CMO

液晶顯示技術：廣視角與快速響應

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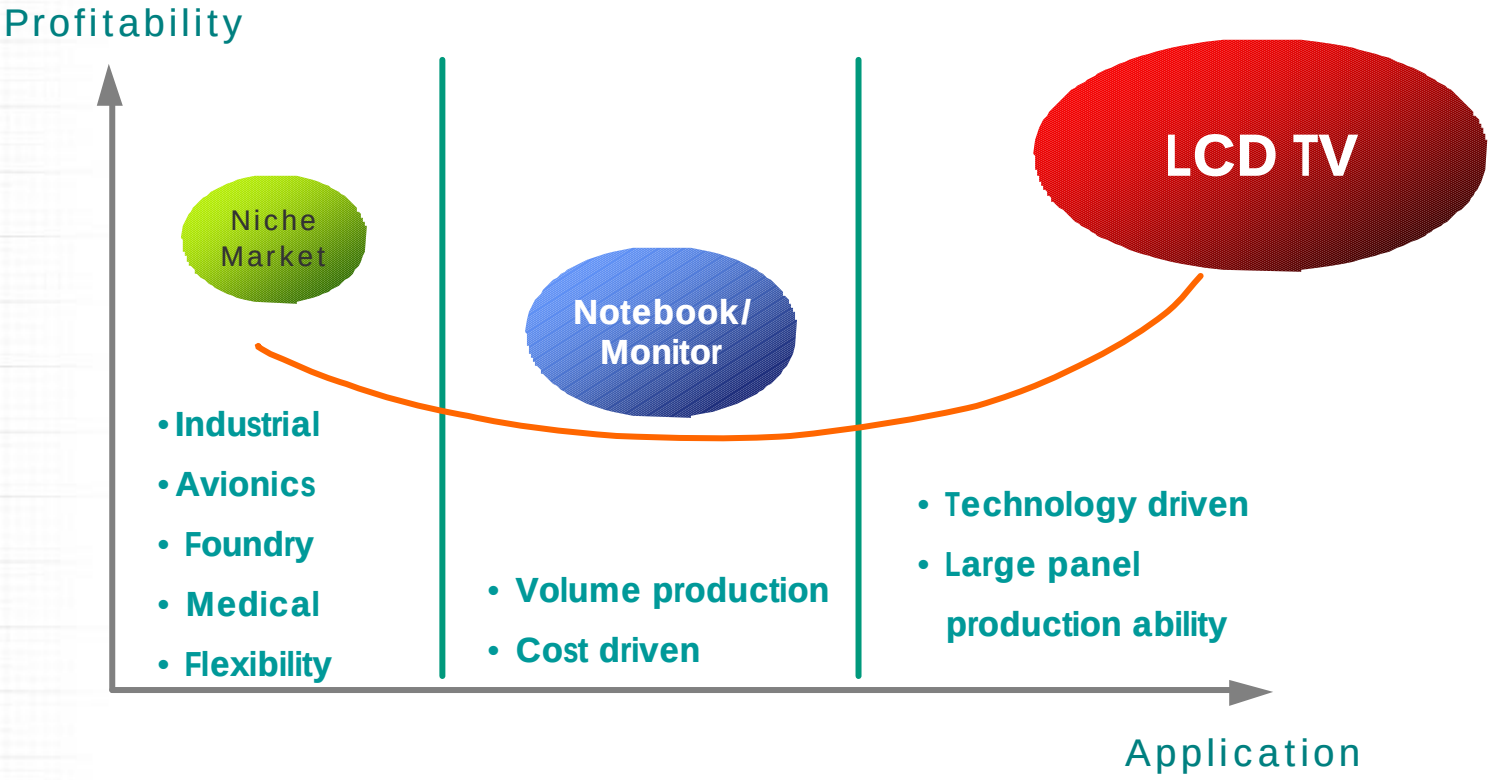
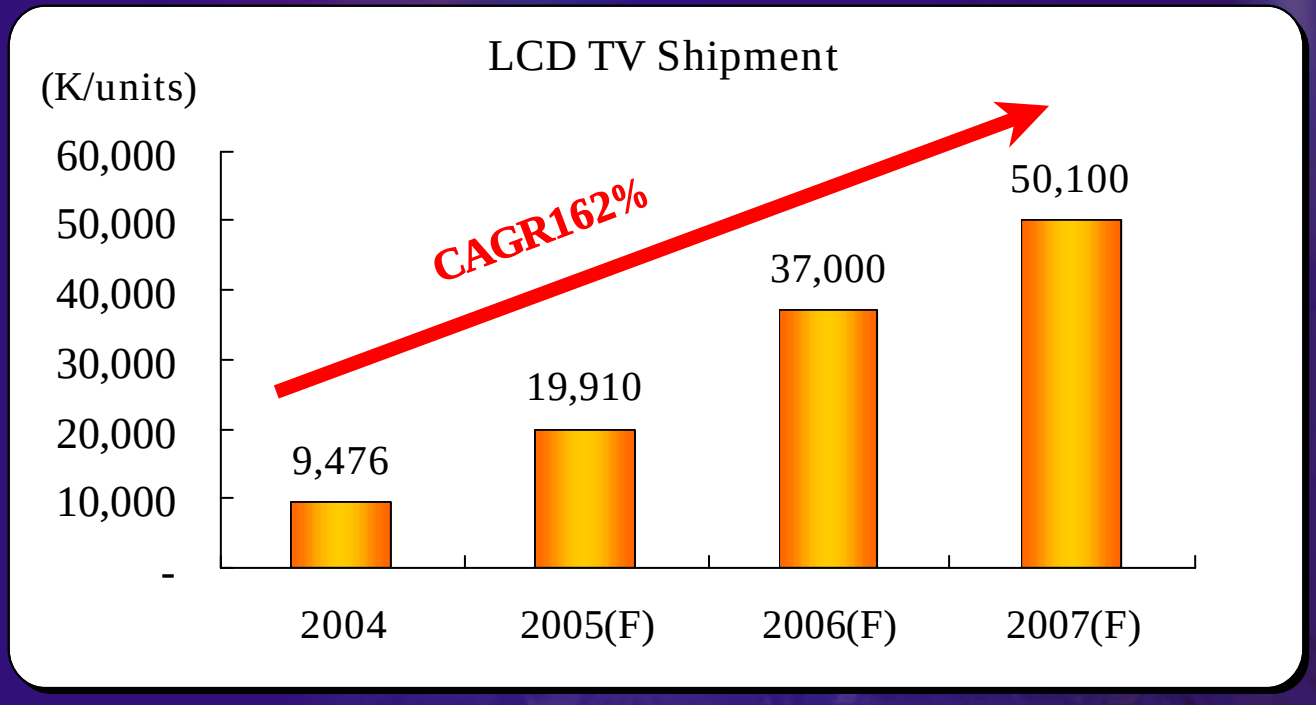
Diversification of applications



LCD-TV Shipment Growth by year



Source:Display Search

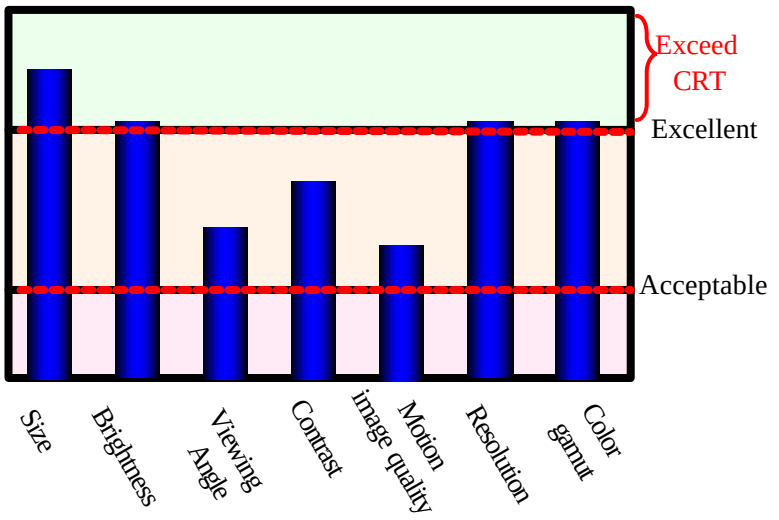
Introduction

Advantages of TFT-LCD for HDTV and multimedia application:

- High brightness
- High color saturation
- High resolution

Further improvement items:

- Contrast
- Viewing angle
- Motion image quality
- ……



Chi Mei Optoelectronics Corp

Wide View Technologies

奇美電子
CHI MEI OPTOELECTRONICS

Contents

- Introduction
- E-O effect in an LCD
- WV Family :TN+film, MVA, IPS…
- Contrast point of view
- Color point of view
- Summary

何謂視角?

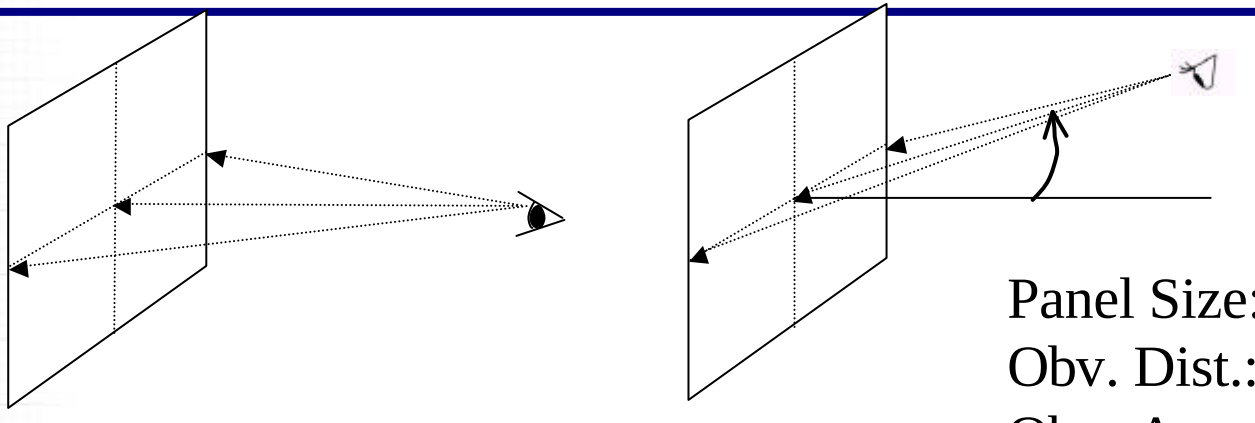
顯示器在特定的角度以內其顯像品質達到一定的水準以上, 此角度稱之為視角

顯像品質

- **對比**(Contrast Ratio, CR)
- **灰階不反轉**(no gray level inversion)
- **色偏**(color shift)
- **輝度**(Luminance)
- …

為何要廣視角？

A.



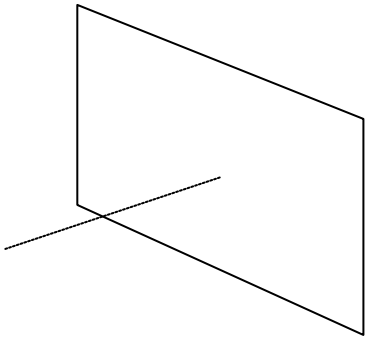
Panel Size: 19”
Obv. Dist.: 30cm
Obv. Ang.: ~60°

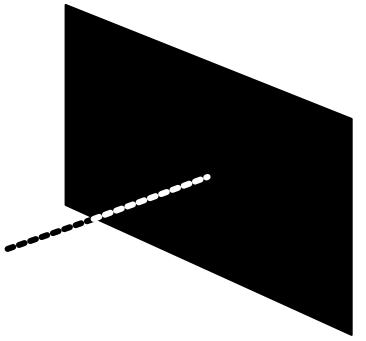
B.

即使是在 14.1“筆記型電腦上

您在看過全面均勻的混色(例如,橙黃色)嗎?

對比(Contrast Ratio, CR)

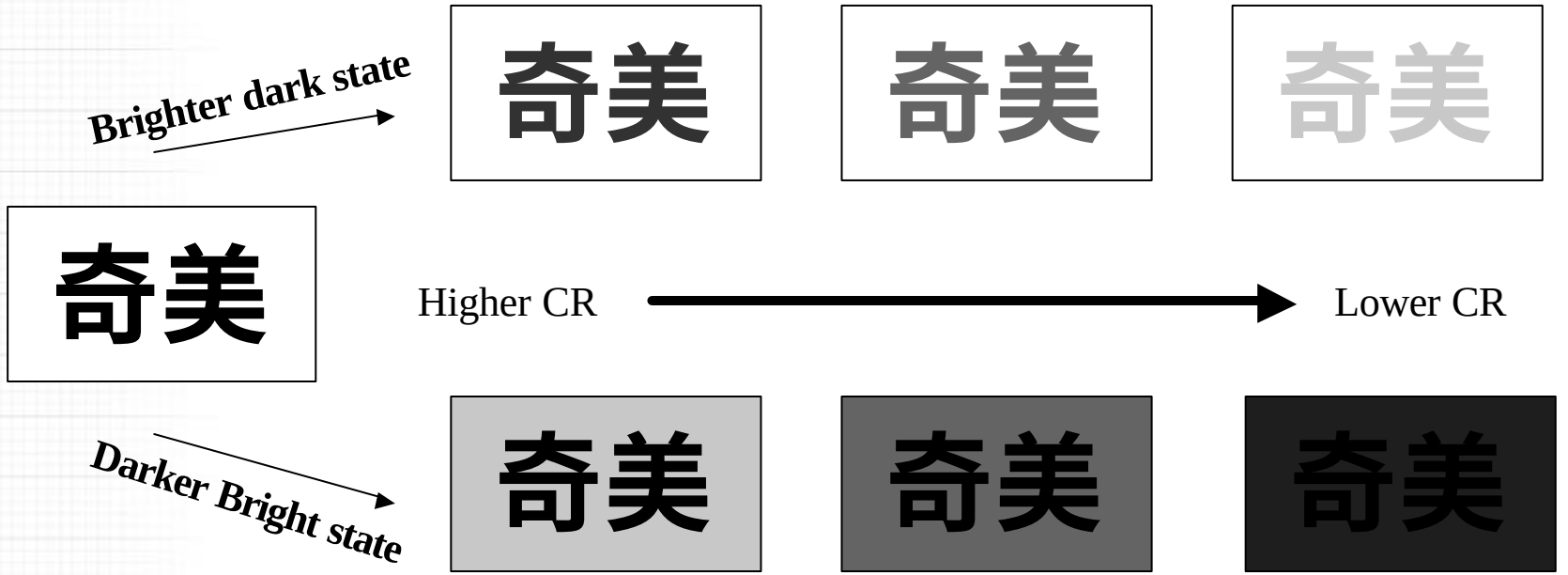




$$CR = \frac{\textbf{Lum. of Bright State}}{\textbf{Lum. of Dark State}}$$

對比 CR 實際的感覺…

$$CR = \frac{\text{bright}}{\text{dark}}$$



Contrast Perception

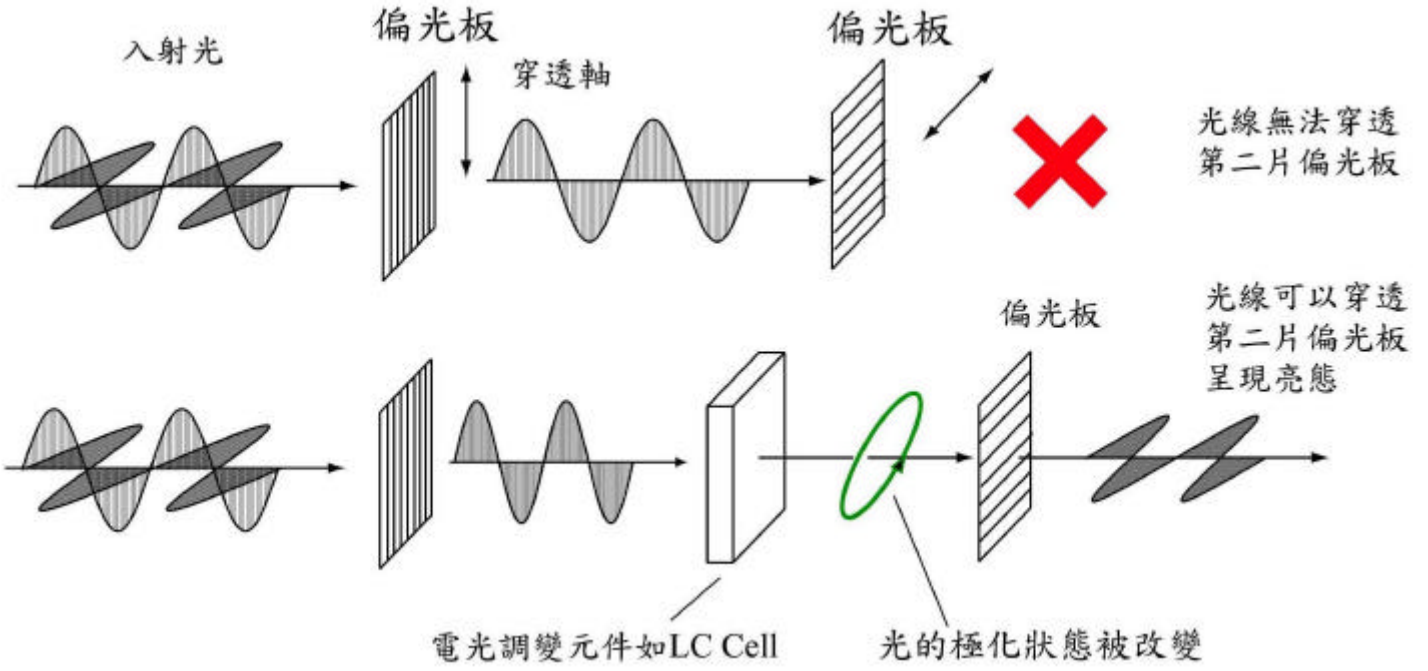
Low Contrast

High Contrast

CONTRAST=brightness of white / brightness of dark

High contrast makes color of image more saturated and sharp.

