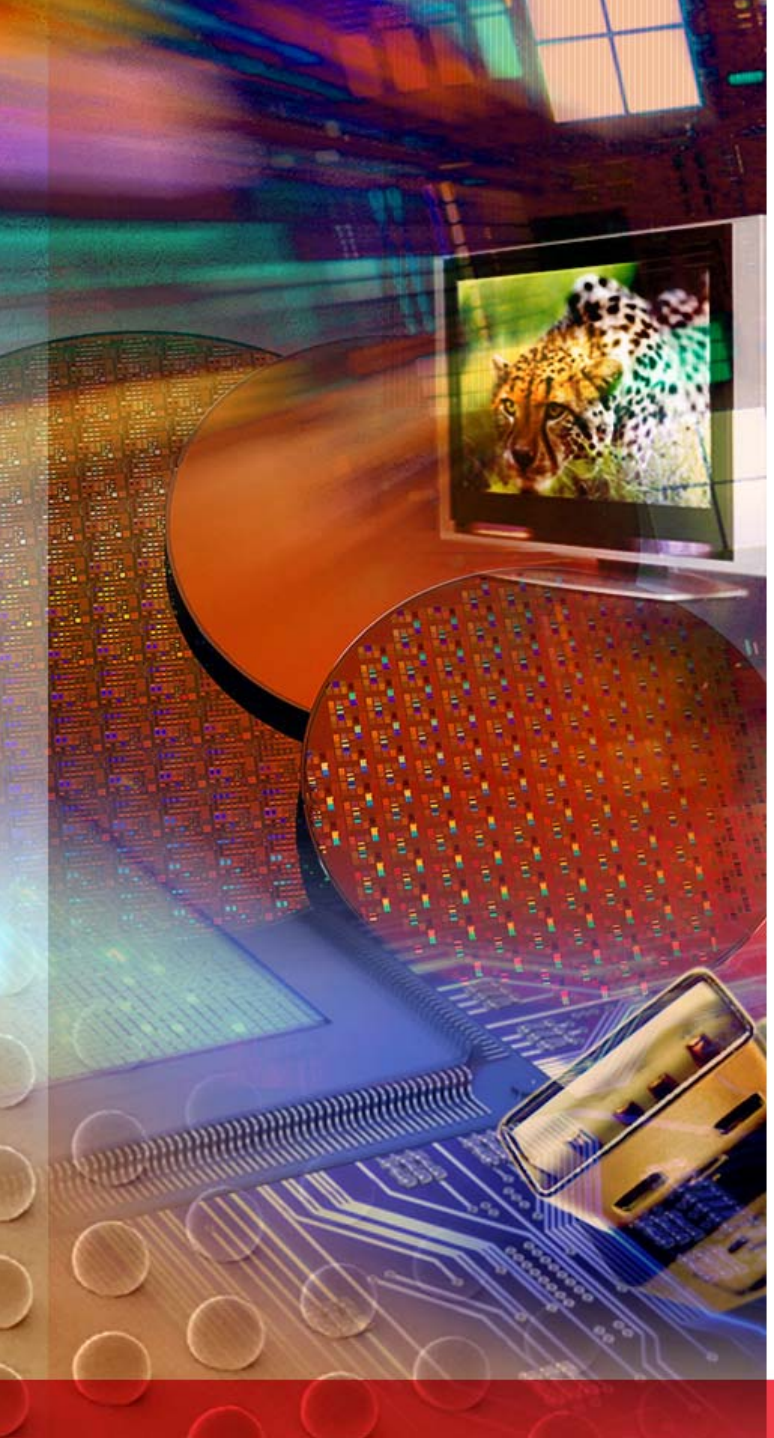


DOW Electronic Materials

Latest Materials for Displays

Feb/24/2011

Symposium on Advanced Composite Materials

Yoshiki Nakagawa

Technical Marketing

DISPLAY CHEMICALS / DISPLAY TECHNOLOGIES

ROHM AND HAAS ELECTRONIC MATERIALS

(DOW CHEMICAL GROUP)

Contents

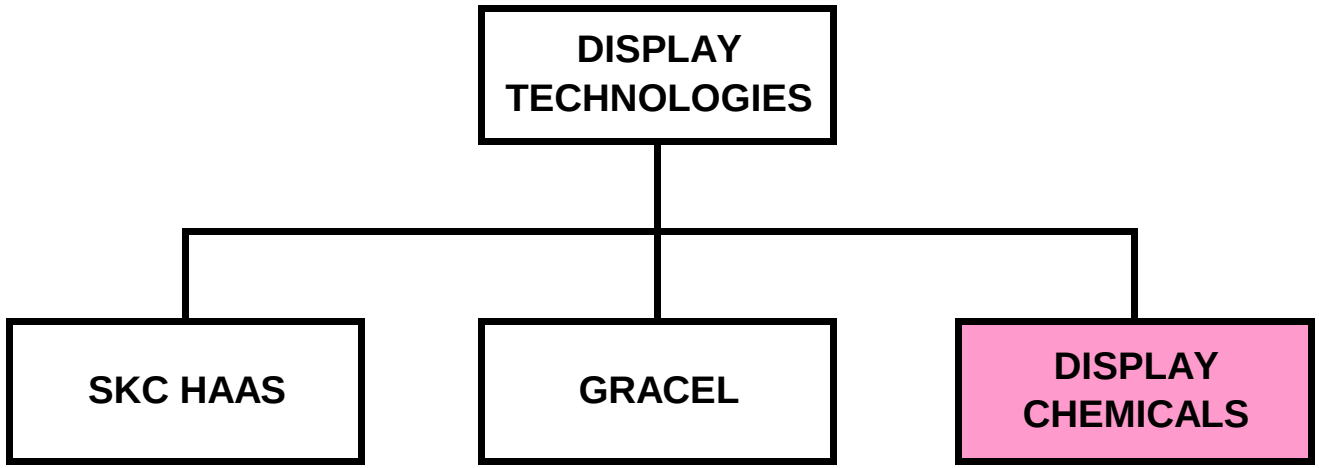
About Dow Chemical Company

On April 1, 2009, Dow acquired Rohm and Haas Company

- **Specialty and electronic chemicals**
- **Market focus**
- **Application technology**
- **$10B, 15,000 employees (2008)**

- **Operational excellence**
- **Global reach**
- **Technology innovation / Base material**
- **$58B, 46,000 employees (2008)**

Display Technologies in Dow Chemical Group



LCD Backlight Film
Functional Film
PDP Optical Filters
Mill Base

OLED Emitting Materials

Patterning Photoresist
LCD Functional Layers

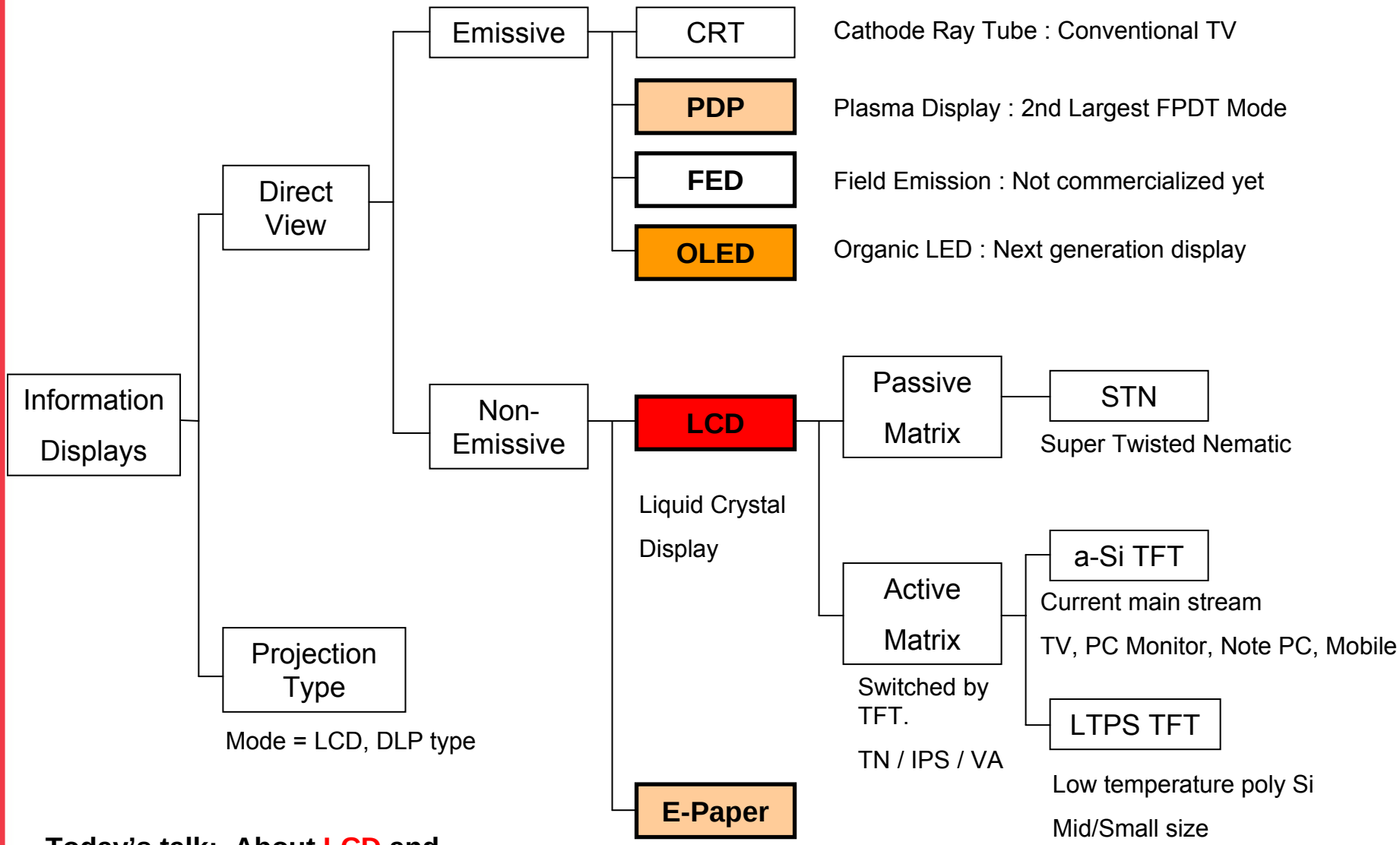
<Display Chemicals Operation Site>

Fab. : Cheonan (Korea), Sasakami (Japan)