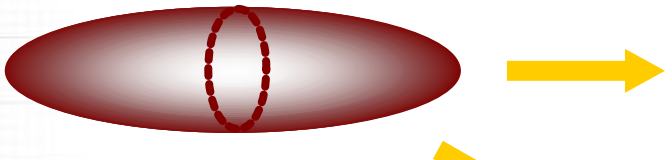
光的偏極化

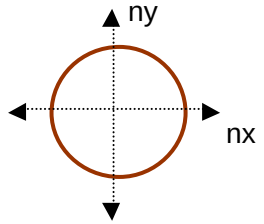


液晶 可改變光的極化狀態

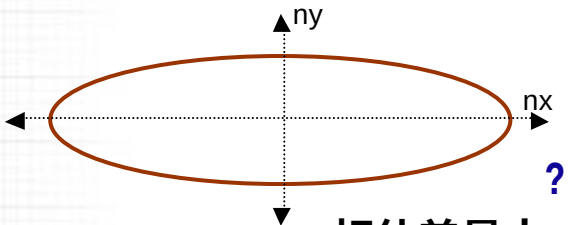
雙折射特性

液晶分子在不同軸向的折射係數不同，造成不同極化方向之間的相位差，進而改變光的極化狀態



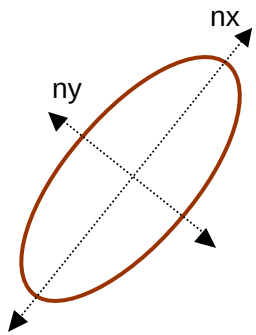


nx=ny → **無相位差**



nx >> ny → **相位差最大**

? n ~ 0.1 !



nx > ny → **有相位差**

D

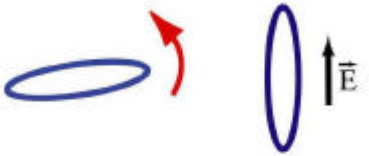
非等向介電性

介電係數表示材料被外面電場誘發極化率的大小，介電係數越大表示極化率越大

$\varepsilon_{\perp}$ $\varepsilon_{//}$

$$\Delta\varepsilon = \varepsilon_{//} - \varepsilon_{\perp}$$

對$\Delta\varepsilon > 0$而言，當有外加電場時，液晶分子的對稱軸方向會傾向於與外加電場方向平行



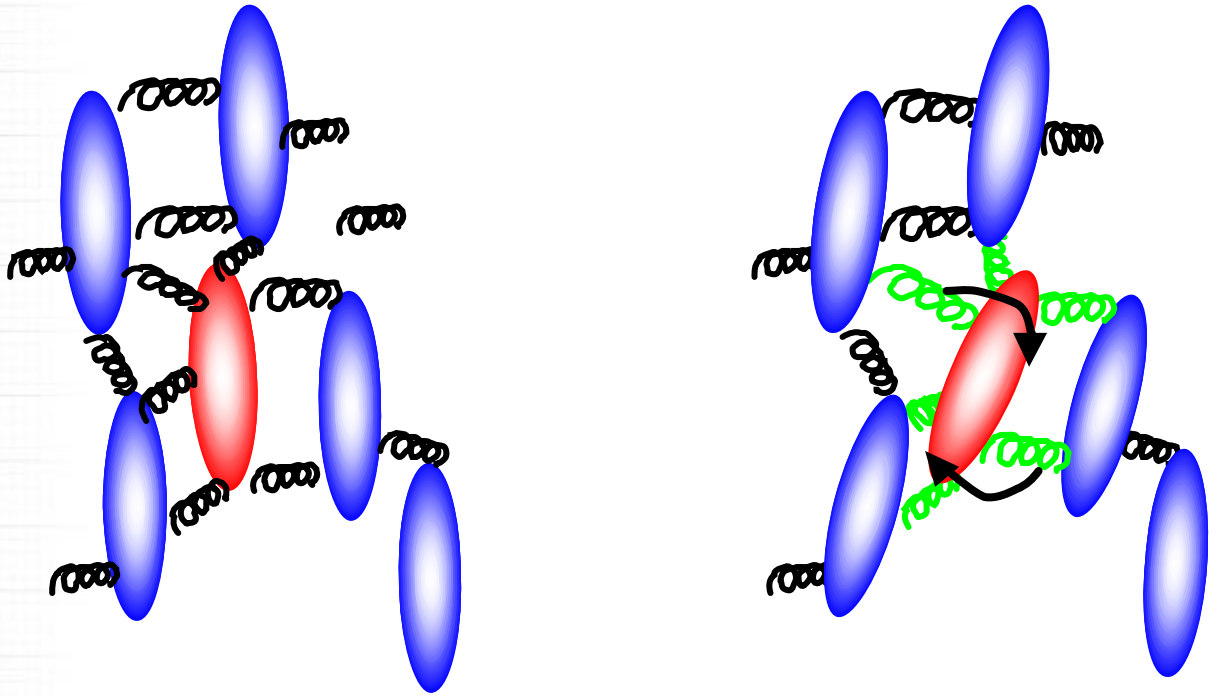
$\Delta\varepsilon > 0$

對$\Delta\varepsilon < 0$而言，當有外加電場時，液晶分子的對稱軸方向會傾向於與外加電場方向垂直

$\Delta\varepsilon < 0$

液晶重要的物理特性

彈性 (elasticity)

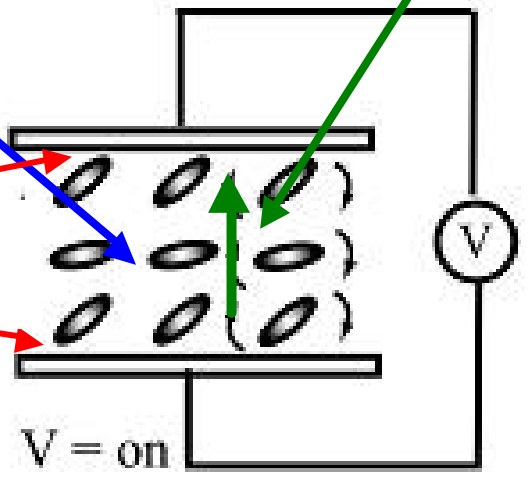


LC with negative dielectric anisotropy ($\Delta\varepsilon < 0$)

1.Elastic force every where (between LC-LC)

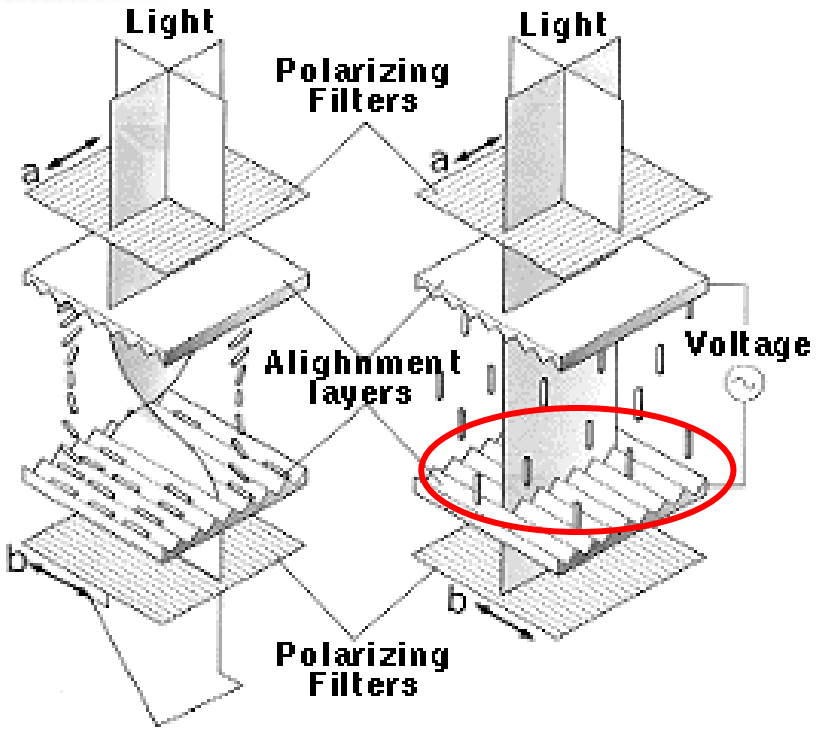
2.Vertically Aligned (**anchoring force,** Ex.between LC-PI)

3.Electric force between E field and LC

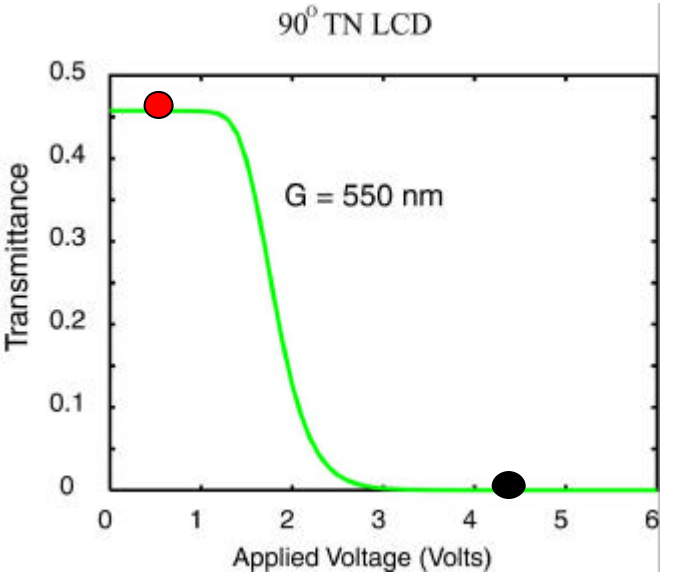


LC with $\Delta\varepsilon < 0$, the director tend to be perpendicular to the applied electric field.