R&D : Cheonan (Korea), Sasakami (Japan), New R&D Center (Korea, 2H/2011)

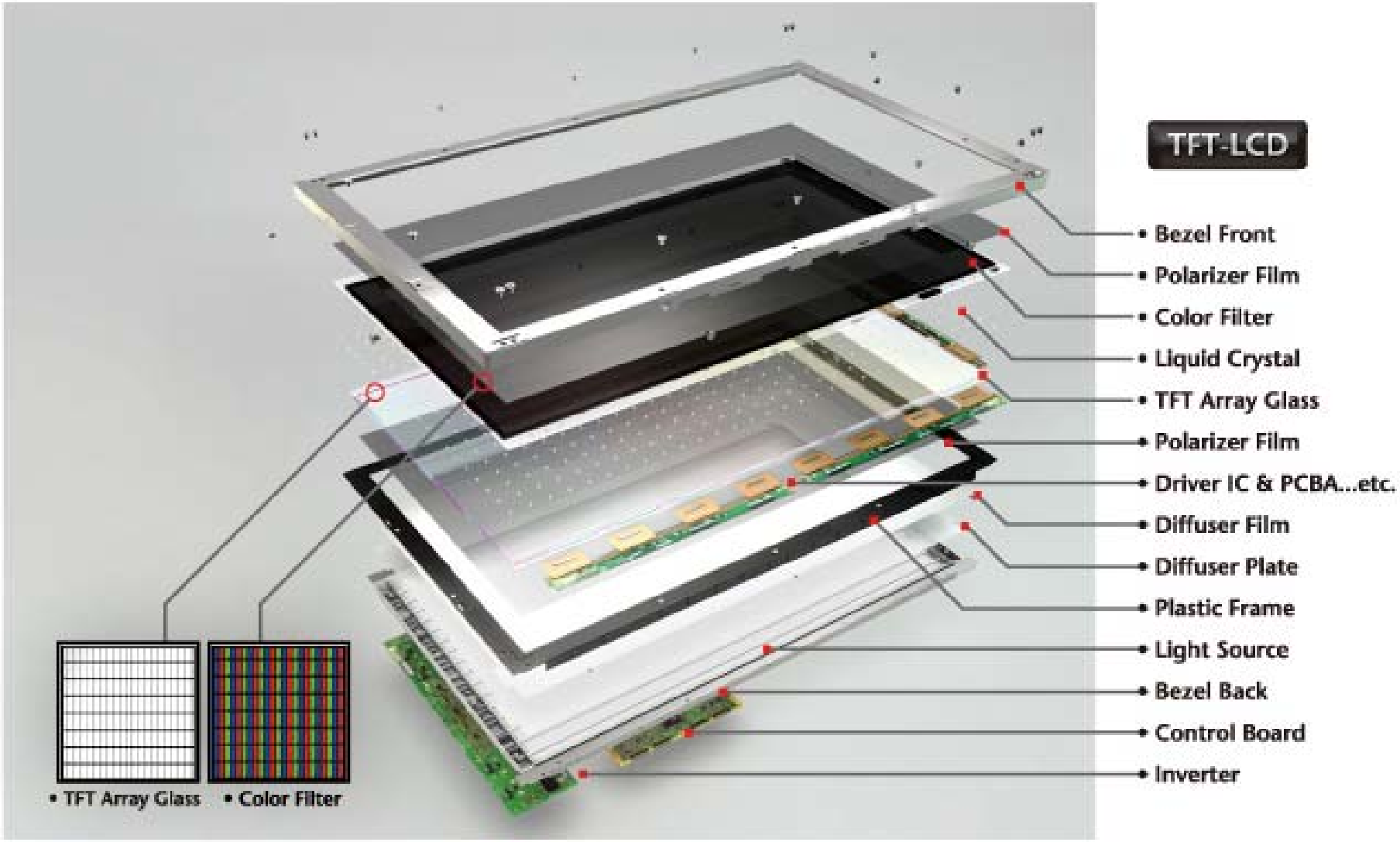
Sales Office : Seoul (Korea), Tokyo (Japan), Tao-Yang (Taiwan), Shanghai (China)

Display Category (What is FPD?)

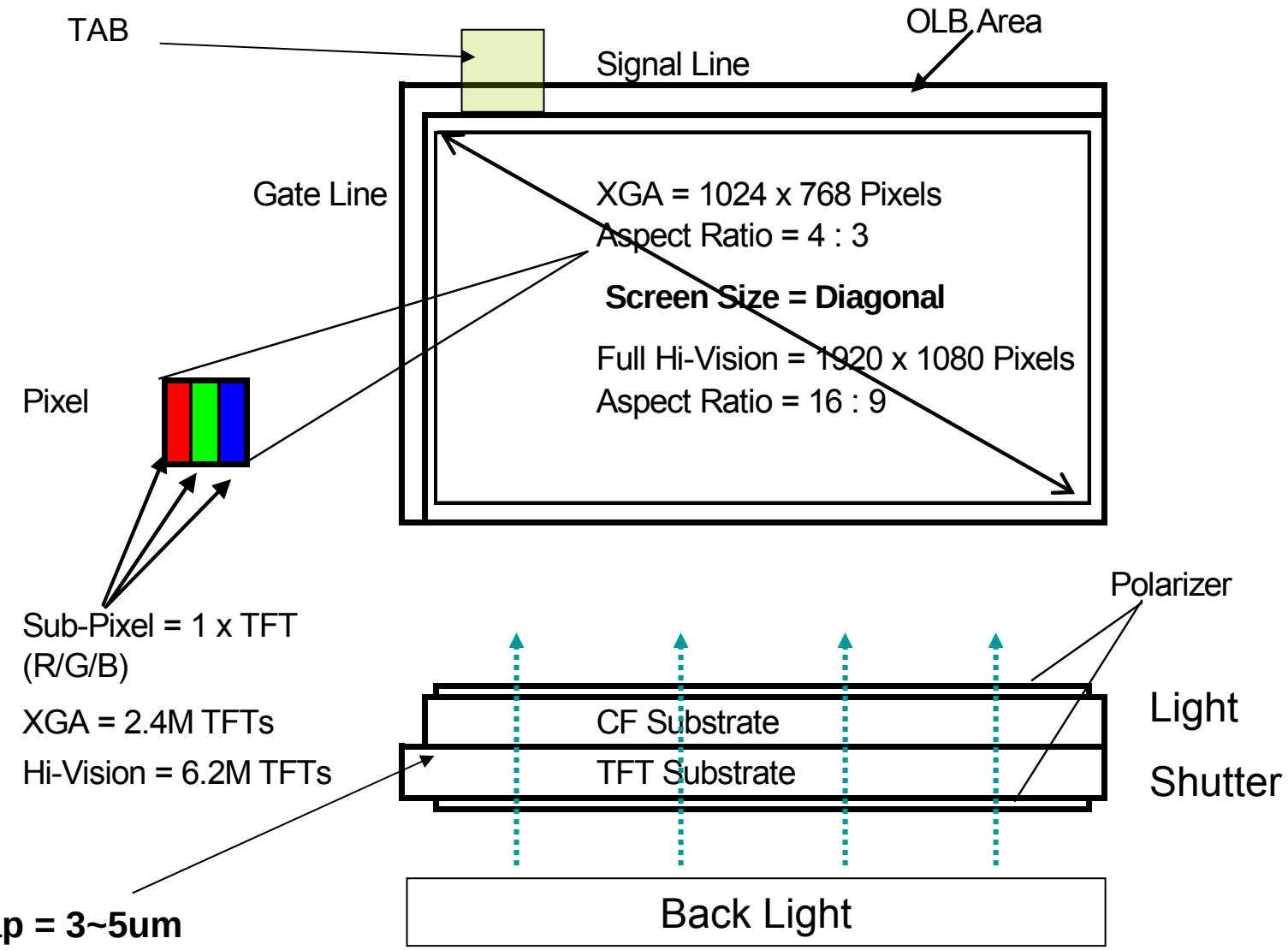


Today's talk: About LCD and E-Paper including Flexible display.