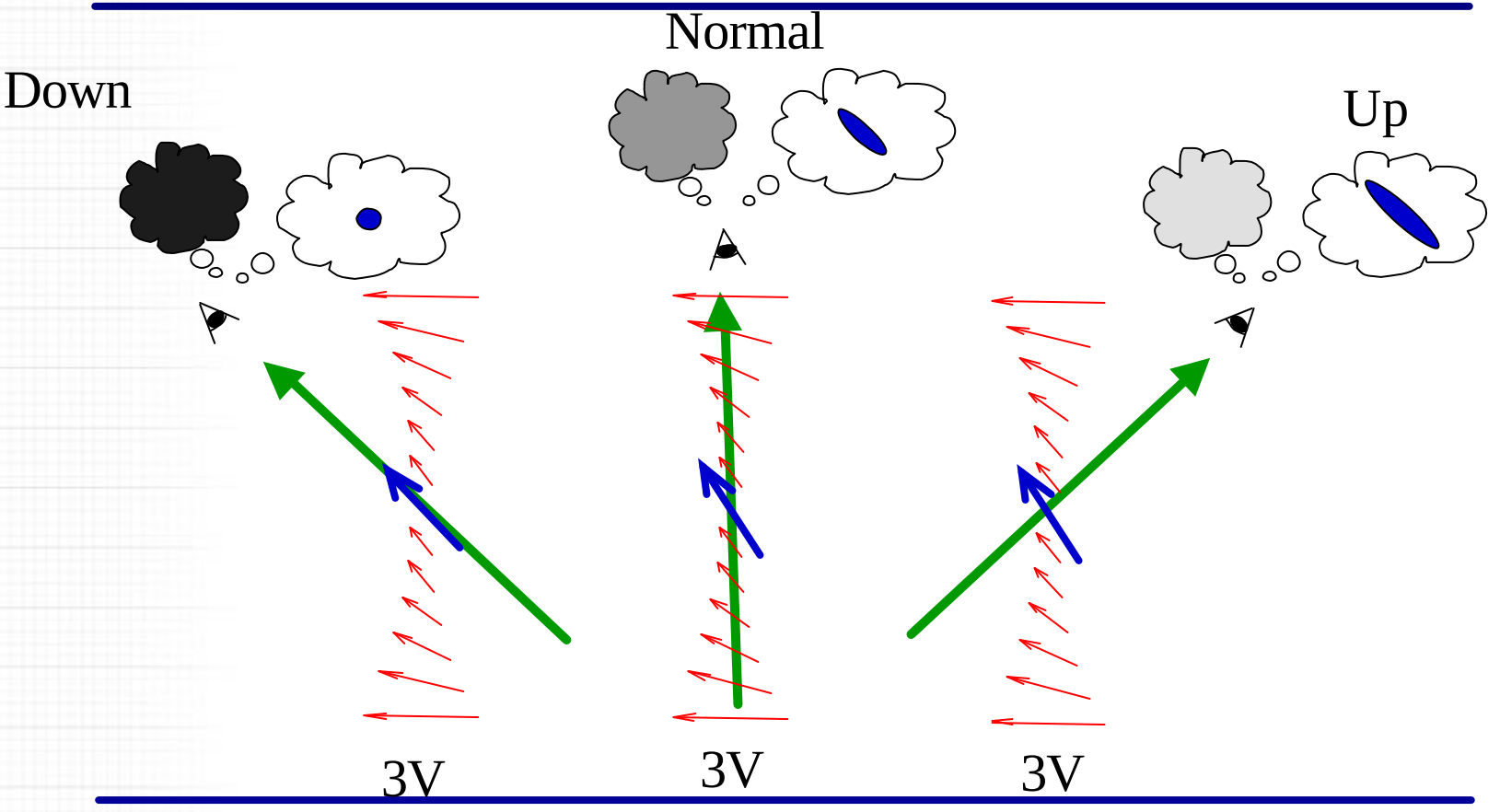
90° Twisted Nematic(TN,扭轉向列型) TFT LCD



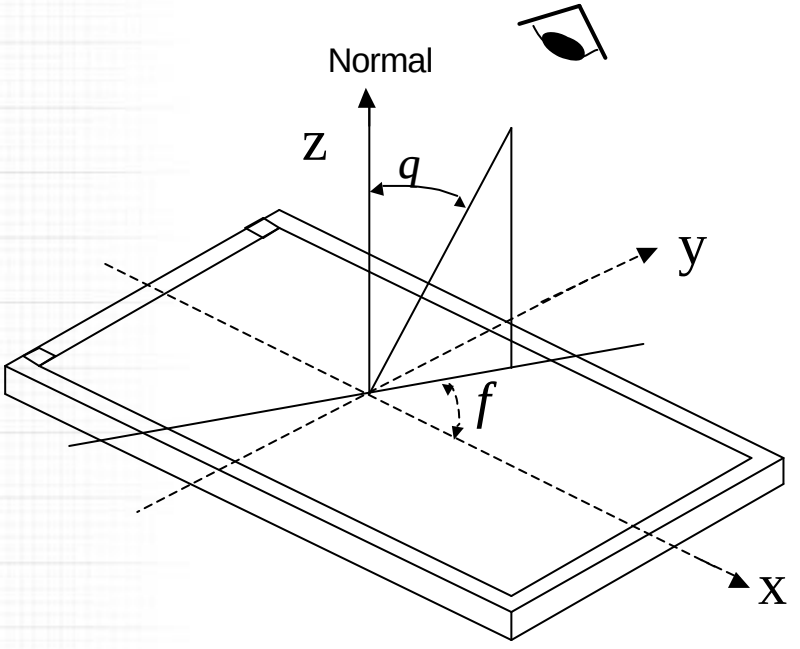
Normal view
T-V curve

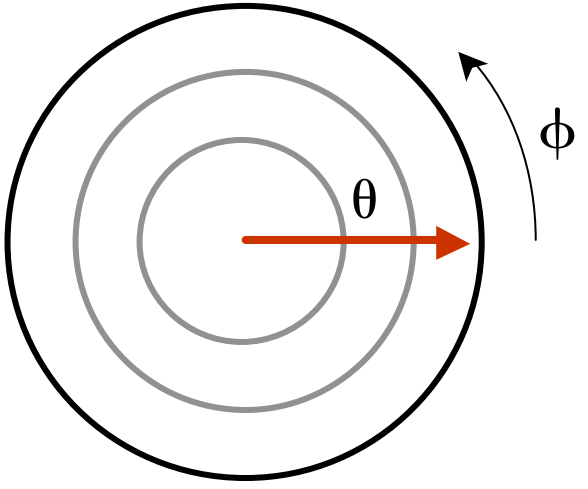


TN LCD 對比視角不對稱/低下 的原因

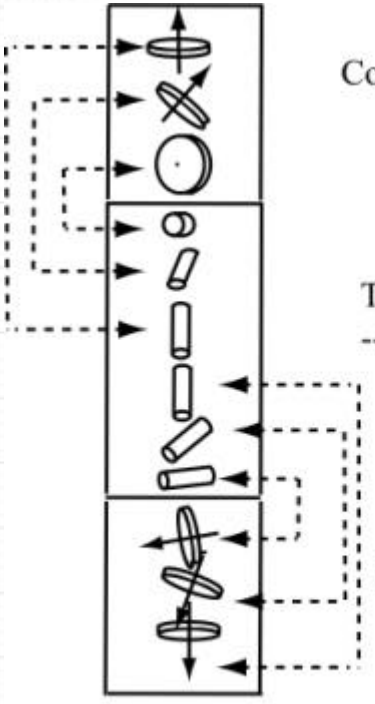


視角表示座標系統





Fuji Photo 廣視角補償膜 + TN TFT LCD

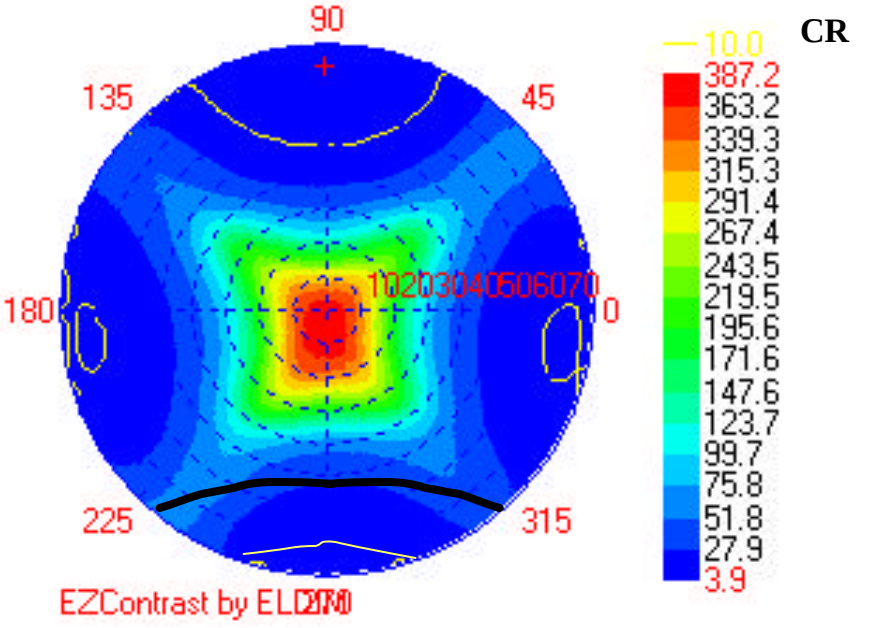


Compensation film
$\Delta n < 0$

TN cell, $\Delta n > 0$
-- (on) dark state

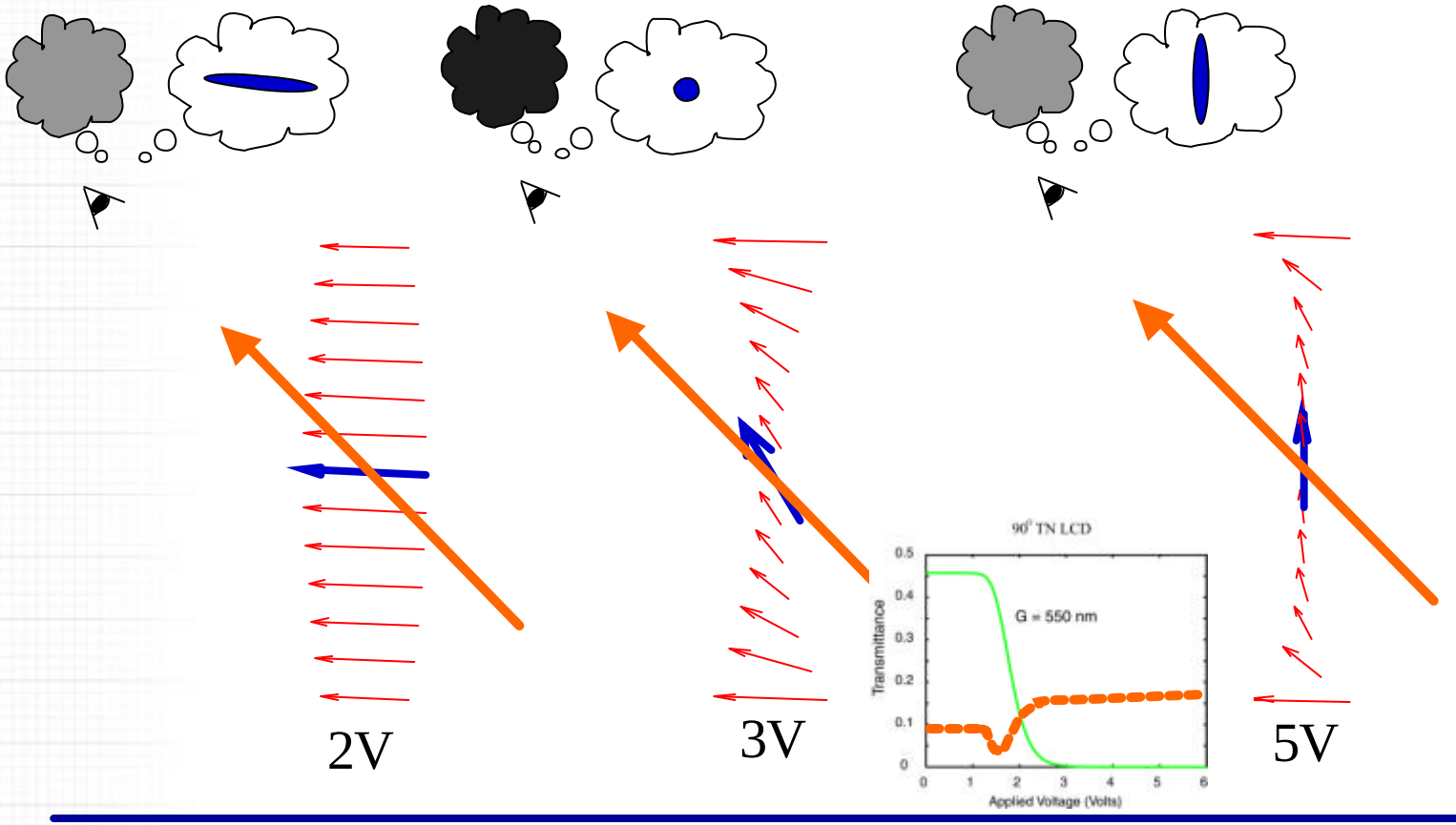
Compensation film
$\Delta n < 0$

The structure of an on-state TN-LCD with discotic negative birefringence films



L: 70°, R: 70°, U: 50°, D: 70°

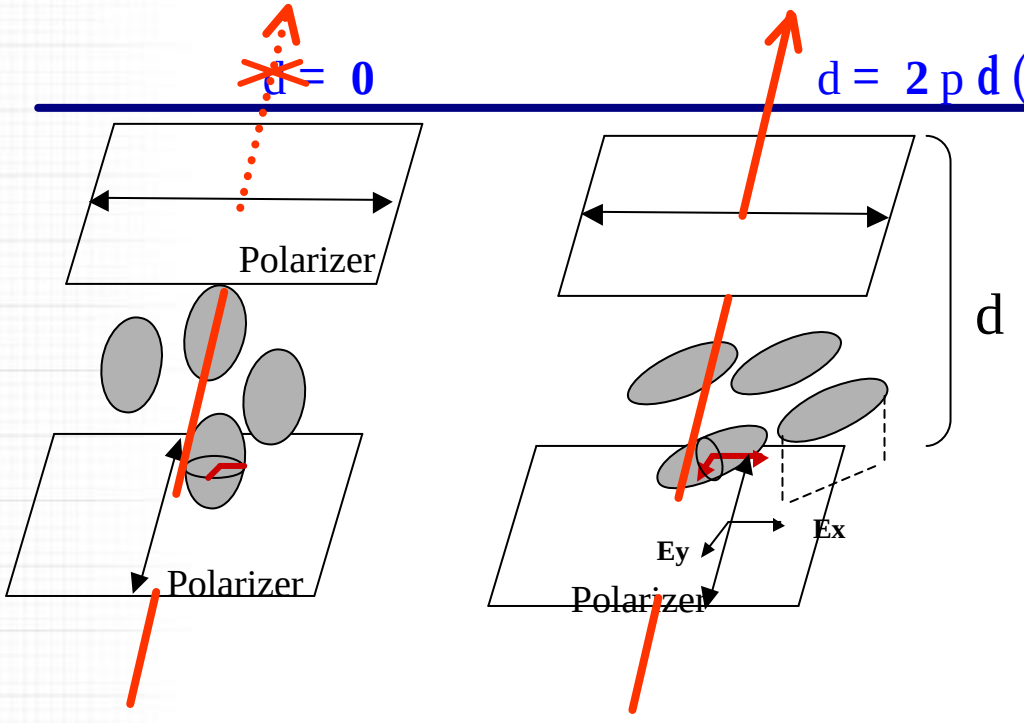
TN LCD發生灰階反轉的原因



TN

- the basic mechanism of CR/Lum/G.I. problems of TN LCD
- the solution of CR/Lum problems of TN LCD
- the CR performance of WV compensated TNLCD
- there is no practical(productivity) solution for G.I. of TN LCD

Vertically Aligned (垂直排列) LCD

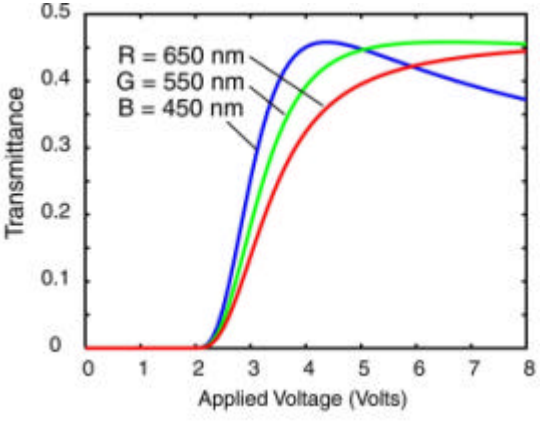


Voltage **OFF**

Voltage **ON** max.

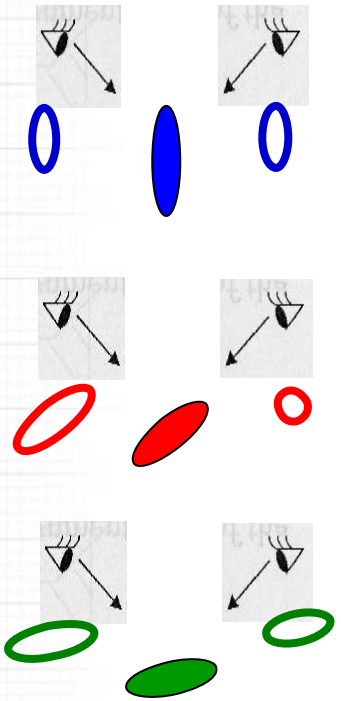
d : **光程相位差**

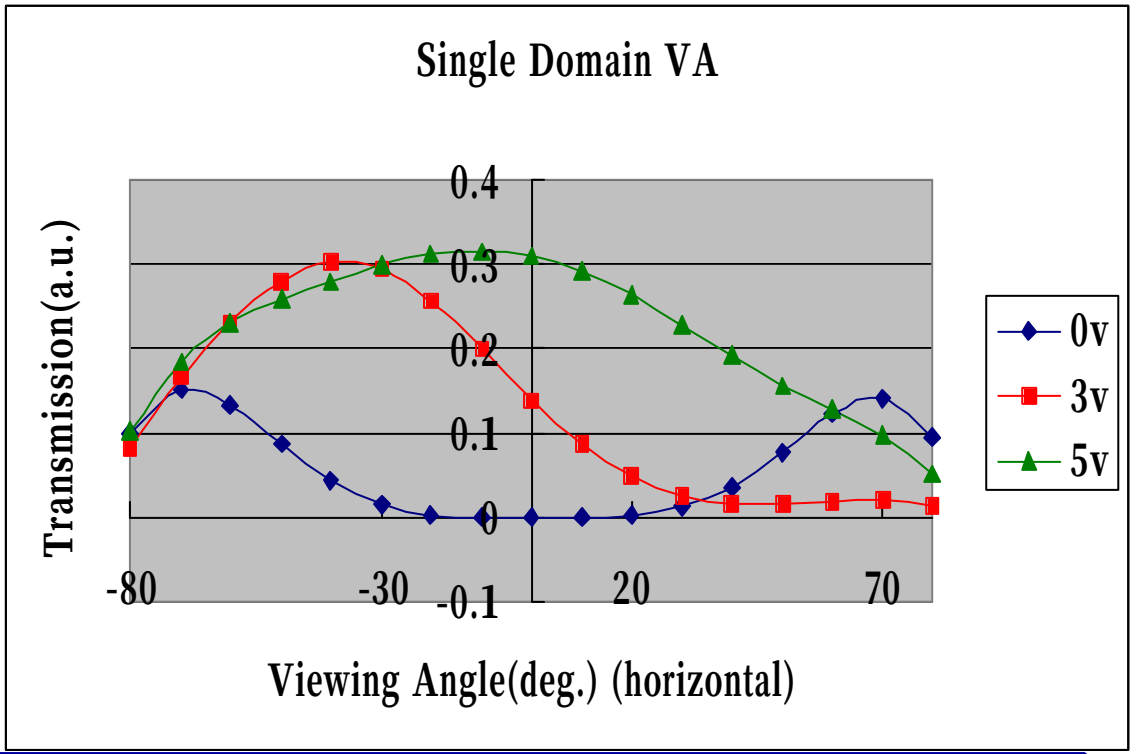
穿透率 ~ Sin²(d/2)



Retardation=0 when voltage off @ normal direction => High contrast ratio

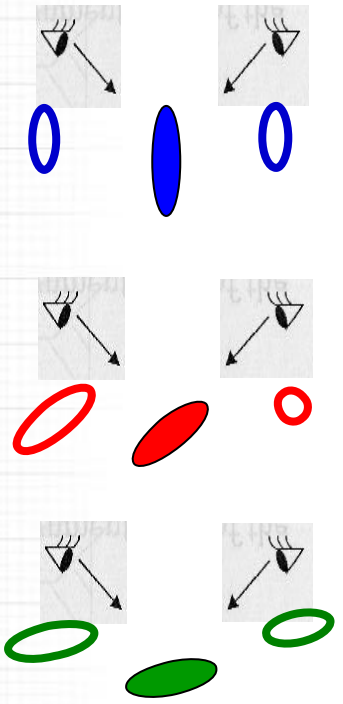
VA LCD 視角問題 --- 灰階時之輝度/視角不對稱

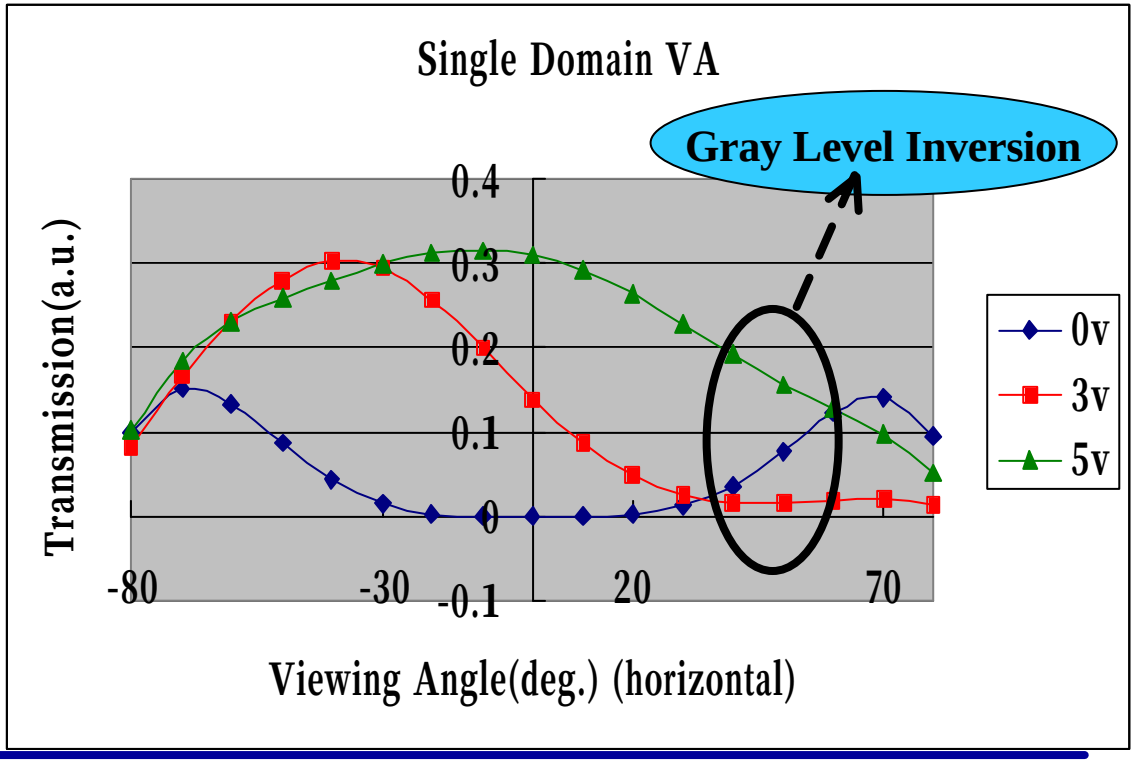




with bare cross polarizer

VA LCD 視角問題 --- Gray level inversion



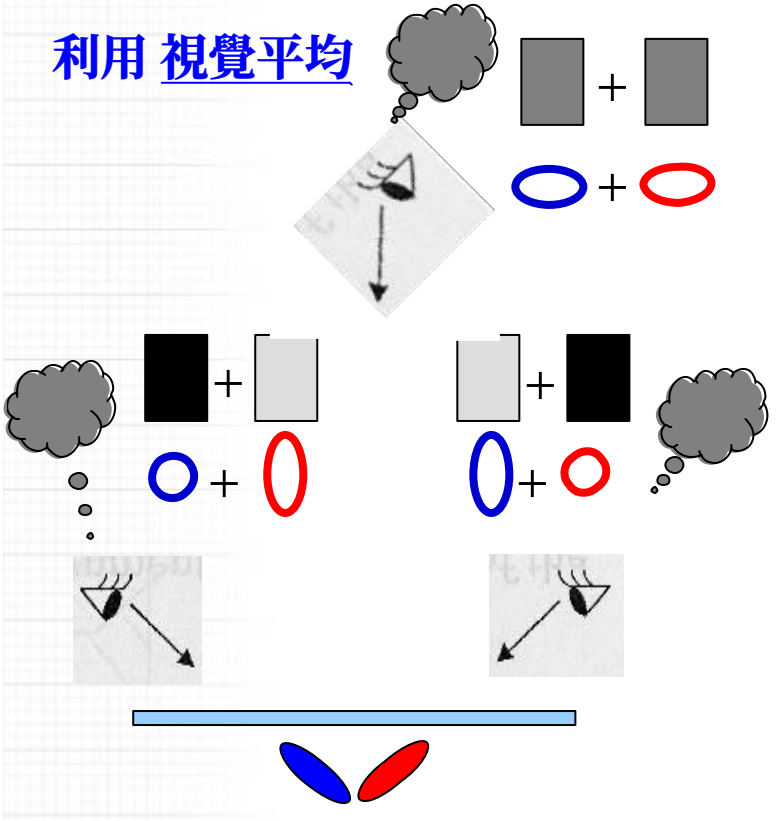


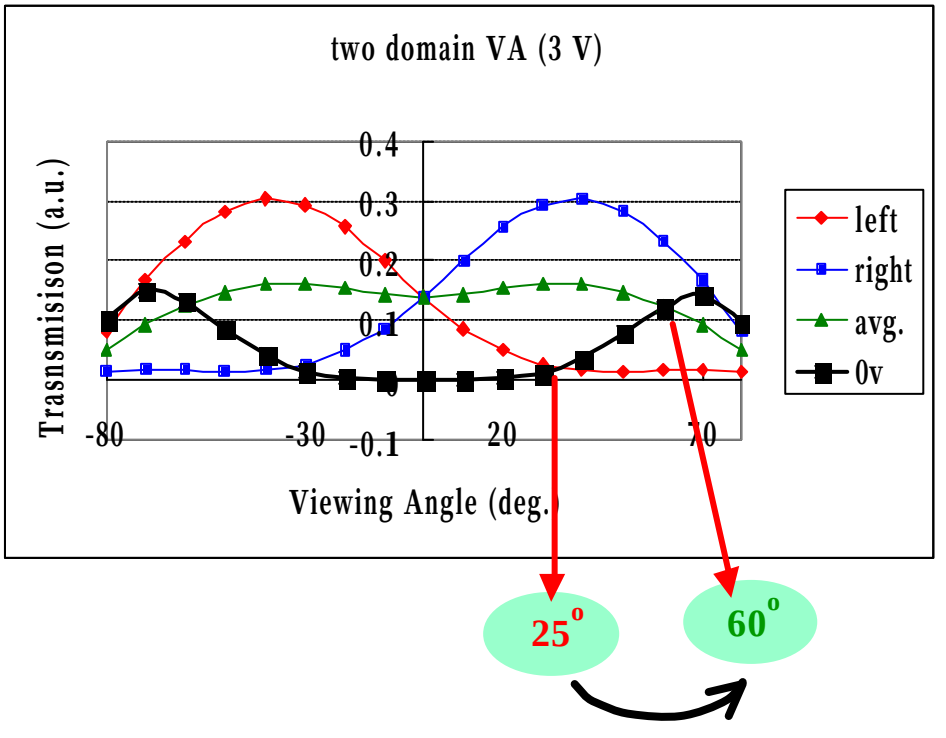
with bare cross polarizer

VA LCD 視角問題 --- 視角不對稱 與灰階反轉 的改進方法

with bare cross polarizer

利用 視覺平均

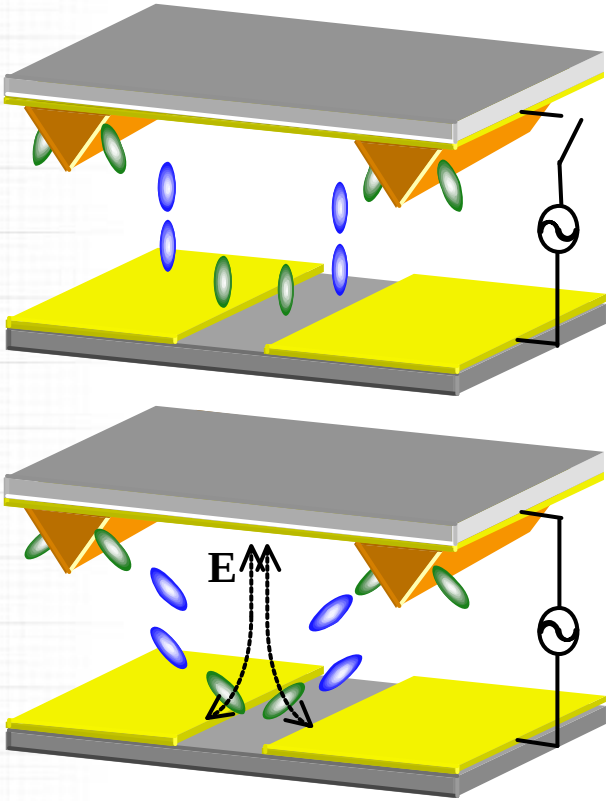


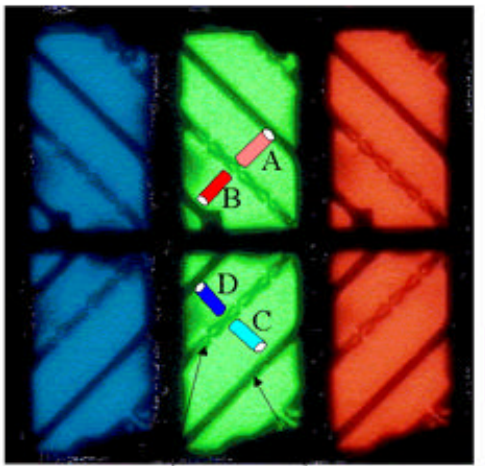


Improved !!

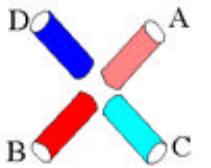
Fujitsu Multi-Domain Vertical Alignment

(1998->1999)





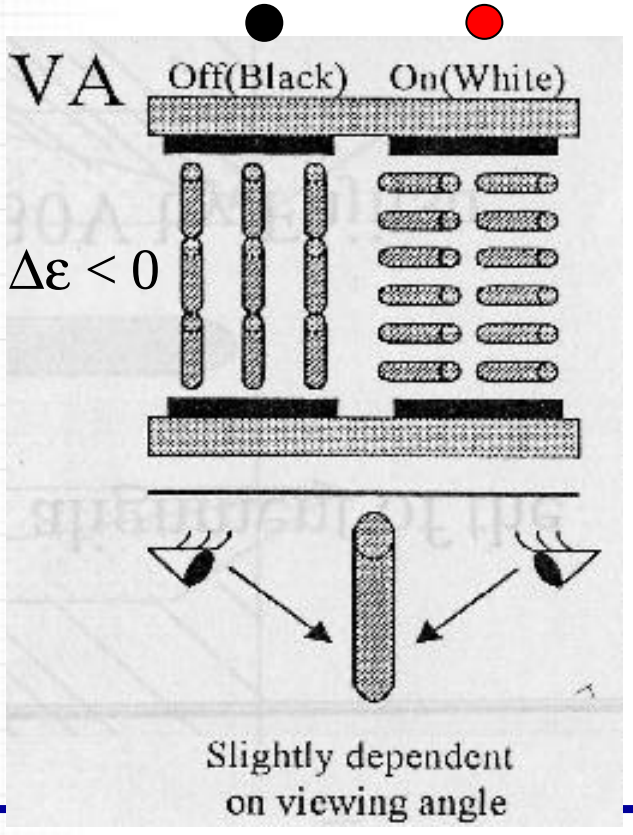
LC domain alignment



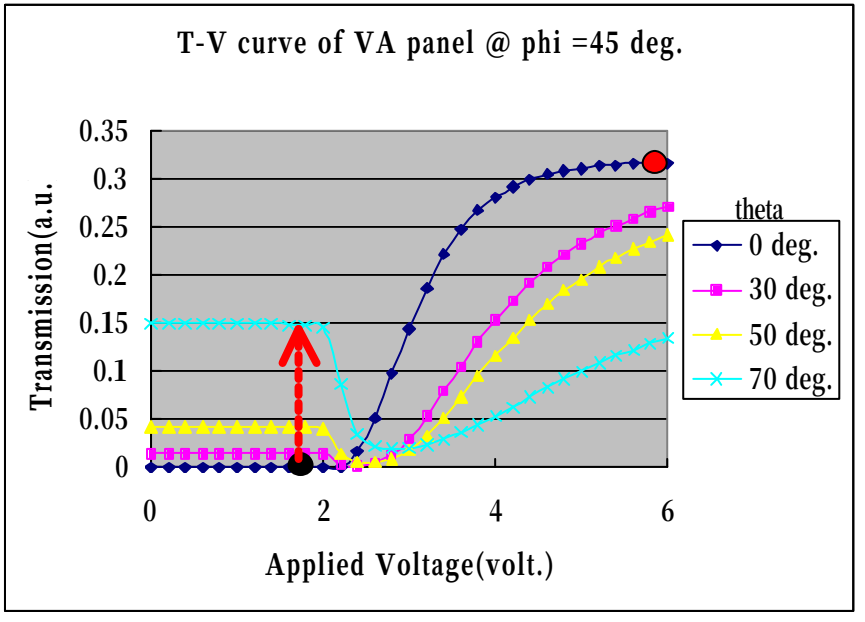
Realization of Multi domain

<4 domains >

VA LCD 視角問題 --- 斜視暗態變差(亮)