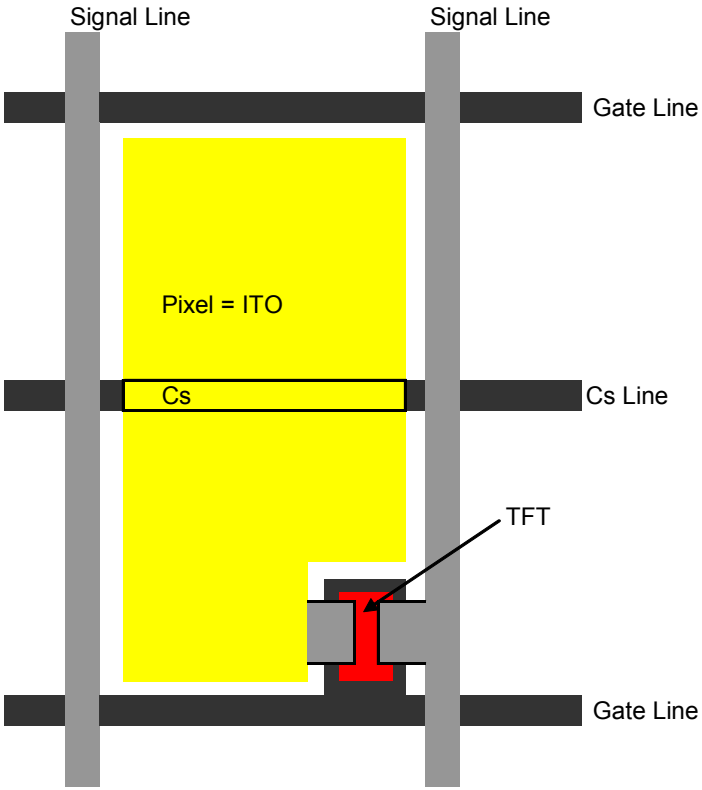
TFT LCD Structure -1

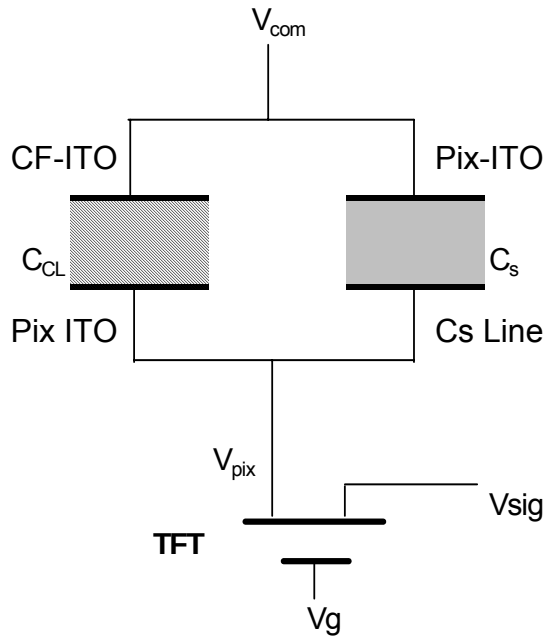


TFT LCD Structure -2



Sub-Pixel Image





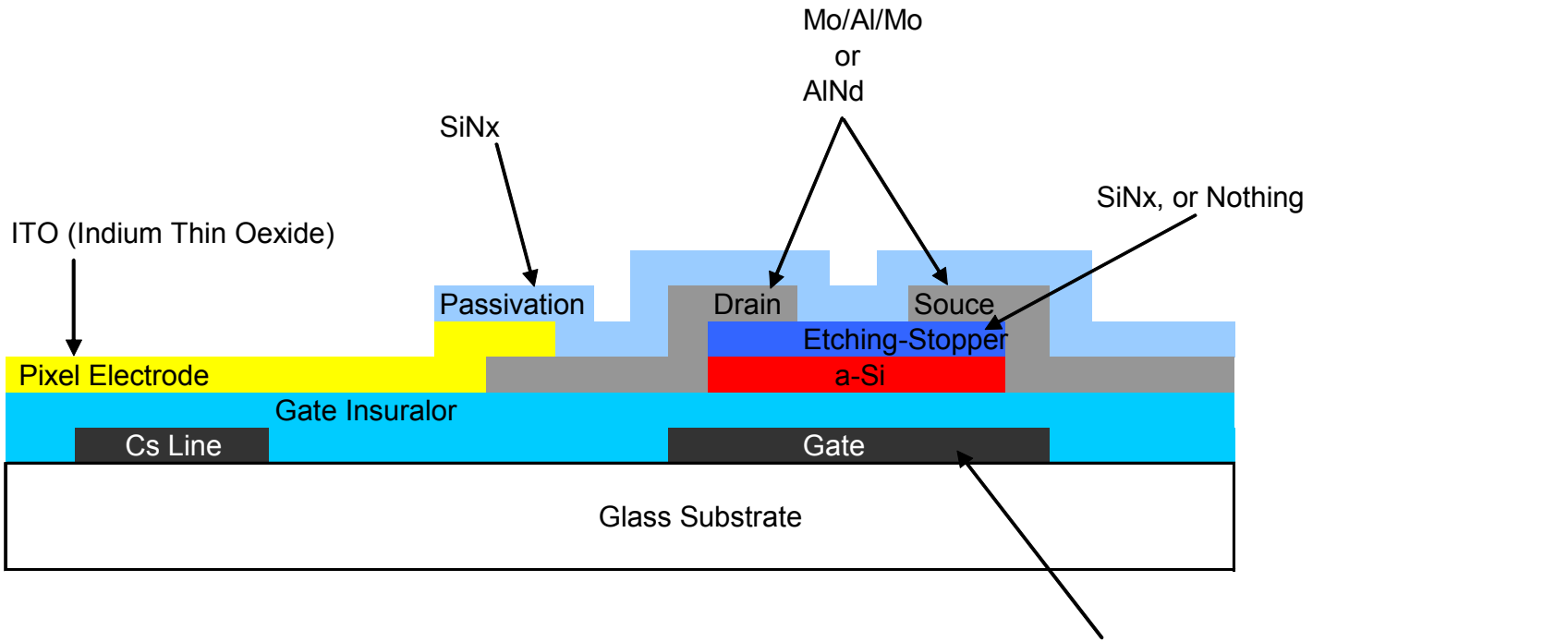
Drive: AC Control

Original TV Signal Frame rate : 60Hz

HDTV = 1080 (V) x1960 (H) dots

TFT X-Section Image

a-Si TFT Structure (Bottom Gate Type)



4 ~ 7 Masks are required.

One mask:

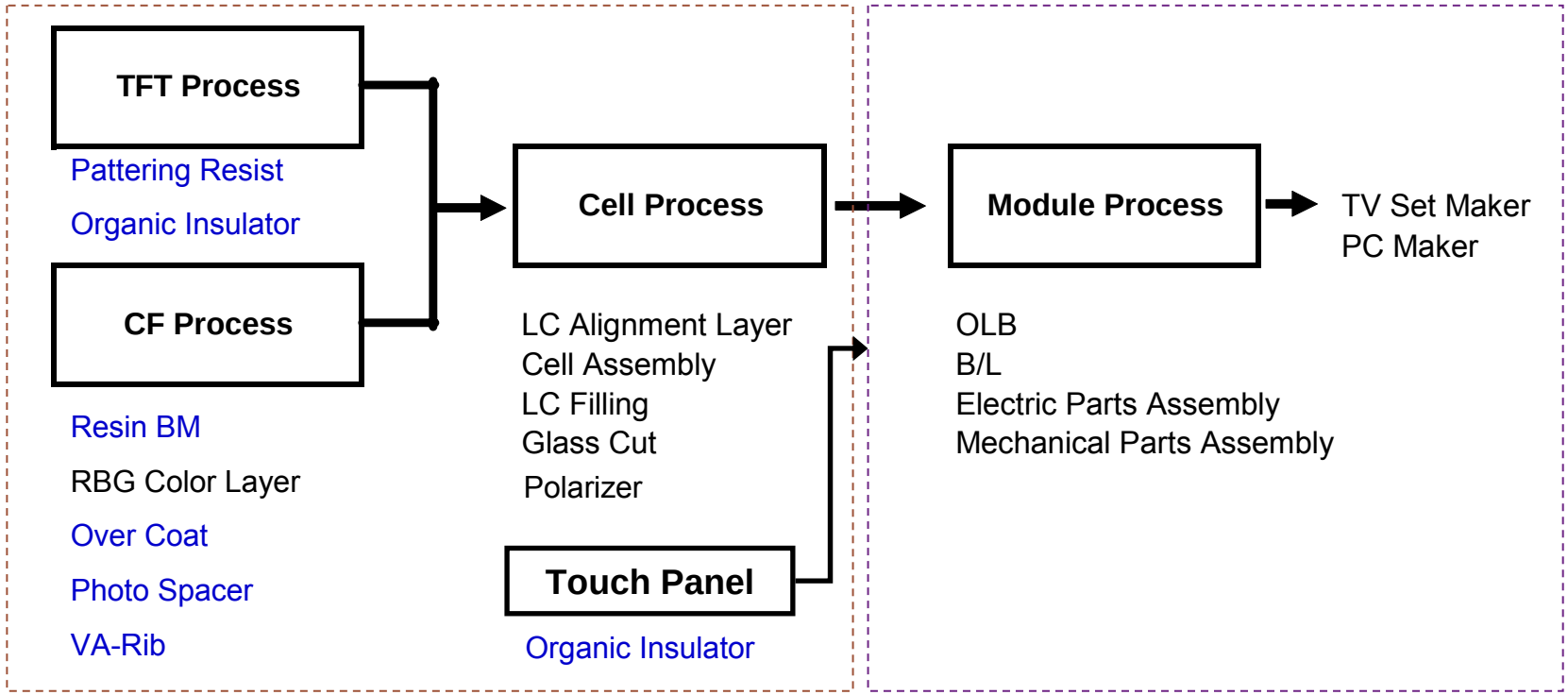
Film Depo.→ Resist Coating

→Photo Litho → Dev. → Etch.→ Resist Remove

Cu Gate technology is ready.

LCD MFG Process / Dow Products

LCD MFG FLOW



Display Chemicals **SKC-HAAS**

Contents

Key Words in FPD Industry : History

Historical Key Words in FPD Industy

Category		1990~	2000~	2010~
Main Customers		Japan	Korea / Taiwan	China
Application		Note PC Monitor	LCD TV Mobile Phone	3D TV Touch Panel
Dipslay Mode		LCD PDP	(OLED)	OLED E-Paper
LCD Key Technology	Back-plane	a-Si TFT	LTPS TFT	Oxide SC TFT Organic SC TFT
	LC Mode	TN	IPS/FFS VA	Photo Alignment VA PSA
	BLU	CCFL		LED

TFT: Thin Film Transistor

LTPS: Low Temperature Poly-Si

TN: Twisted Nematic

IPS: In-plane Switching

VA: Vertical Alignment

PSA: Polymer Sustainable Alignment

BLU: Back Light Unit

FFS: Fringe Field Switching

CCFL: Cold Cathode Fluorescence Light

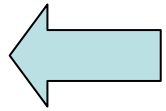
Key Words in FPD Industry : 2010~

KEY WORD in 2010 ~

	Key Word	Sub Key Words	Technical Words	
	Green	Low Power Consunption	High Trasmittance	CF on Array Rib-Less Design(Photo-Alignment, PSA) 4 Pixels Design (Yelllow or White)
			LED BLU	Low Power, Hg Free Local Deming, Slim Design
	China	Large Consumer Maket	Low cost product	Fast LCD Shft from CRT LCD TV price down
		New TFT Fab Construction	New Customers	
New Applications	3D	3D Movie	Avatar, New TV Channel	PDP is also matched with 3D.
	Touch Panel	Windows 7	To Support Touch Panel Function	IPS/FFS (Strong for Finger Touch)
		i-Pad	Full Touch Panel Function	
	E-Paper	Amazon Kindle, SONY Reader	E-Ink, Flexible Sustrate (in the futre) Digital Sinage	

Another Key Word : **M&A, Alliance** (e.g. Innolux/CMO/TPO ➔ CMI)

Contents



3. Latest Materials in LCD & Others (Summary)

1. New Semiconductor for TFT : Next mode of LTPS, High Mobility

Oxide SC : TAOS (Transparent Amorphous Oxide Semiconductor)

Organic TFT

2. Fast Response LC Mode : 3D, High Frame Rate

PFA : Polymer sustainable alignment for VA mode

Photo Alignment for VA mode

3. Wide Aperture Technology: Low Power Consumption

Transparent Polymer Film on TFT Array Technology

CF Layers on TFT Array Technology

4. Touch Panel: New Application

Very High Transmittance

5. Flexible Display/E-Paper: New Application

Low temperature process-able materials for plastic substrate

6. CVD Layer Replacement: Low Cost MFG, Dry → Wet Process

Gate Insulator

TFT Passivation Layer

There are other new materials are also discussed.

For example: Blue Phase LC Mode, Ink Jet Printing Process, etc.

3-1. New Semiconductor for TFT: Oxide Semiconductor

TAOS: Transparent Amorphous Oxide Semiconductor (Prof. Hosono, TIT)

High TFT channel mobility

Almost same as LTPS (Low Temperature Poly-Si)

Sputtering Process (a-Si = CVD)

Material: IGZO (InGaZnO: In_2O_3 + ZnO + Ga_2O_3), etc..

Needs: 1) To replace for LTPS (About 9 Mask) → OLED TV

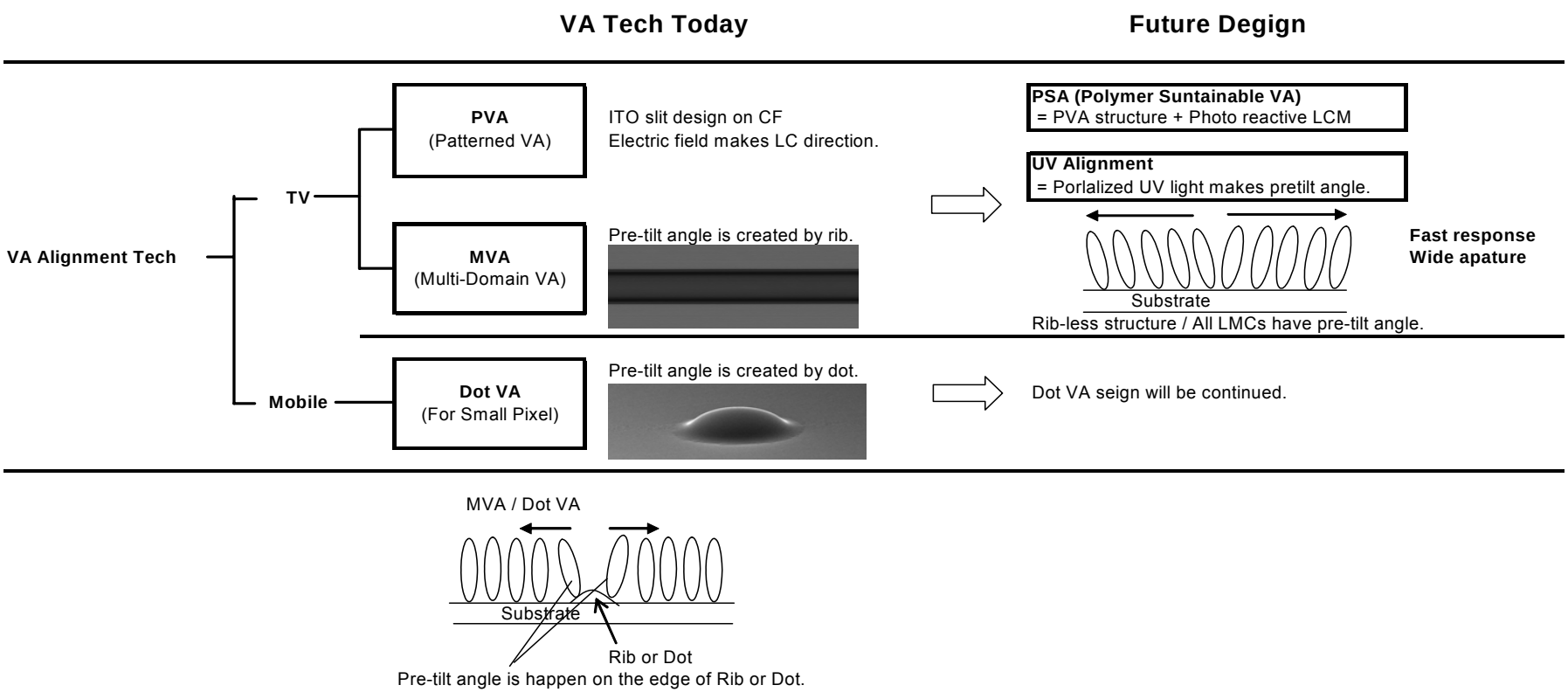
SONY, AUO

2) Large size TV + High Resolution (2kx4k) + High Frame Rate (>120Hz)

Samsung, 70”, Dot=2kx4k, 3D-TV (2010)

3-2. Fast Response LC Mode

New LC Vertical Alignment Control Technology



IDW'10: H. Okada et. al., Sharp, Japan

The UV²A Technology for Large Size LCD-TV Panels

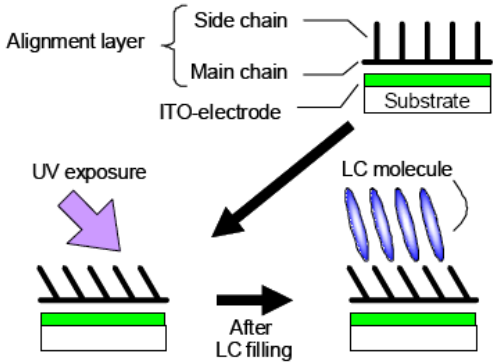


Figure 1. Schematic illustration of alignment behavior.

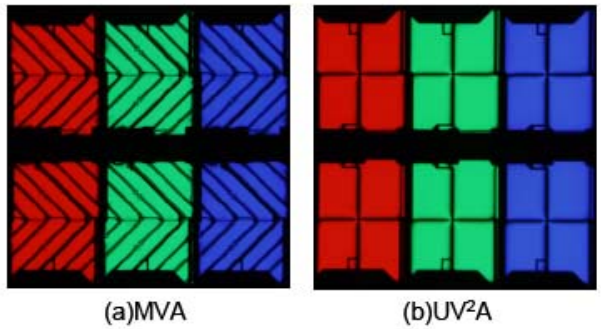


Figure 2. Photographs of On-state.

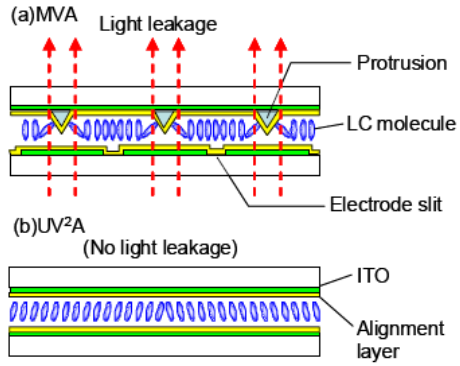


Figure 5. Schematic illustration of Off-states.

Photo alignment makes following Merits.

1) Wide aperture
2) Low photo leakage
3) Fast response
4) Matched with new 4 pixels design.
   (=MVA needs symmetric rib design.)

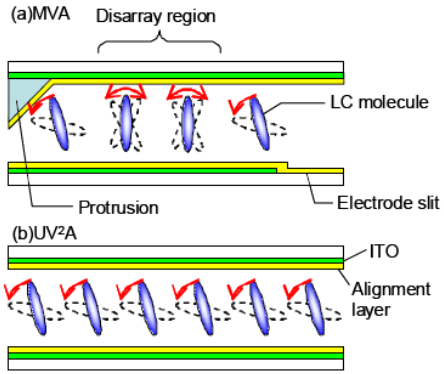


Figure 8. Schematic illustration of switching behavior.

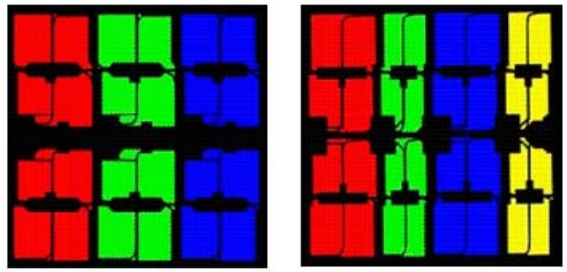
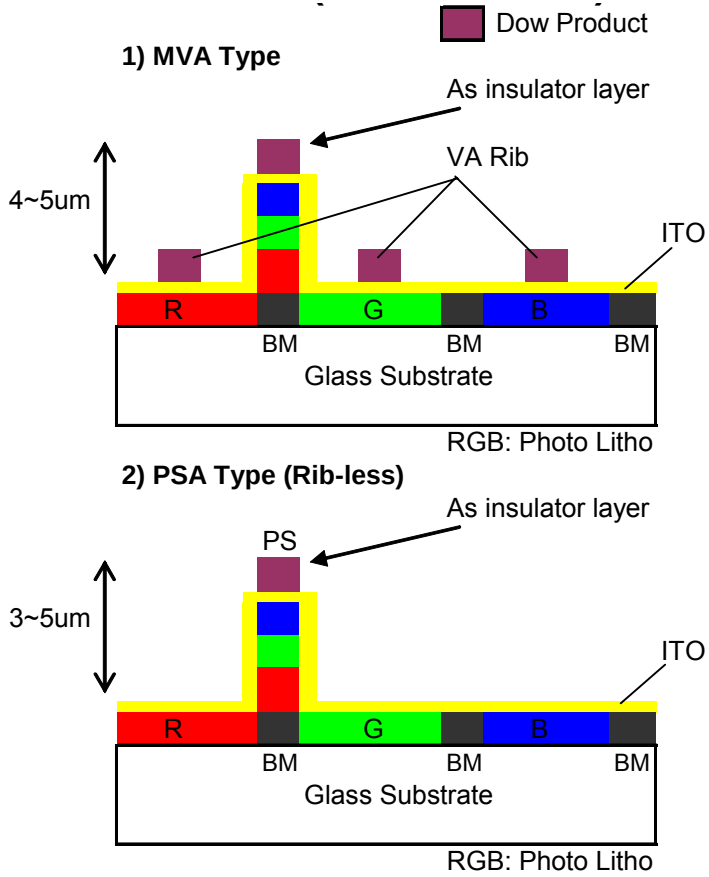