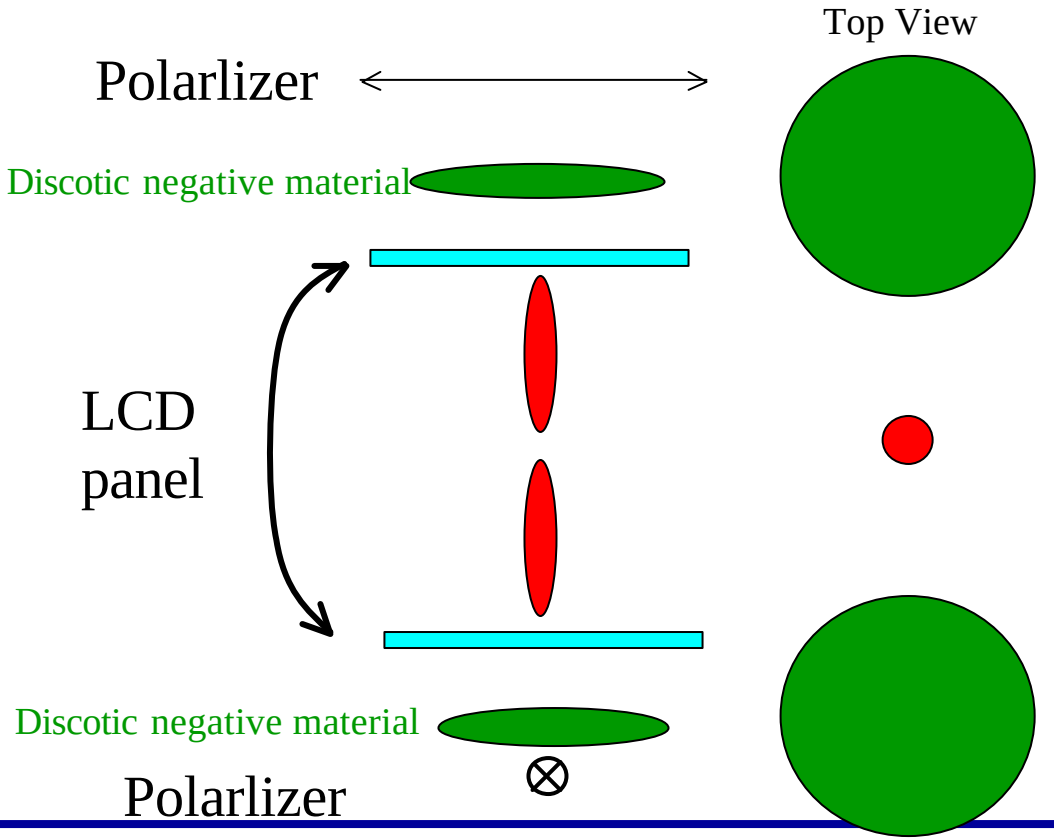


穿透率 ~ $Sin^2(\delta/2)$

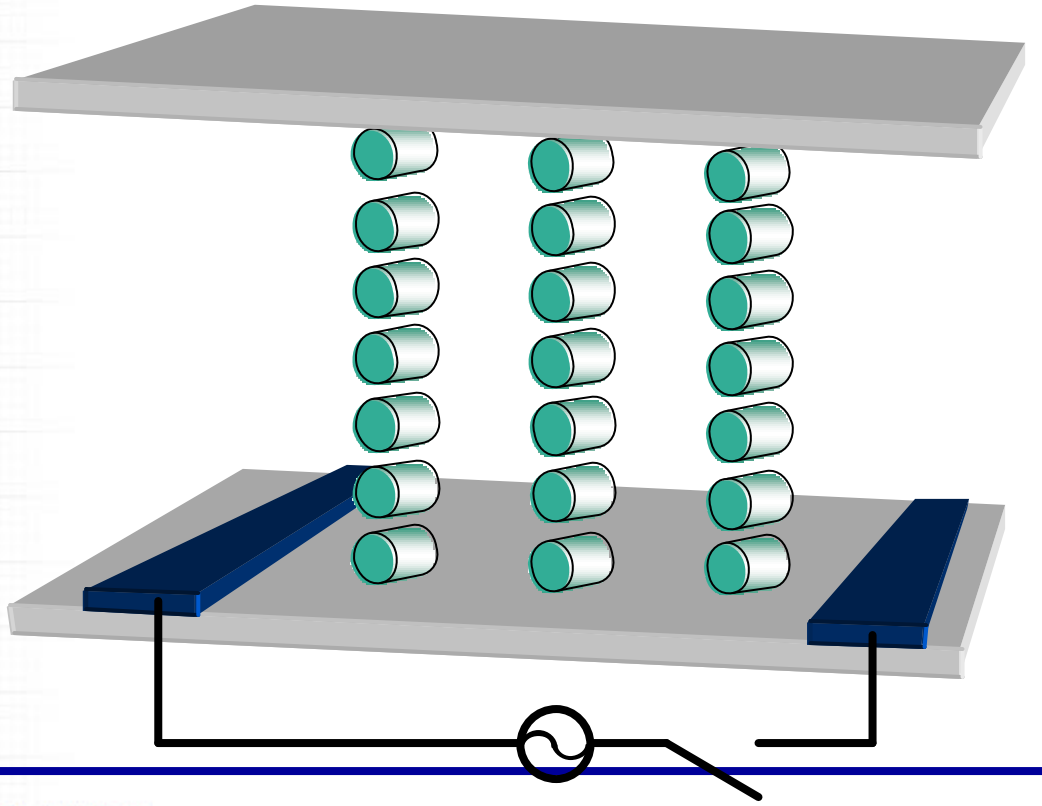


VA LCD 視角問題之對策 --- 暗態補償

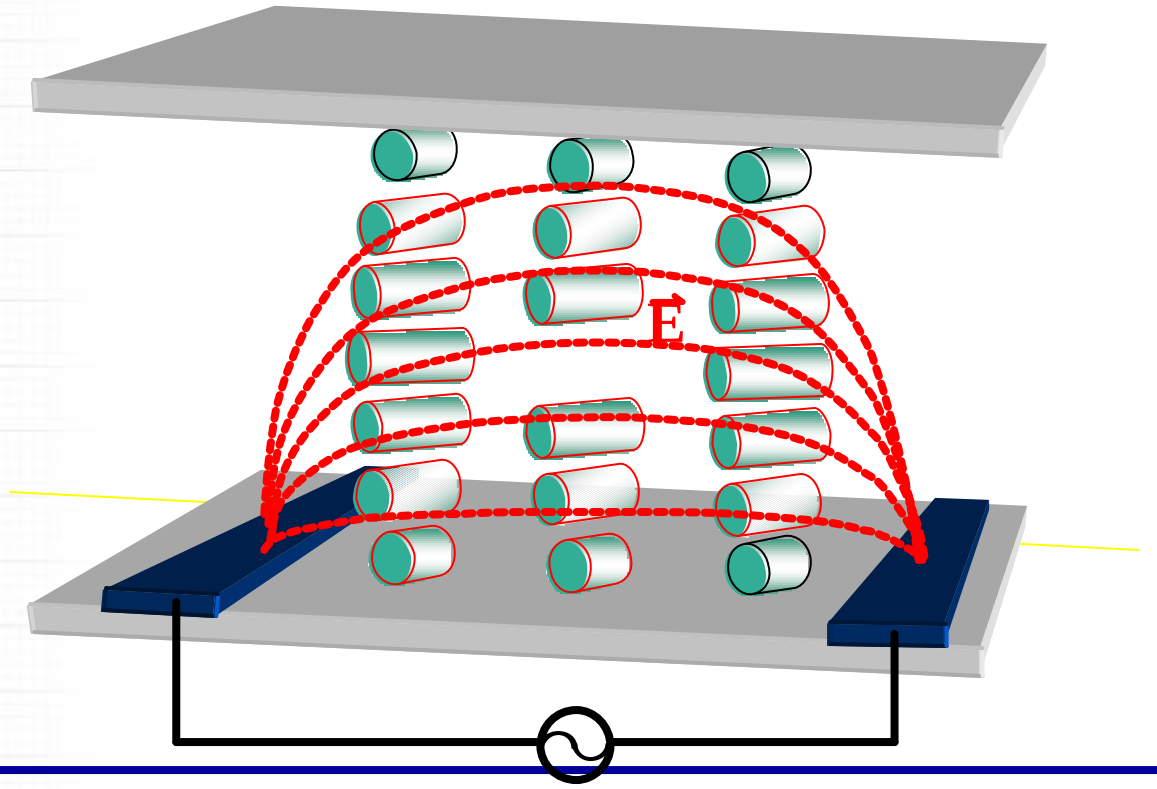
Compensate the leakage light of dark state of VA LCD



IPS (In Plane Switching) Mode – Voltage OFF

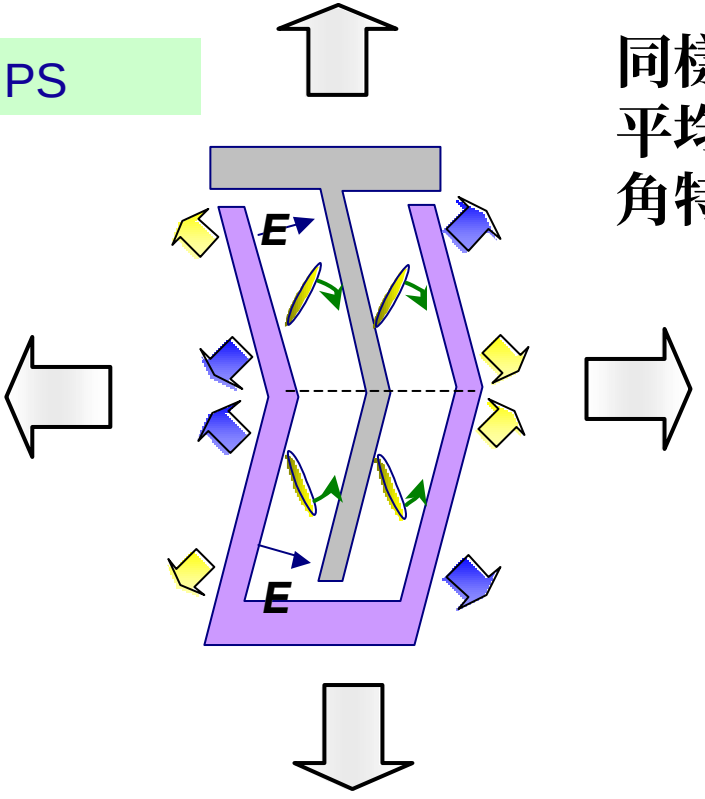


IPS (In Plane Switching) Mode – Voltage ON



Super IPS(S-IPS) : 2-domains case

S-IPS



同樣利用空間不同疇區平均效果來盡一部提昇視角特性

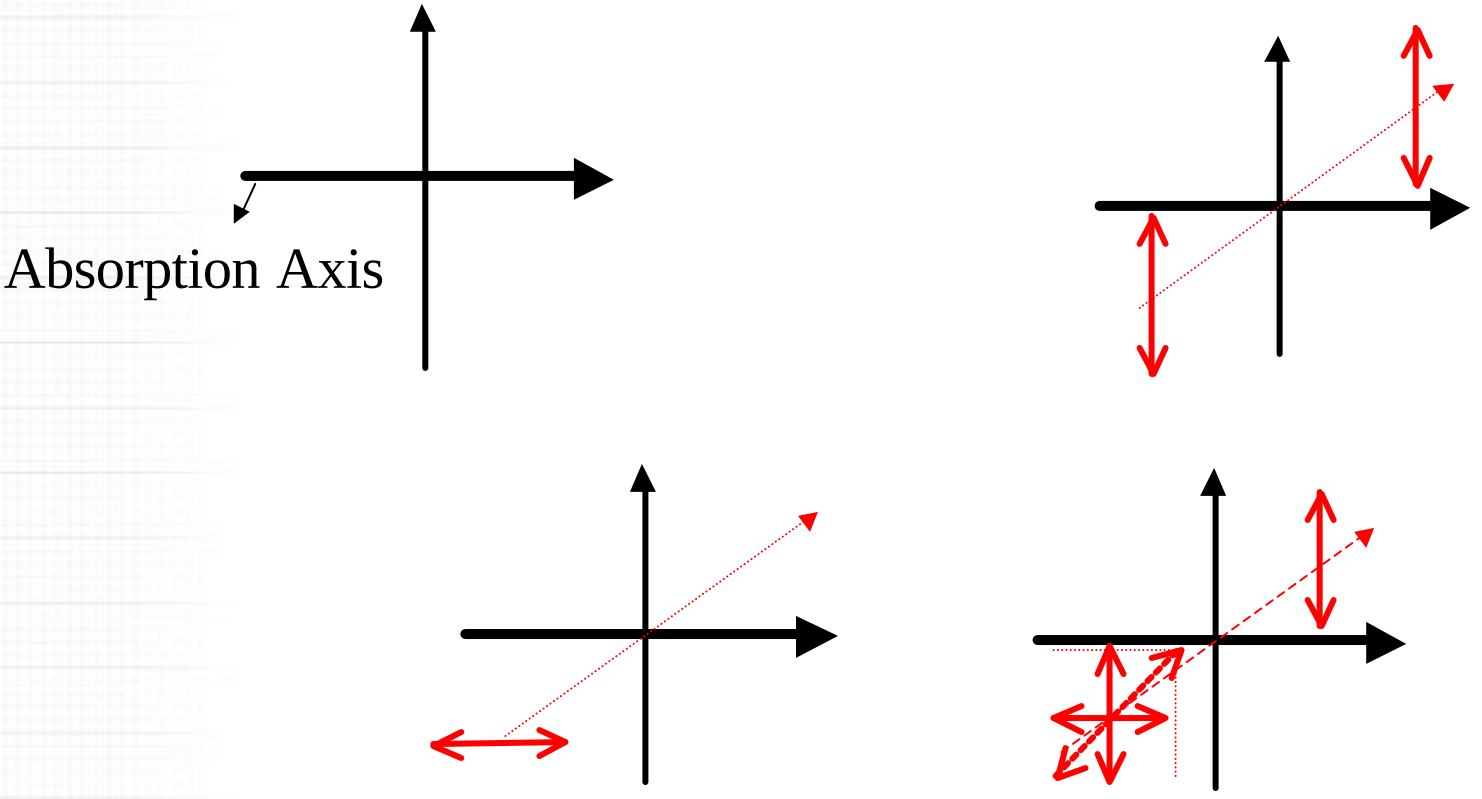
MVV/IPS

- the basic mechanism of CR/Lum/G.I. problems of VA cell
- the solution of CR/Lum/G.I. problems of VA /IPS LCDs

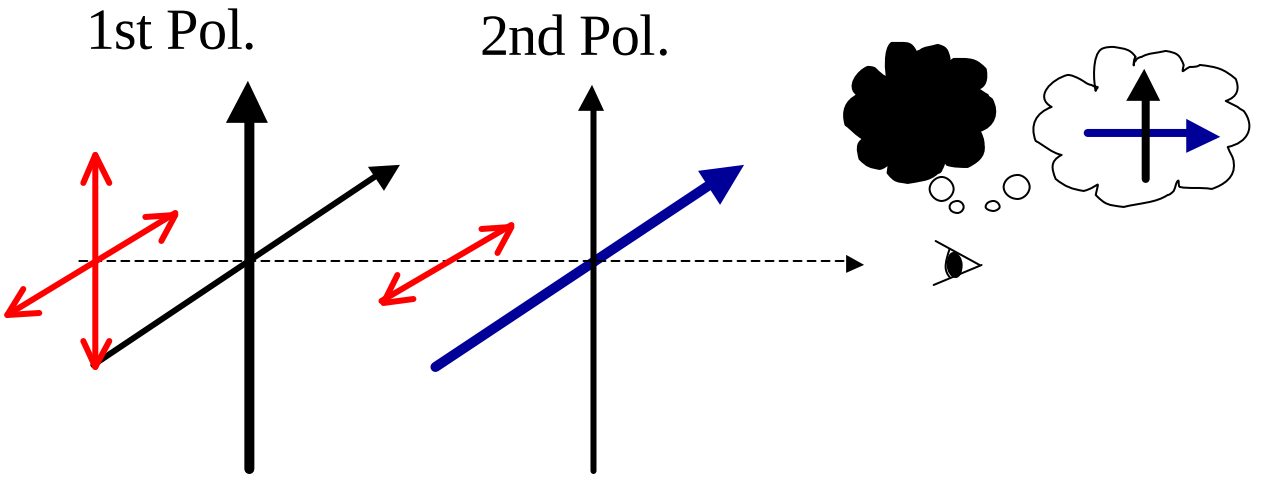
Leakage light from cross-polarizer @ diff. view angle

- What is polarizer?
- Working mechanism of a sheet polarizer
- Why leakage light from polarizer @ oblique view.
- Why leakage light strongly related to color shift
- Idea to eliminate the leakage light to improve color shift properties of LCD