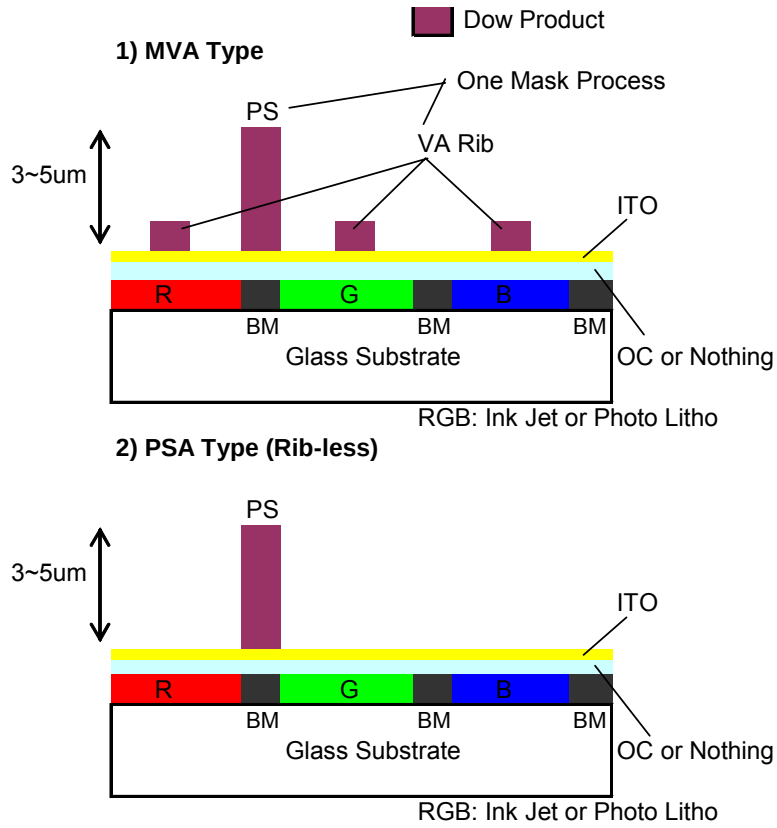
Figure 9. Pixel design.

Compatible CF Process (Rib / Rib-less)

TYPE-1



TYPE-2



Dow: Novolac Resin Base Products

3-3. Wide Aperture Technology

1. CF Layers on TFT Array Substrate Design

To reduce glass alignment tolerance between CF And TFT.

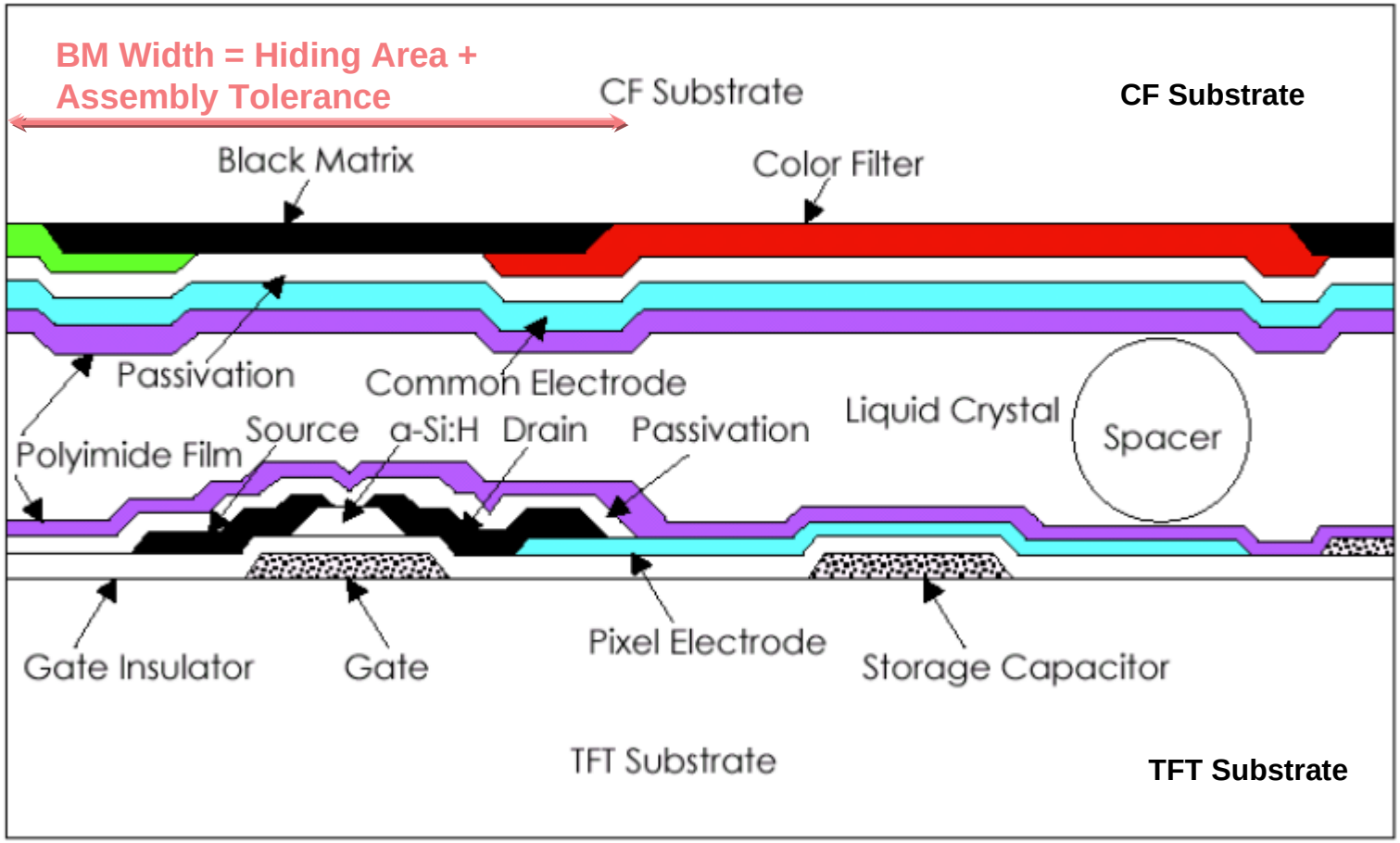
2. Organic Insulator on TFT Design

Bubble Decker structure = To reduce unexpected Capacitor

ITO pixel electrode

Reduce Glass Alignment Tolerance

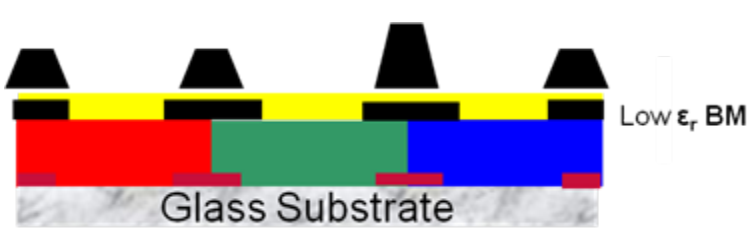
Cross-sectional View Through an AMLCD Pixel



Black Matrix : Needs to set glass assembly tolerance between CF and TFT substrate.

At least BM layer should be moved to TFT substrate side from CF.

Black Matrix on TFT Array



-Consolidation BM + CS : 1Mask reduce
-Cover all of BM areas

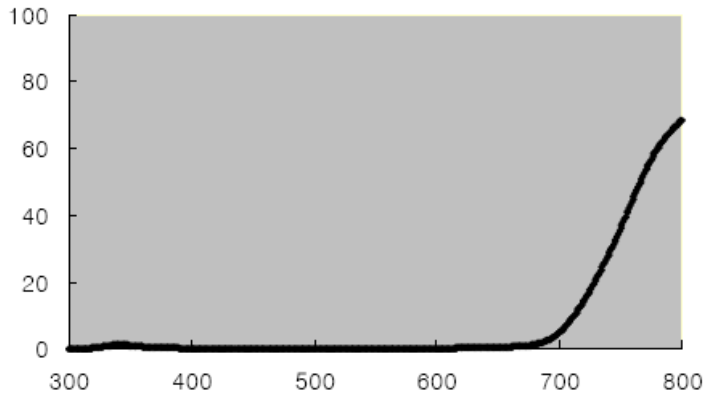
Figure : CF on TFT Array Design (Black Matrix and R/G/B layers are moved to TFT substrate side.)

- ***Dielectric constant***

-On 1MHz / Agilent 4284A

Material	Organic insulator material	Organic black material	Carbon black material
ε_r	3.34~3.42	3.35~3.45	>15

- ***UV-Vis***



FT = 2.5um

Dow Products:

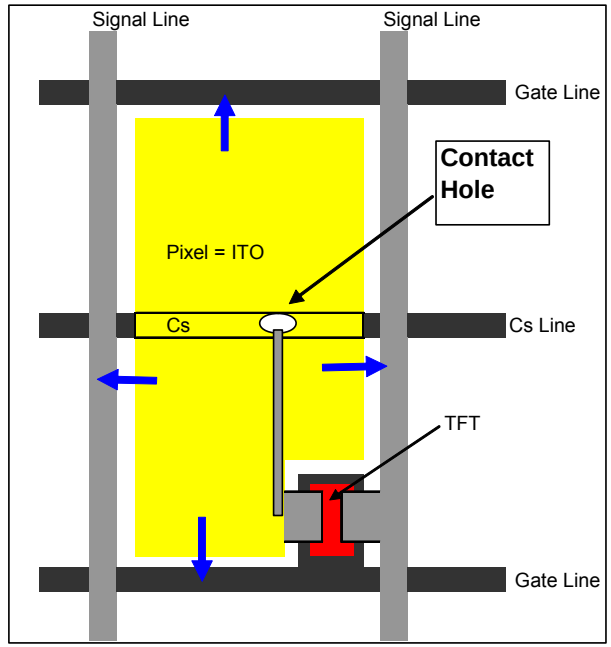
Special black material was applied.

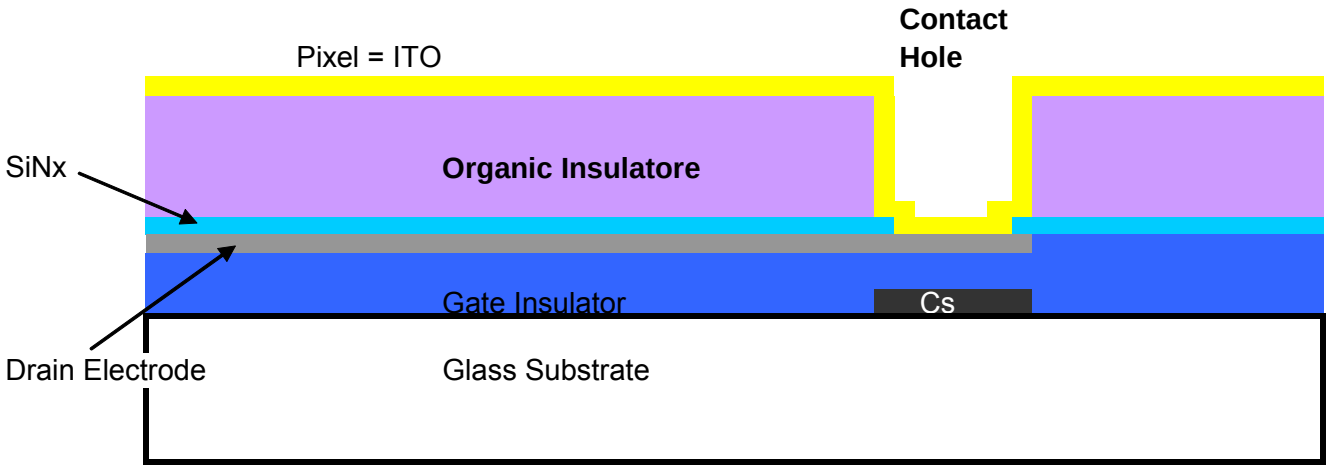
"OD" value requirement can be relaxed for BM on Array design, due to metal lines under BM.

Organic Insulator for Wide Aperture

Wide Aperture Design

Using Organic Insulator on TFT Array





Organic Insulator for Wide Aperture

Conventional Material :

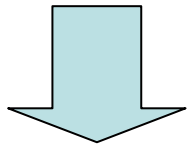
Positive tone system (PAC) + Acrylic polymer

Needs to improve

1) Higher sensitivity (short tact time)

2) Lower out gas

3) Higher thermal resistance (Yellowish color, >230degC)



Dow supposed PAC is the cause of these points.

Dow products: 1st Step (for TV application)

Negative tone system (Photo Initiator + Photo reactive monomer) + Acrylic polymer

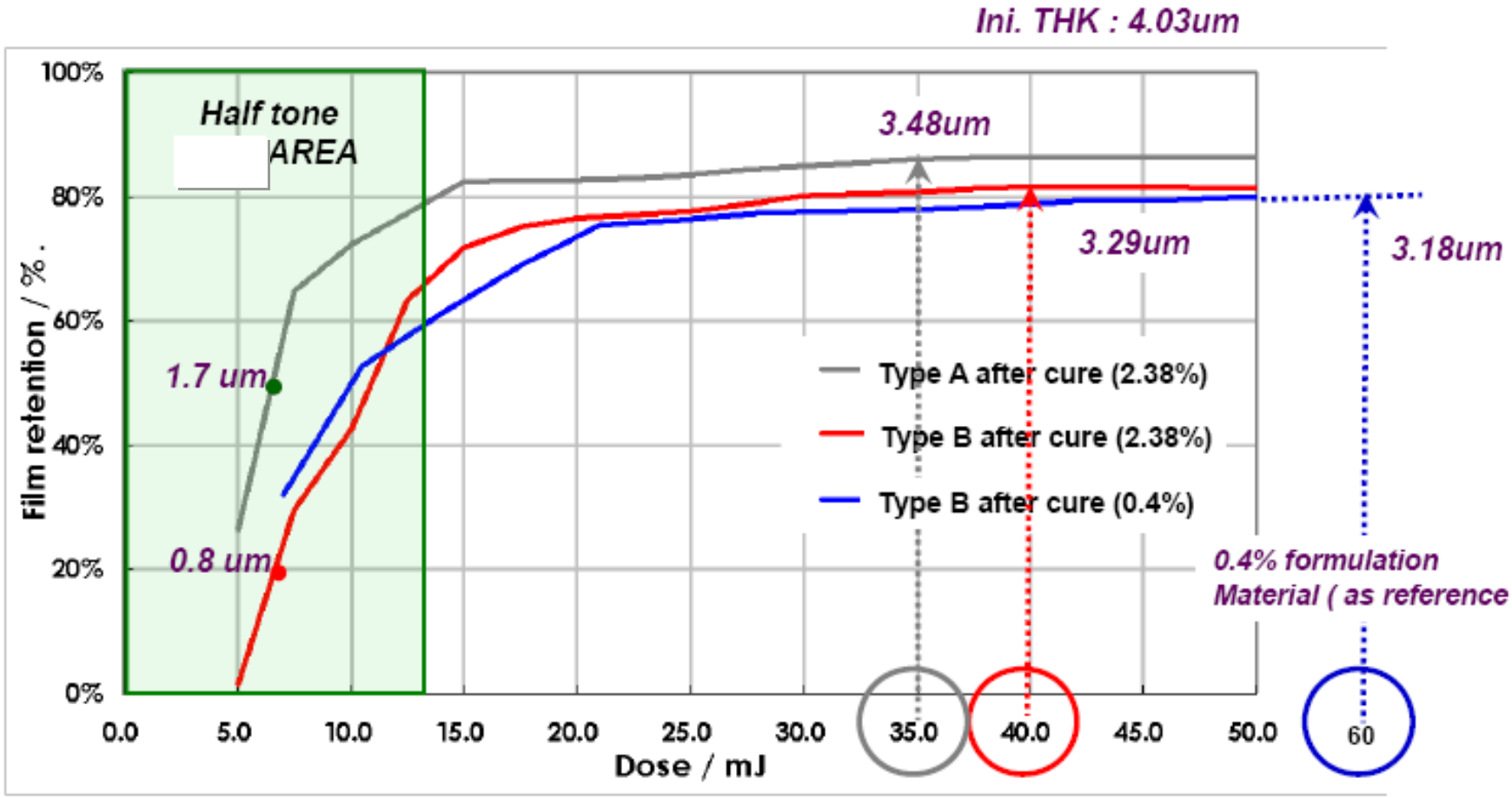
We needed to improve following general weak points of Negative Tone.

a) Resolution of contact hole size

b) Half tone control (multi height by halftone mask)

PAC: Photo Active Compound

Organic Insulator for Wide Aperture



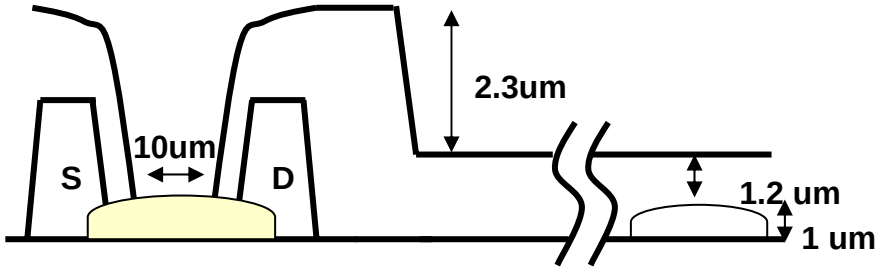
Next Direction of Negative Tone Insulator

1st NPL	2nd NPL (Current stage)	3rd NPL (Already Started)
High Transmittance **High sensitivity** **High Aperture ratio**	↓	↓
	1ST NPL Properties **+** **High process margin** **High Resolution (< 6um)**	**New material** **High RI material** **& High Resolution (~4um)**
Developer = 0.4% TMAH version	**<New Product>** **Developer** **2.38% TMAH Version**	

NPL : Negative tone organic passivation layer (= Still it it is not actual passivation layer)

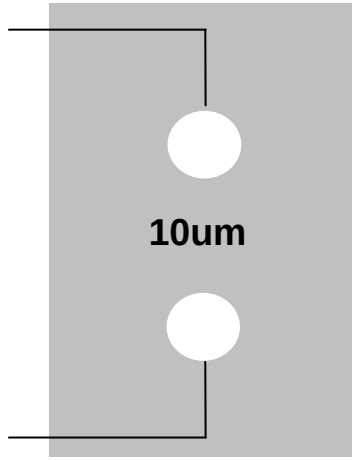
TMAH: Tetra-methyl ammonium hydroxide

2nd NPL : More Higher Resolution

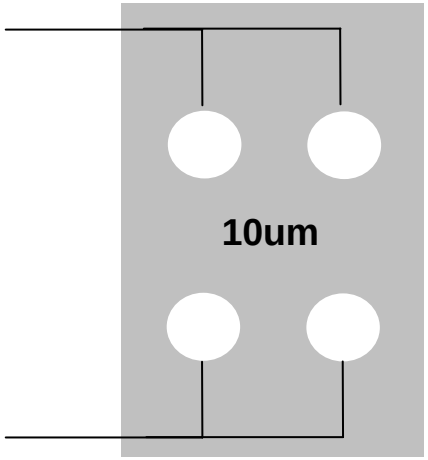


<Nega. Passivation Architecture>

S-PVA (120Hz) : 1Gate-2Data line

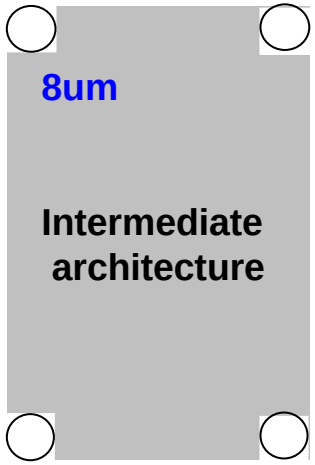


S-PVA (240Hz) : 1Gate-4Data line

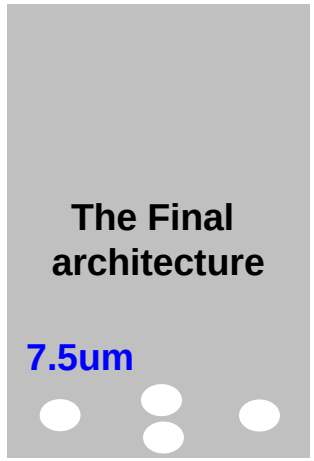


More smaller C/T hole is needed to overcome Aperture ratio down.