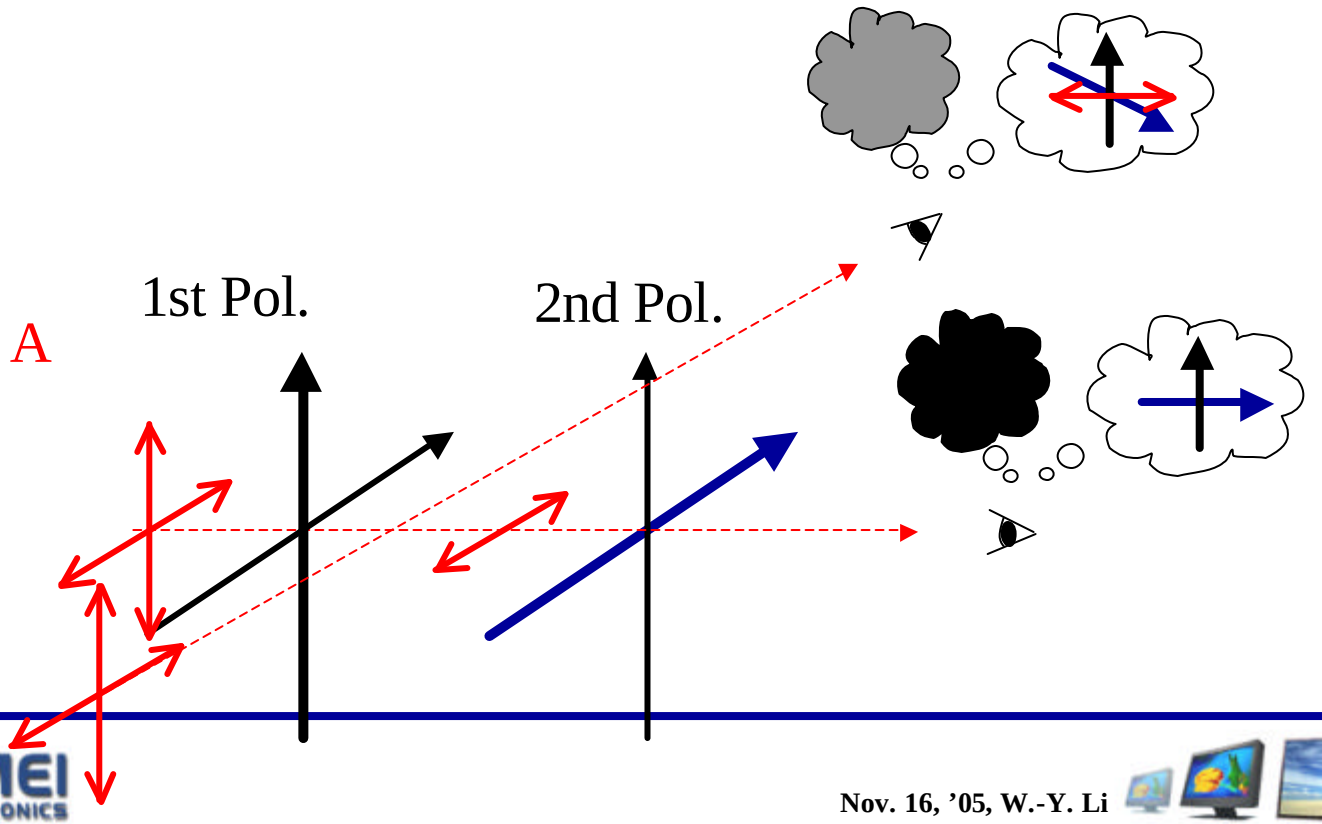
Working Mechanism of Sheet Polarizer



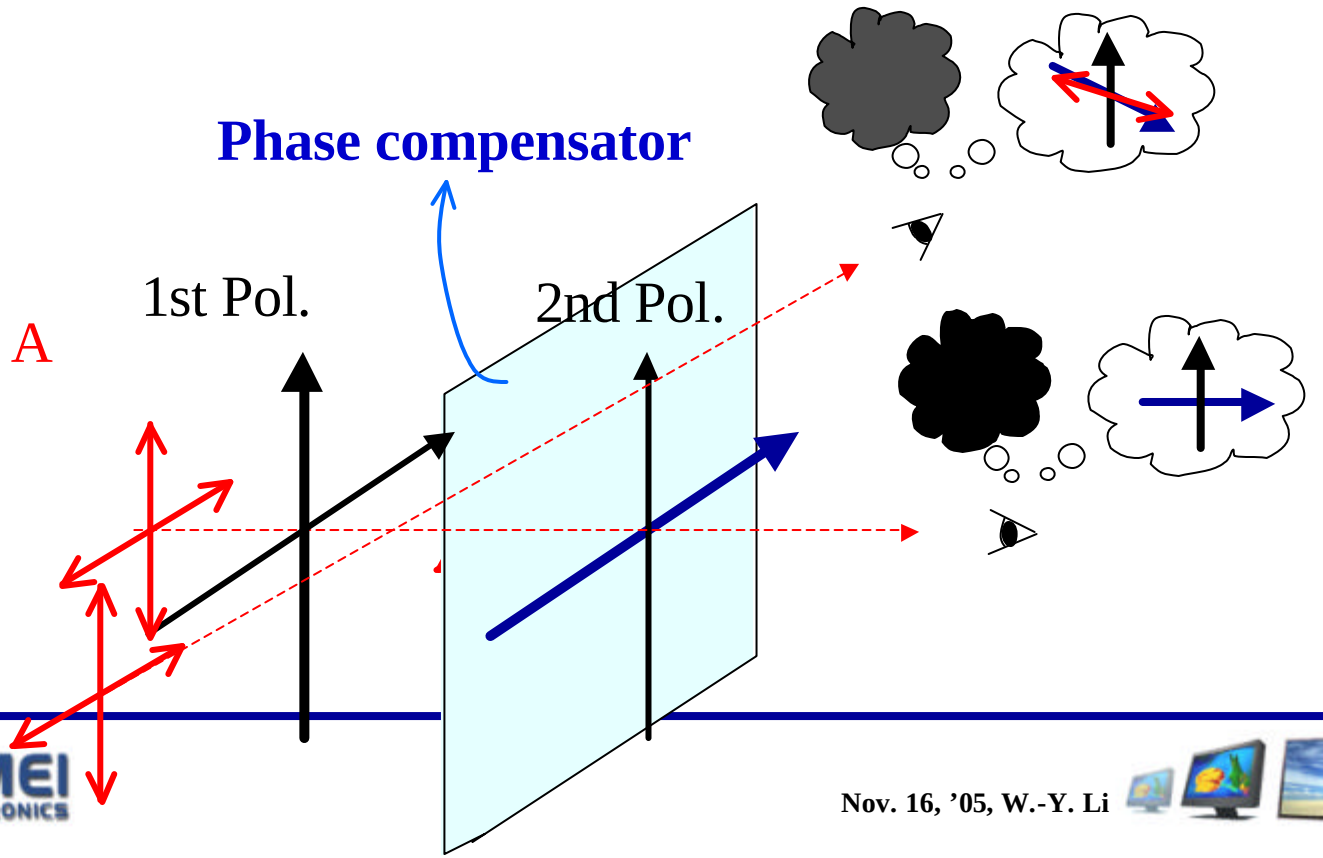
一對 理想的正交 偏光板 .....



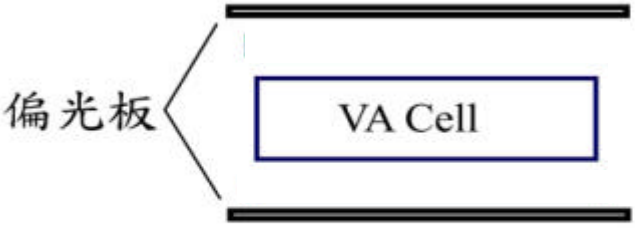
理想正交偏光板的漏光原因



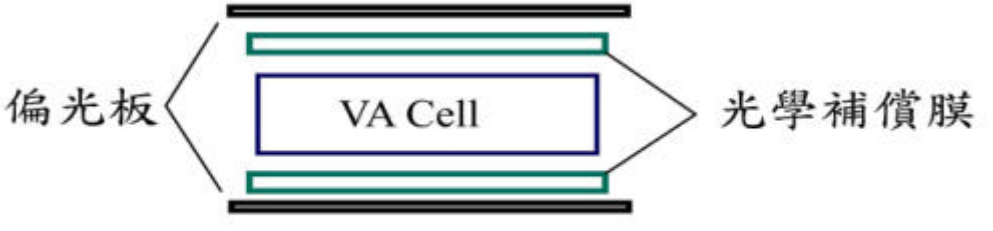
消除 斜角漏光的概念



Structure of VA family displays



VA 顯示器結構



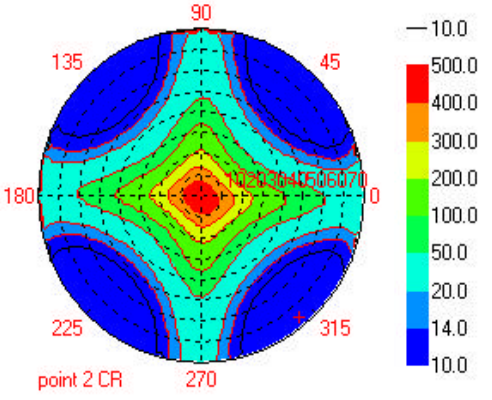
廣視角 VA 顯示器結構

S-MVA, VAExtreme

View Angle : Contrast and primary color shift

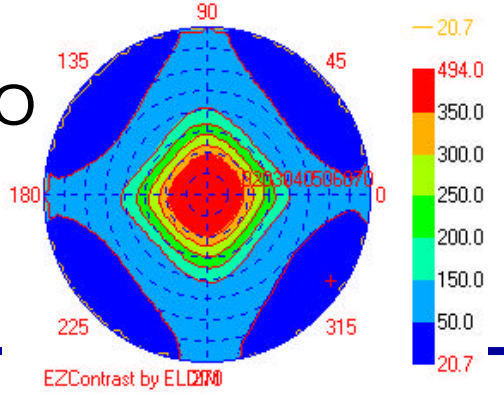
Iso-contrast countour

2001
17.4 MVA

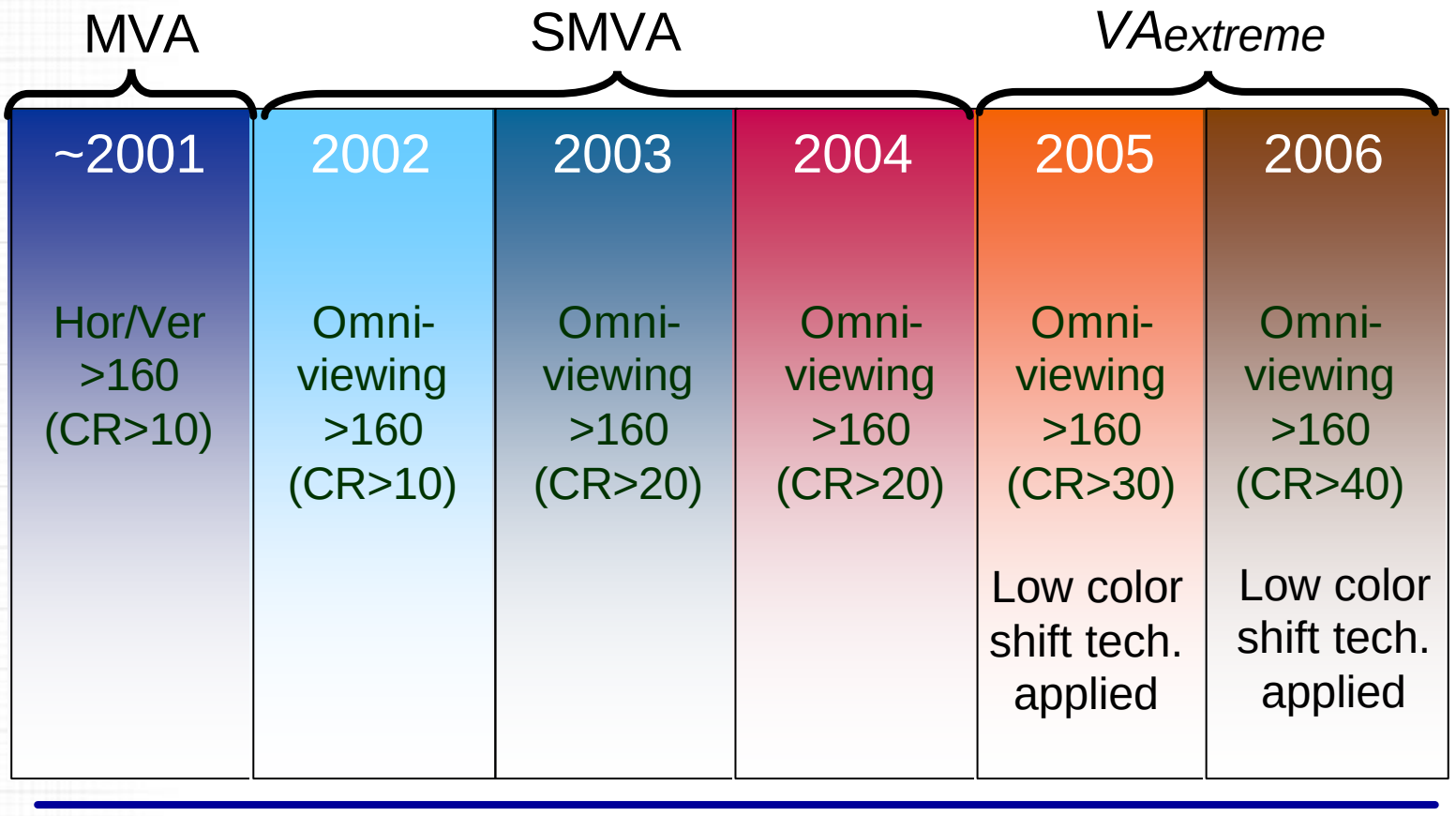


Super MVA 2002, CMO

180E1
SMVA

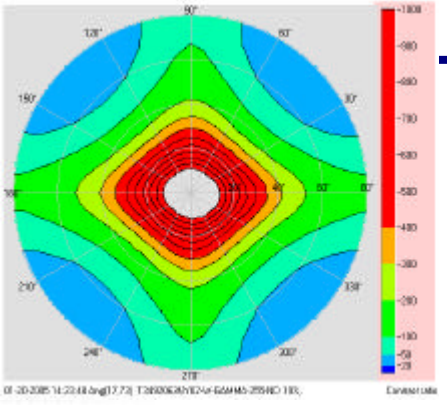


Viewing Angle Trend



Contrast Contour Chart

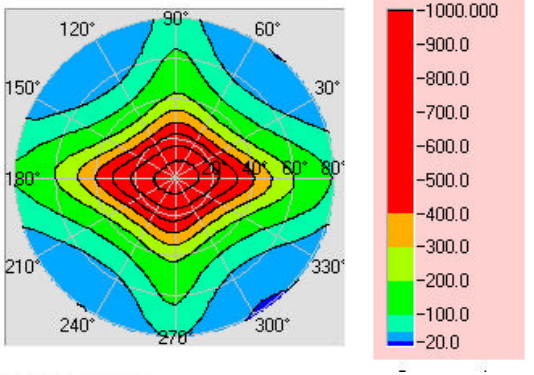
***Omniview* CONTRAST**



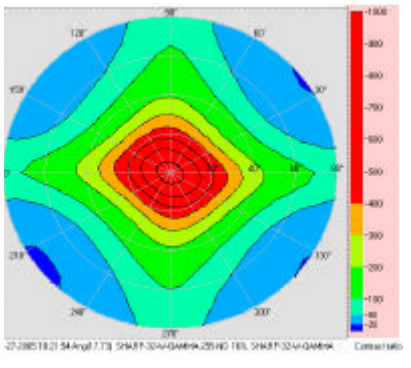
Omniview CONTRAST improves the contrast in large viewing direction and has top level in the world

1. Omni-CR >30
2. CR>100 in horizontal direction (green area)
3. No gray level inversion

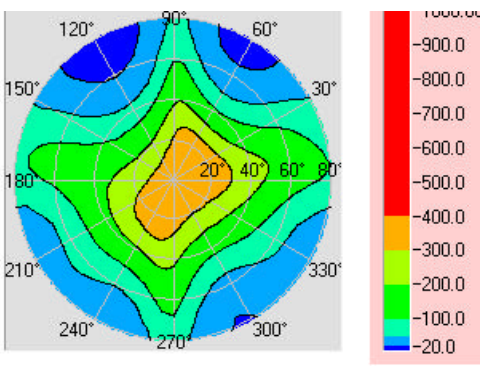
VAextreme, CR>1000 in direct front view (white area)



PVA



ASV



AS-IPS

VAextreme

Contrast and Color difference at Off-Angle

TW IPS

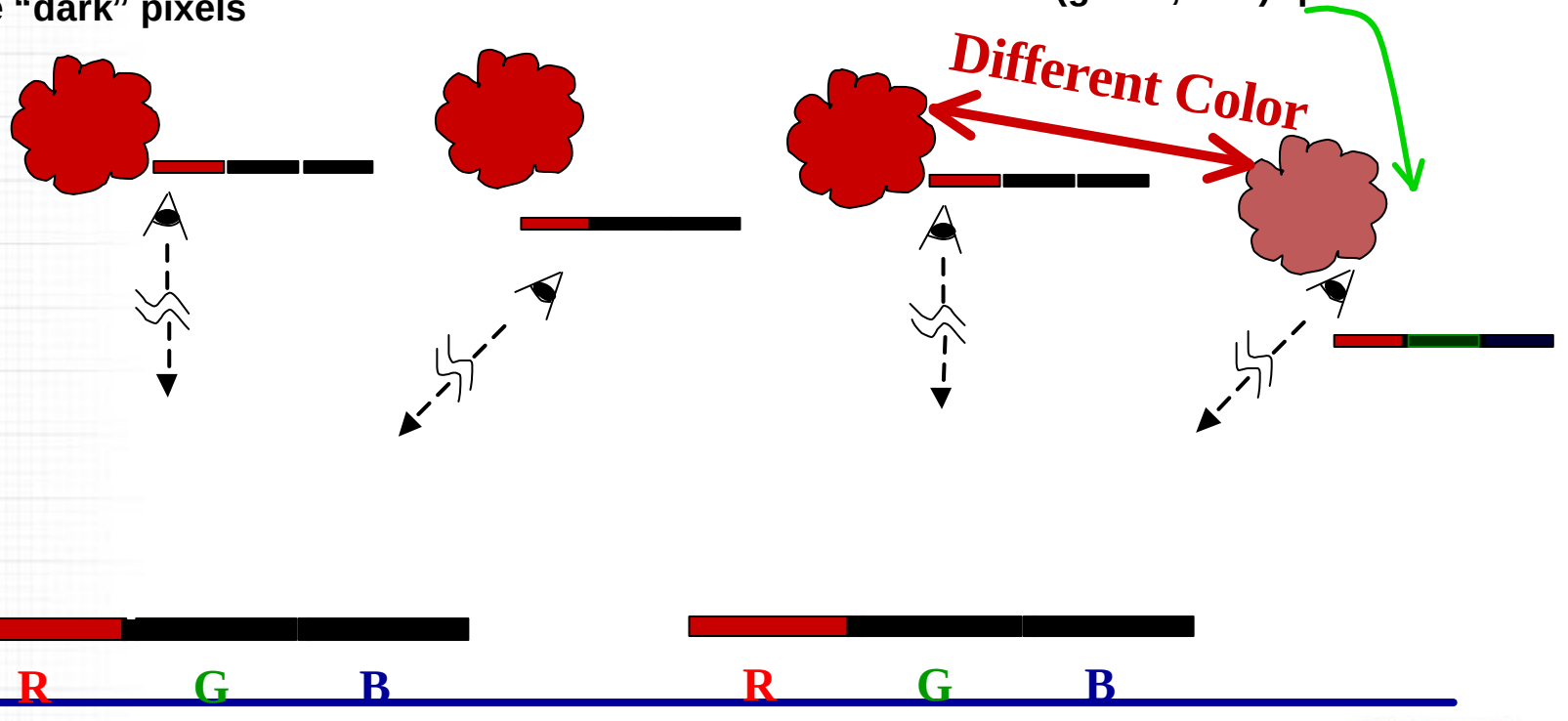
VAextreme

Conventional VA

Viewing Angle – Color stability

Idea case:
No leakage light emerge from the "dark" pixels

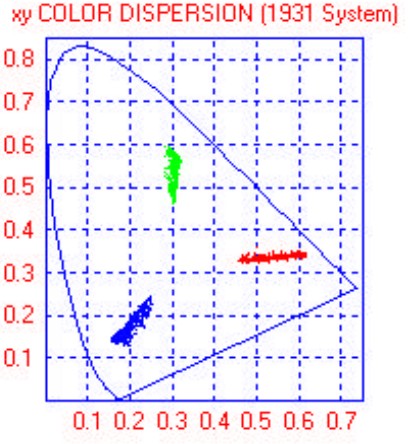
Real case:
Leakage light emerge from the "dark(green,blue)" pixels