New



New



Technical Barrier : High Resolution with Taper & Enough DoF margin

3rd NPL : Higher Reflective Index

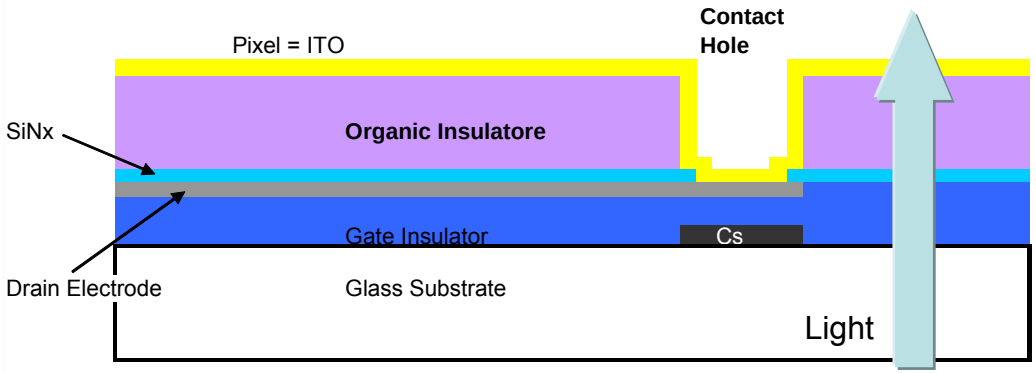
- ***Reflective Index VS. Transmittance***

RI of Passi	RI of IZO	Transmittance (%)
1.45	1.89	86.8
1.55		90.1
1.65		93.2

RI of Passi	RI of SiNx	Transmittance (%)
1.45	1.68	92.6
1.55		96.0
1.65		99.1

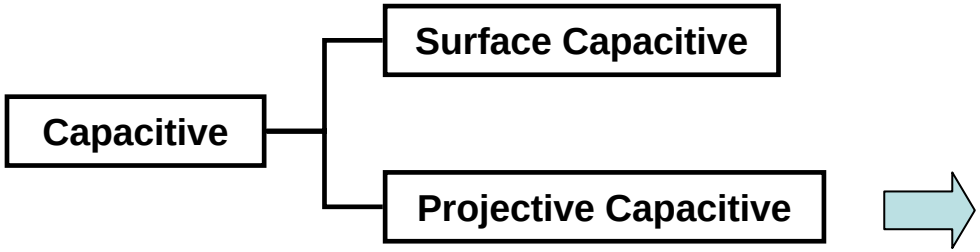
RI of Passi	RI of IZO	RI of SiNx	Transmittance (%)
No layer	1.89	1.68	94.1
1.45			87.2
1.55			90.3
1.65			93.3

Pixel Electrode
= ITO or IZO



Technical Barrier :
1. New Material is needed
2. Keeping the Transmittance 98% in material itself.
3. Keeping the litho performance

3-4. Touch Panel



Prj-Cap type is applied for recent smart phone and tablet PC.

Finger Multi-Touch can be applied.

High transparent material is needed.

For inter-layer and top coat.

Resistive

Fine resolution.

Pen touch input is matched with this mode.

Optical / Acoustic

Additional panel is not needed on FPD screen.

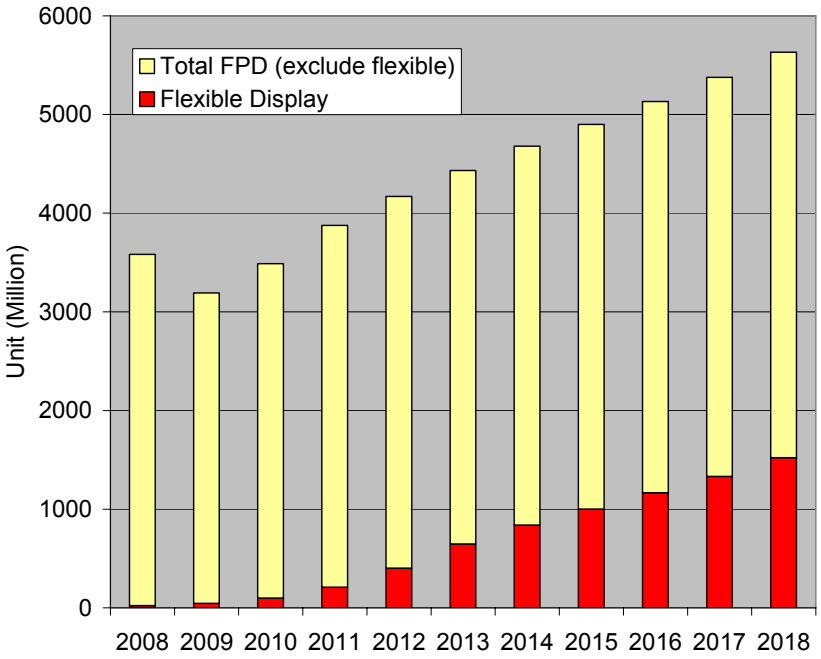
Large size TV will pick up these modes.

In Cell Type

Sharp, TMD, and others are developing this mode.

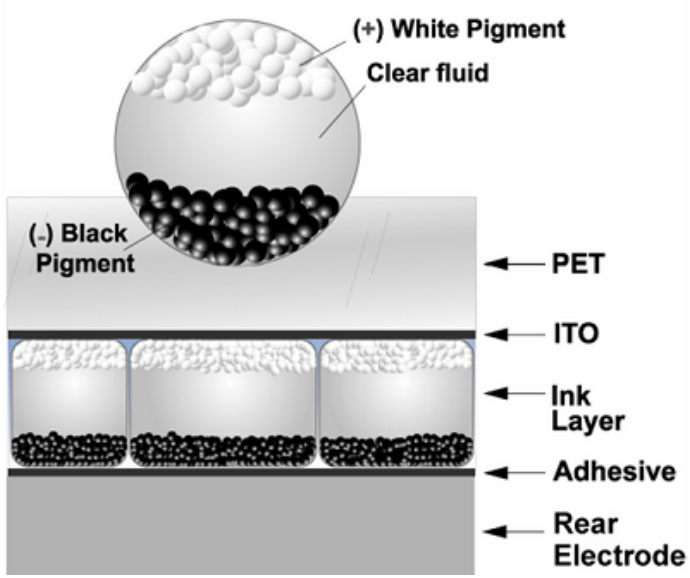
TFT is used for Photo Sensor.

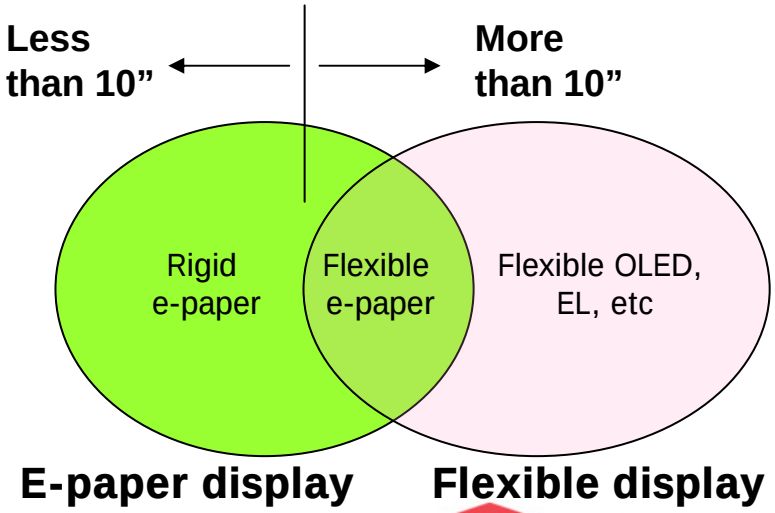
3-5. Flexible Display / E-Paper



From Display Search (Jan/2010)

Electrophoretic Mode: E-Ink

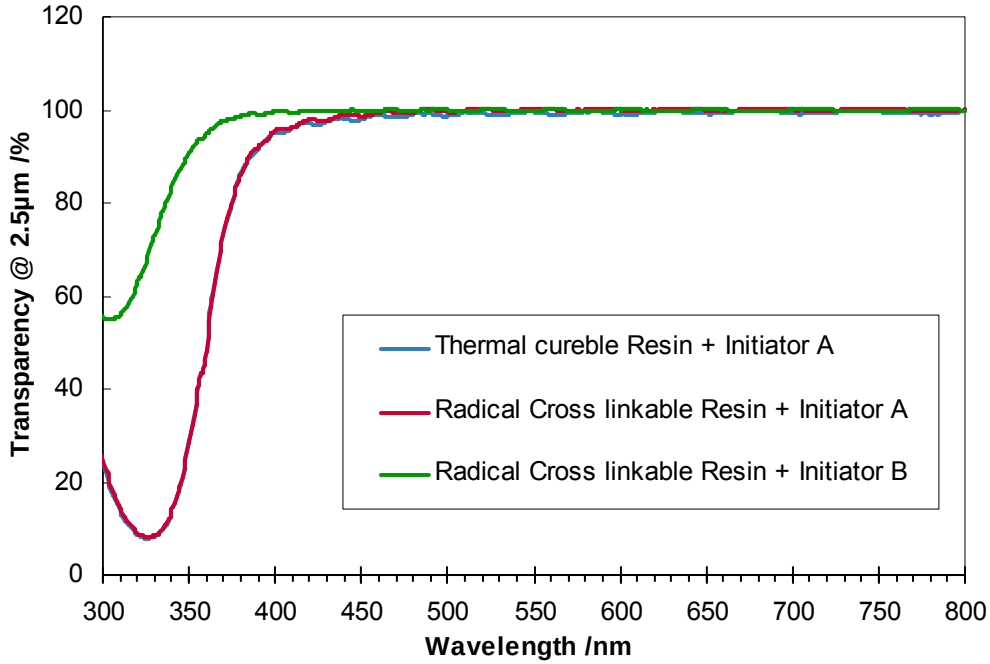




Substrate : PET, PEN

Process Temperature Requirements; =< 150degC

High Transmittance & Low Temperature Curable Material



SUB: 4'' Si Wafer

FT: 2.5μm (after cure)
SB: 100° C / 90sec
EXP: (g+h+I), ≦330 cut filter
PROX GAP: 50μm
DEV: 0.4wt%TMAHaq
HB: 150° C / 5min

		Transparency at 2.5μm		
Polymer	PI	400nm	380nm	360nm
Thermal Curable	A	95.0	86.2	45.7
Radical Cross linkable	A	95.2	85.9	45.7
Radical Cross linkable	B	99.5	98.6	94.4

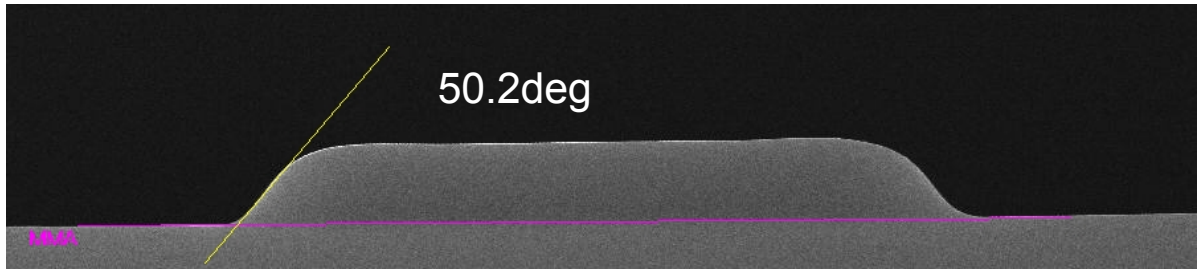
Acrylic Resin Base Product

- Transparency was improved by selecting high efficient photo initiator.

Taper Angle Control for Touch Panel and Flexible/E-Paper

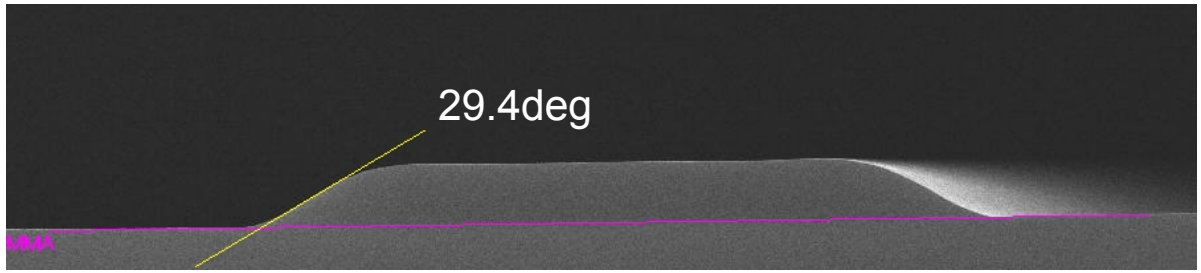
Cross Linker A

49mJ/cm²



Cross Linker B

40mj/cm²



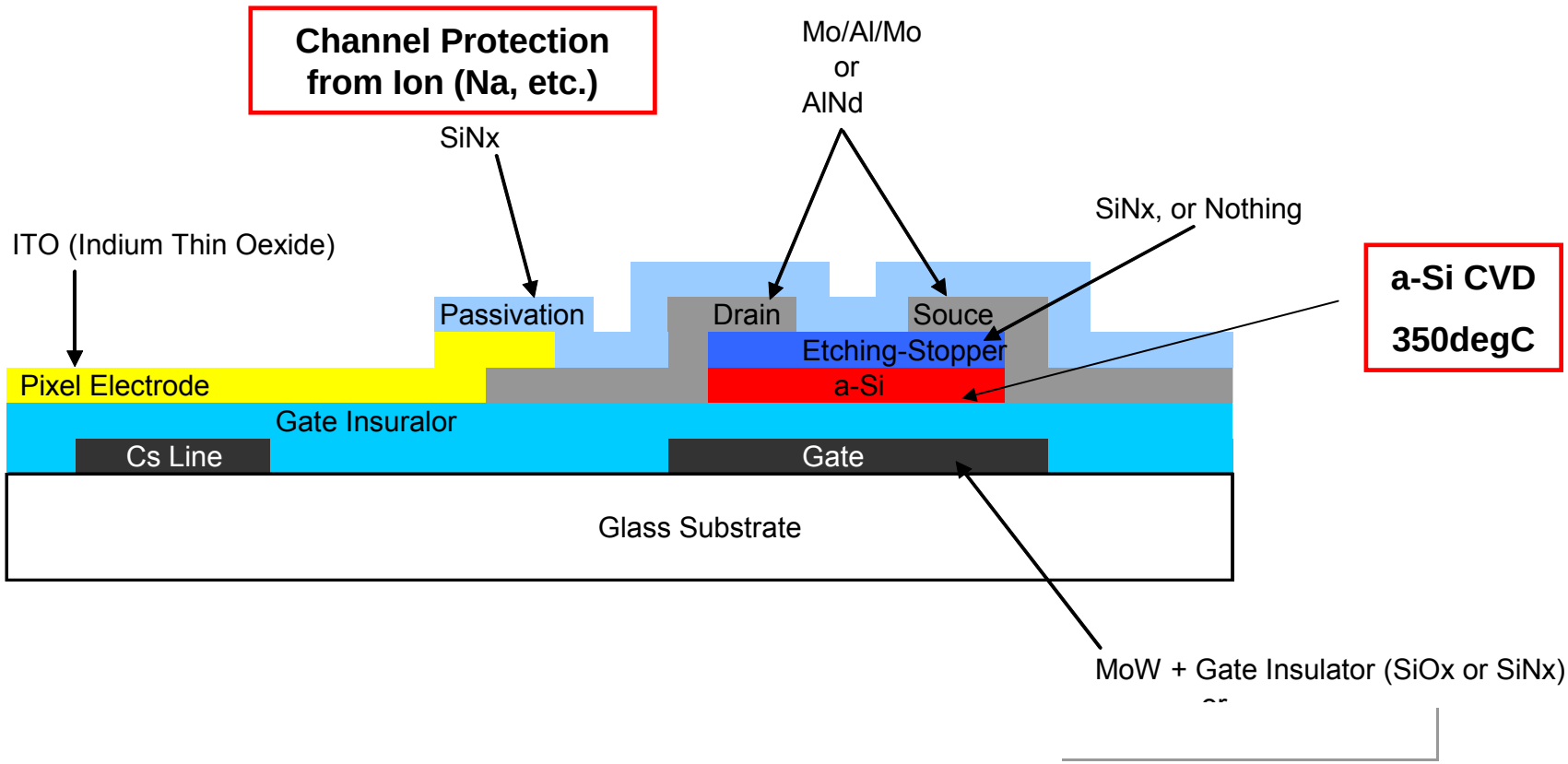
SUB: 4'' Si Wafer
FT: 2.5μm (after cure)
SB: 100° C / 90sec
EXP: (g+h+I), ≦330 cut filter
PROX GAP: 50μm
DEV: 0.4wt%TMAHaq
HB: 150° C / 5min H.P.

Thermal flow properties can not apply for low temperature curable application.

- Side wall angle can be adjustable by selecting cross linker.

3-6. CVD Layer Replacement

a-Si TFT Structure (Bottom Gate Type)



3-6. CVD Layer Replacement

	Gate Insulator	TFT Passivation
Current Material (CVD)	SiOx or SiNx	SiOx or SiNx
Thermal Resistance	350degC (at least > 320degC)	230degC for LC Alignment layer bake
Transparency	High Transmittance is required.	It depends on design. Some design needs transparency.
Moisture Barrie	Not required.	Mobile: Not so sevir TV: Almost same as SiNx (50nm)
Others	Basically photo-imagable property is required, but non-photo-imagable is an option for total balance.	

3. Latest Materials in LCD & Others (Summary)

1. New Semiconductor for TFT : Next mode of LTPS, High Mobility

Oxide SC : TAOS (Transparent Amorphous Oxide Semiconductor)

Organic TFT

2. Fast Response LC Mode : 3D, High Frame Rate

PFA : Polymer sustainable alignment for VA mode

Photo Alignment for VA mode

3. Wide Aperture Technology: Low Power Consumption

Transparent Polymer Film on TFT Array Technology

CF Layers on TFT Array Technology

4. Touch Panel: New Application

Very High Transmittance

5. Flexible Display/E-Paper: New Application

Low temperature process-able materials for plastic substrate

6. CVD Layer Replacement: Low Cost MFG, Dry → Wet Process

Gate Insulator

TFT Passivation Layer

There are other new materials are also discussed.

For example: Blue Phase LC Mode, Ink Jet Printing Process, etc.

DOW Electronic Materials

THANK YOU FOR YOUR ATTENSION.