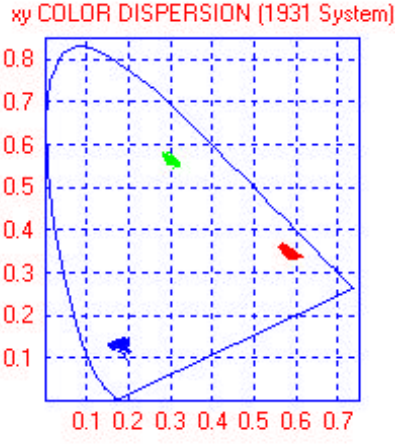
Viewing Angle – Color stability

Color Shift v.s. Viewing angle

Conventional MVA

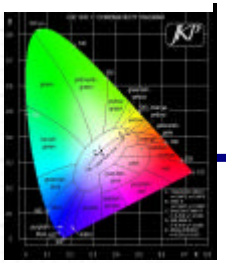


CMO's Super MVA

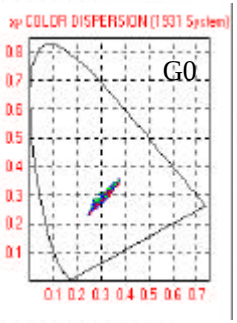


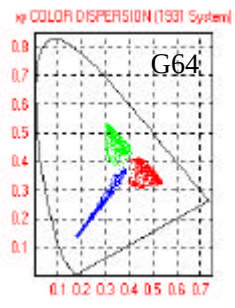
Omniview COLOR

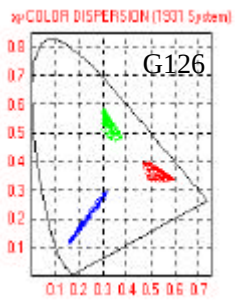
Primary Colors

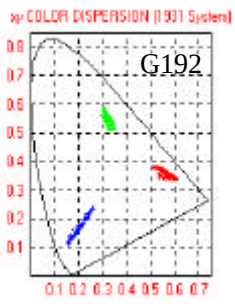


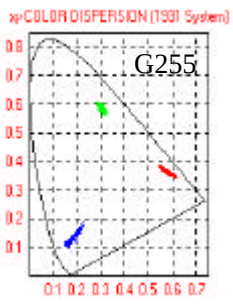
Super IPS

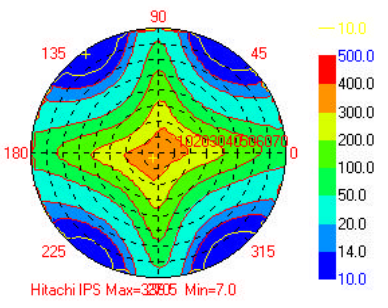




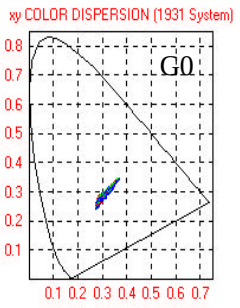


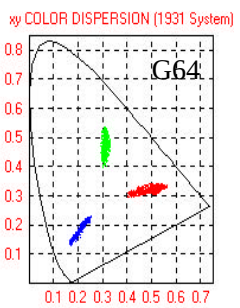


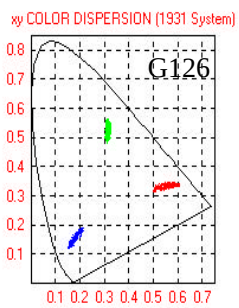


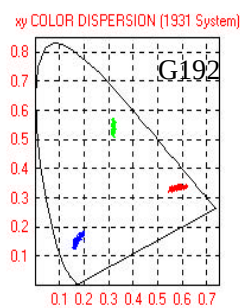


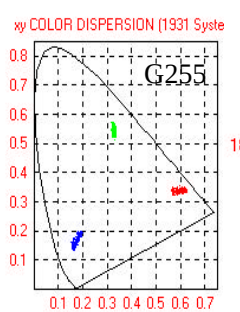
VAextreme

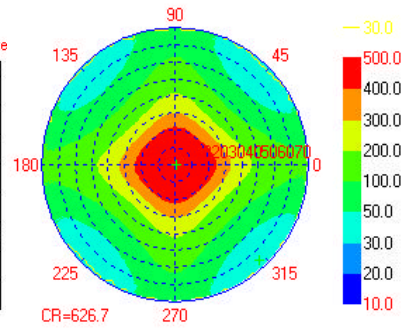












Omniview Color

Other VA
Direct front view

Other VA

Image source: JIS XYZ/SCID

Omniview Color

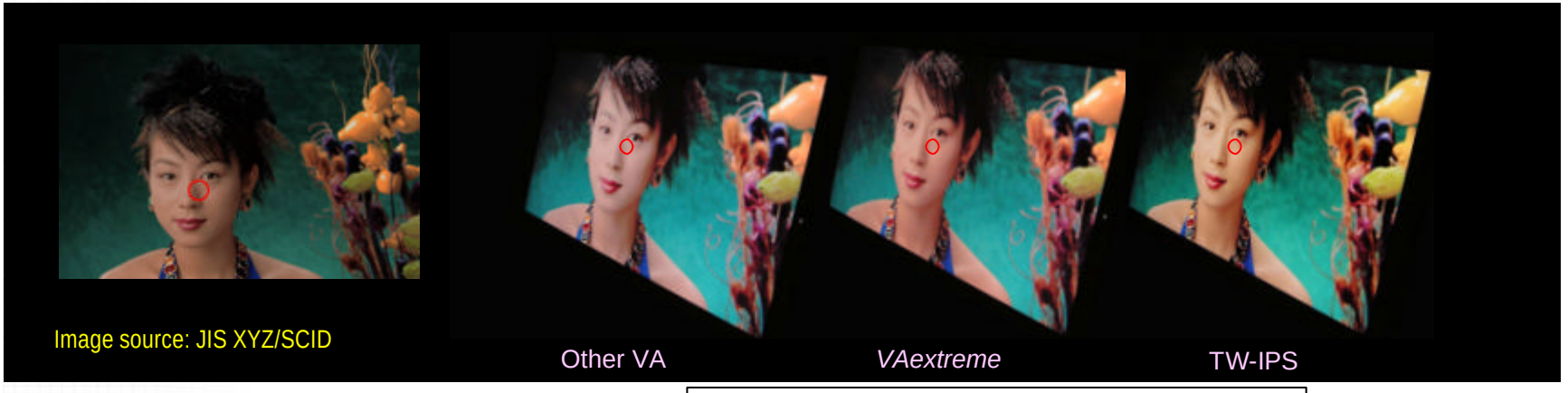
2005 Gold Panel Awards – Best Technologies

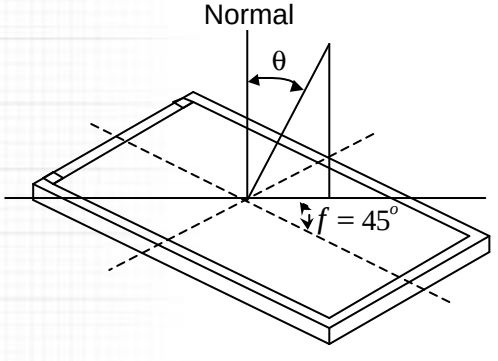
VA EXTREME
Direct front view

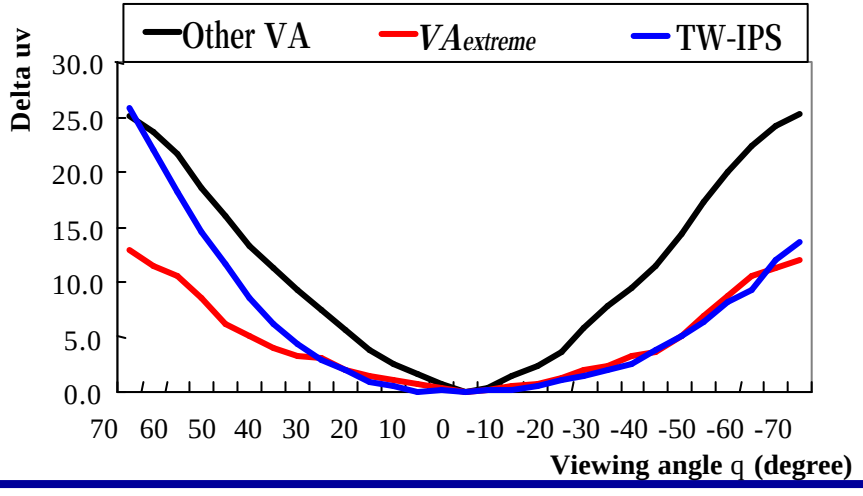
Image source: JIS XYZ/SCID

Color Shift at Azimuth 45°

Omniview COLOR







Polarizer/MVA/IPS

- working mechanism of a sheet polarizer
- the reason why leakage light from polarizer @ oblique view
- idea to eliminate the leakage light to improve color shift properties of LCD
- the solution of C.S. problem/solution of MVA LCD
- the CR/C.S. performance of MVA/SMVA LCD

Comparison of Current WV-Tech for Large Size TFT LCD

	MVA	SMVA	VAextreme	SIPS	TN+Film
CR	O	O	OO	Δ ~ O	Δ ~ O
Color Shift (Primary Color)	Δ	Δ ~ O	O	Δ ~ O	X
Color Shift (Mixed Color)	X~Δ	X~Δ	O	OO	X
Response Time	O	O	O	O	O
Transmision	Δ	O	O~OO	Δ(~O: with extra process)	OO
Symetry of Lum.	O	O	O	O	XX
Yield	O	O	O	X ~ Δ ~ O(?)	O

OO:excellent, O:good, Δ : acceptable, X: under acceptable

Wide View Technology …
Thank You for Your Attention !

CHI MEI OPTOELECTRONICS

Chi Mei Optoelectronics Corp

Fast Response Technologies

奇美電子 CHI MEI OPTOELECTRONICS

Outline

- Introduction
- Slow Response of Liquid Crystal
- Perceptual Phenomenon on a Hold-Type Diplay
- Reduce the Blur Edge Width
- Summary

A Typical Blurred Image

Root causes of the Blurred Image

There exists blur edges in motion images on conventional LCD. The root causes are:

- The slow response of liquid crystal
- The residual image in retina while human eyes are tracing the moving objects on hold-type display

Root causes of the Blurred Image

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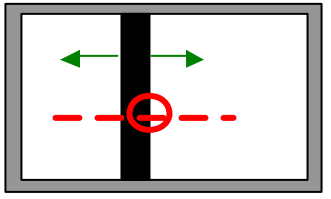
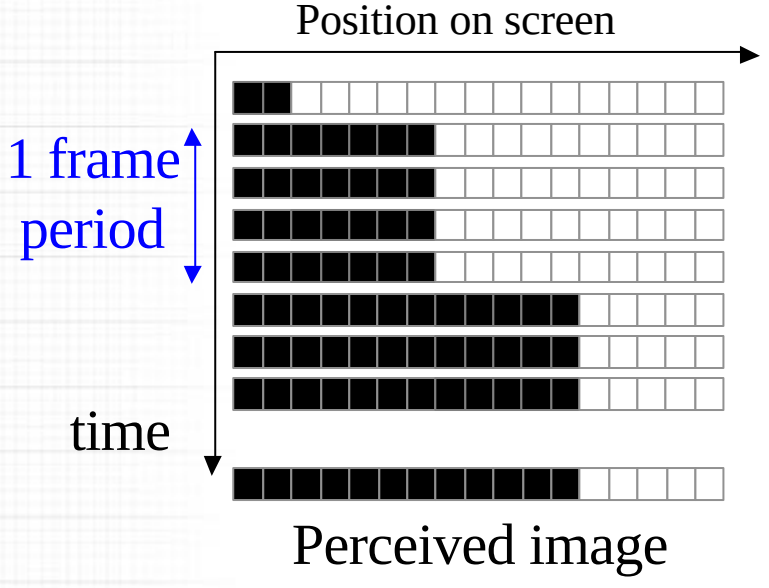
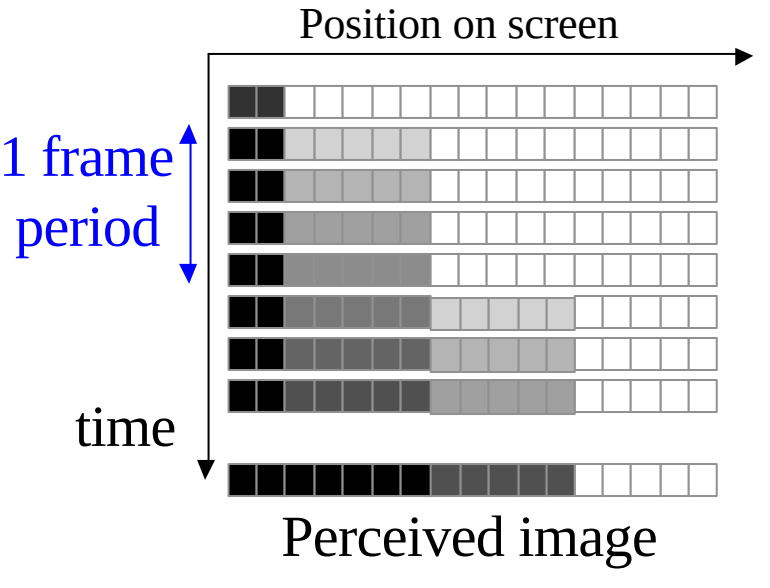
Slow Response of Liquid Crystal



< response time ~ 0 msec>



< response time ~ 40 msec>



Slow Response of Liquid Crystal

The train(moving object) is blurred because of the slow response of liquid crystal.

Real world image

Slow response LCD

Solution of fast response Liquid Crystal

Molecular response time constant

$$t_0 \propto \frac{g_1 \cdot d^2}{k}$$

- Modifying material parameters :
  - Rotational viscosity coefficient $\gamma 1$
  - Elastic constants k_{11}, k_{22}, k_{33}
  - Dielectric anisotropy $\Delta\varepsilon$
- Reducing cell gap *d*

Slow Response of Liquid Crystal
--- Solution ---

To improve the on-off response of liquid crystal:

- Low viscosity liquid crystal
- Thinner cellgap
- …….

To improve the gray-to-gray switching:

- Over drive technology

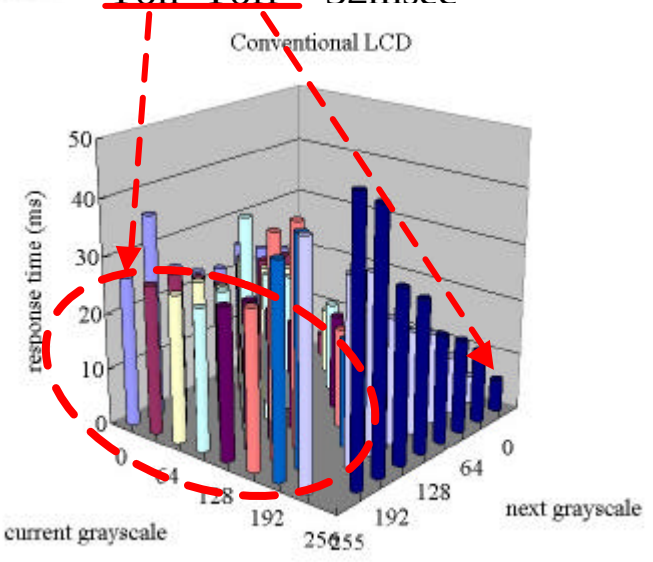
A 16msec response time of gray-to-gray switching is the basic requirement for 60Hz frame rate video images.

Response of a LCD

* TN mode LCDs

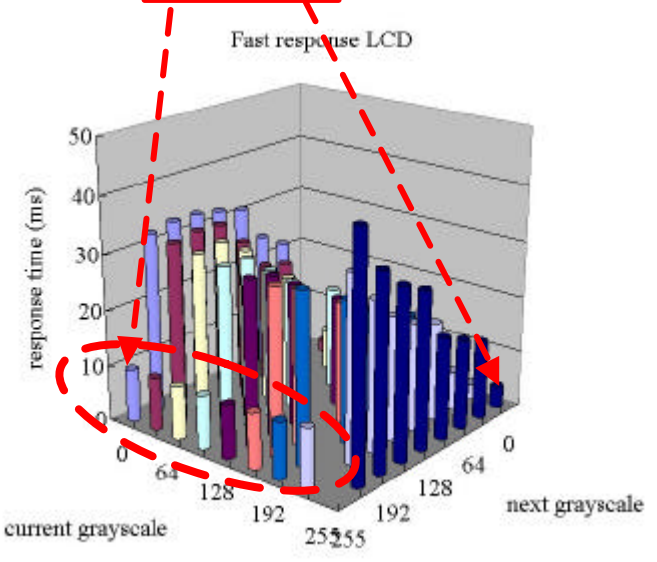
Slow response LC

Ton+Toff ~ 32msec

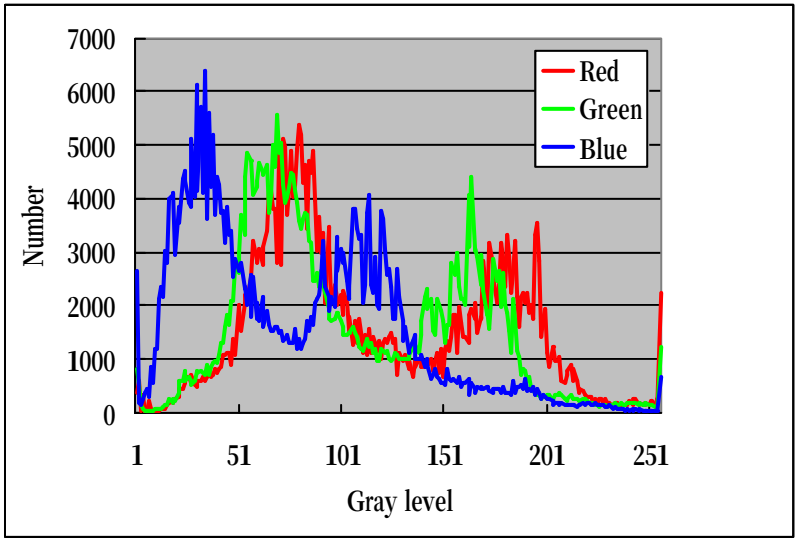


Fast response LC

Ton+Toff < 16msec



Gray level distribution of images

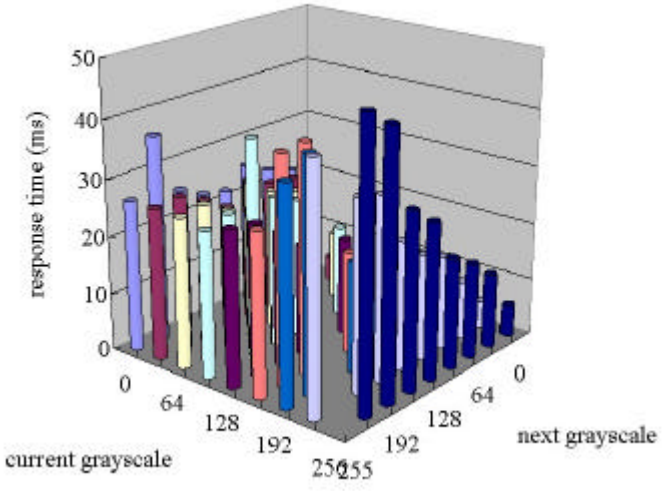


Response of Conventional LCD

* TN mode LCDs

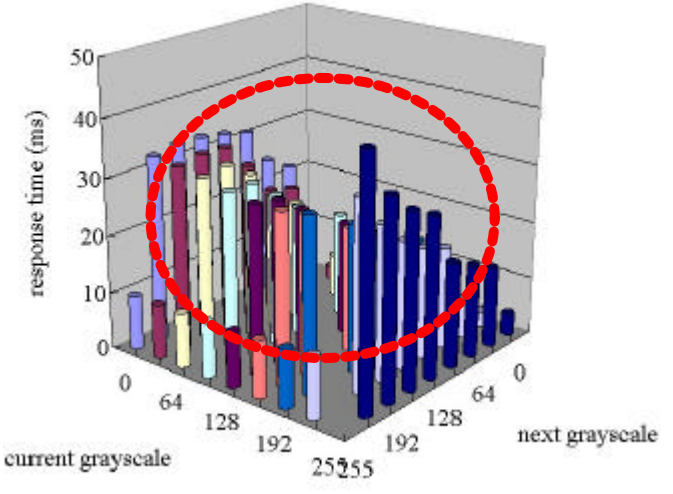
Conventional LC

Ton+Toff ~ 32msec



Fast response LC

Ton+Toff < 16msec



CHI MEI OPTOELECTRONICS

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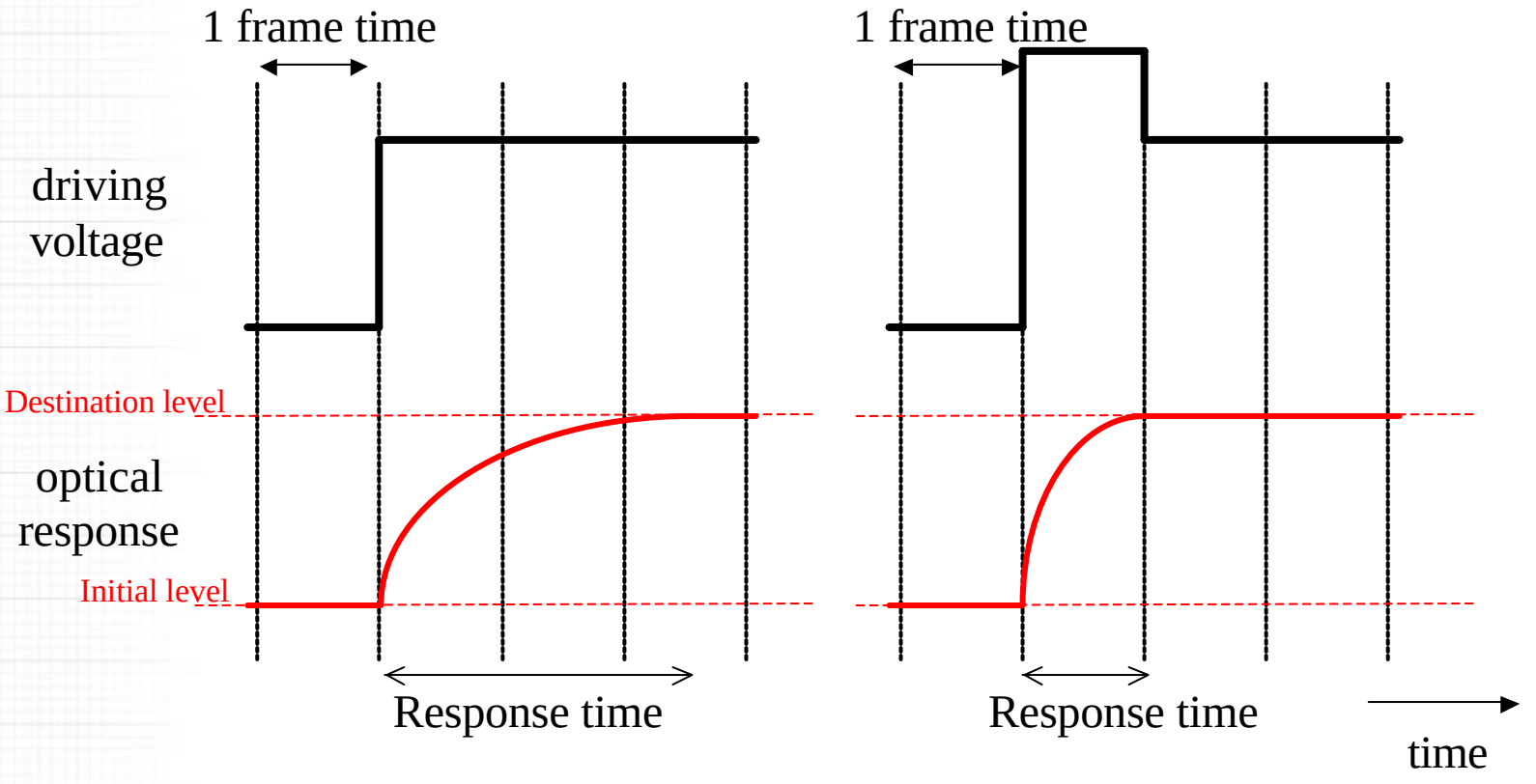
Over Drive Technology

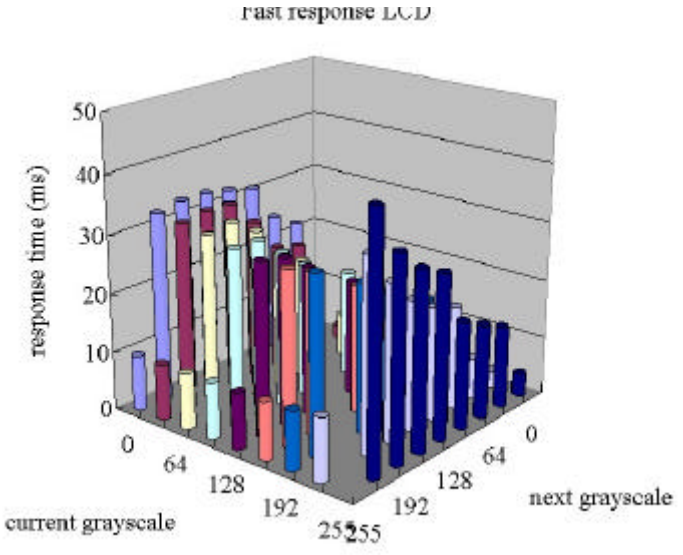


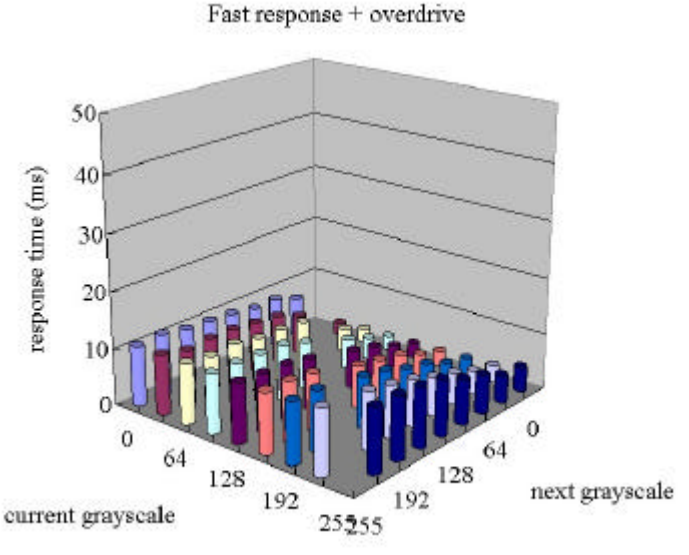
Performance of Over Drive Tech.

Fast response LC

Ton+Toff ~ 16msec

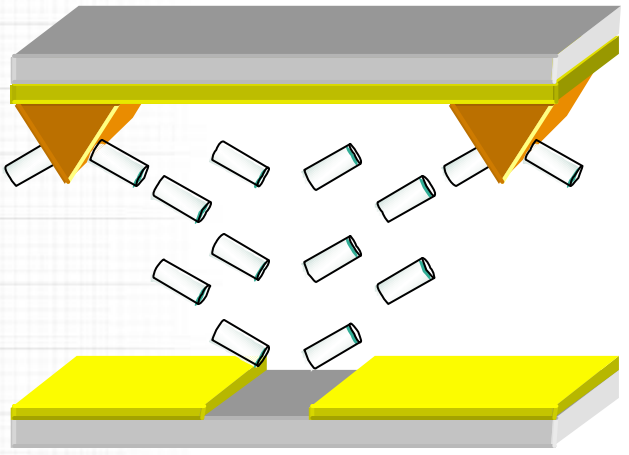
All grayscale switching <16ms

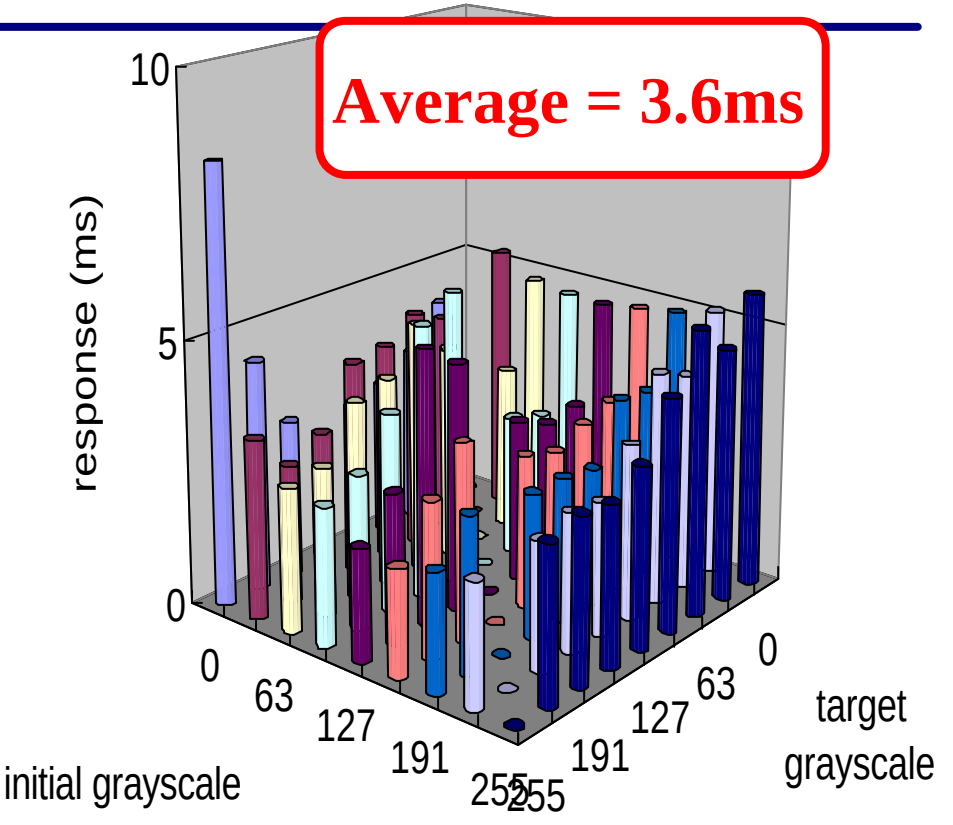




The Fastest Response MVA In The Wrold

ON





2004 International FPD at Yokohama

Slow response of LC operations

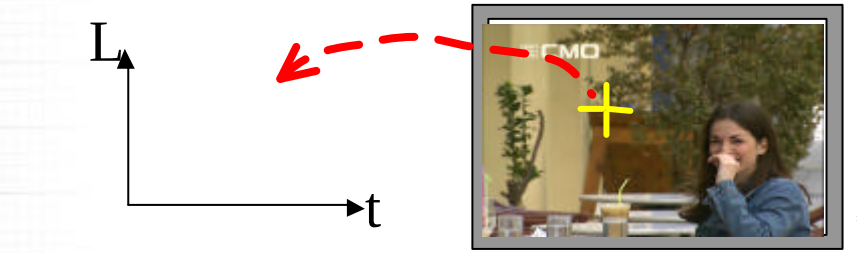
- what's response time, on-off and gray switching
- slow response of LC operation impact to motion picture quality
- the root cause of slow response
- the ways to solve slow response of LC switching

Root causes of the Blurred Image

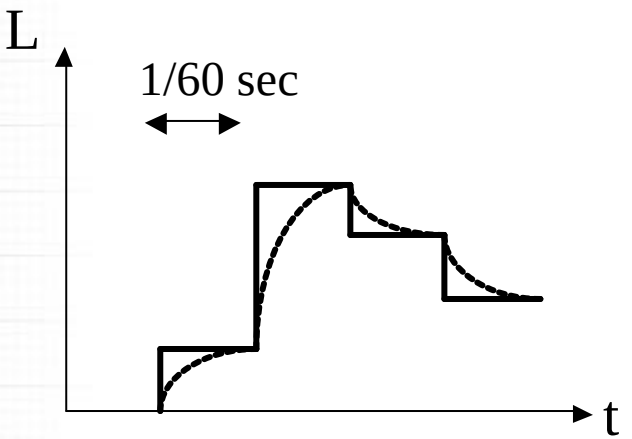
There exists blur edges in motion images on conventional LCD. The root causes are:

- The slow response of liquid crystal
- **The residual image in retina while human eyes are tracing the moving objects on hold-type display**

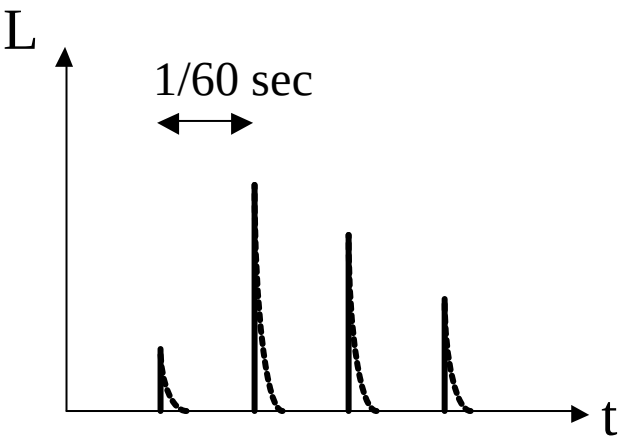
Hold Type and Impulse Type Display



*Frame rate : 60Hz

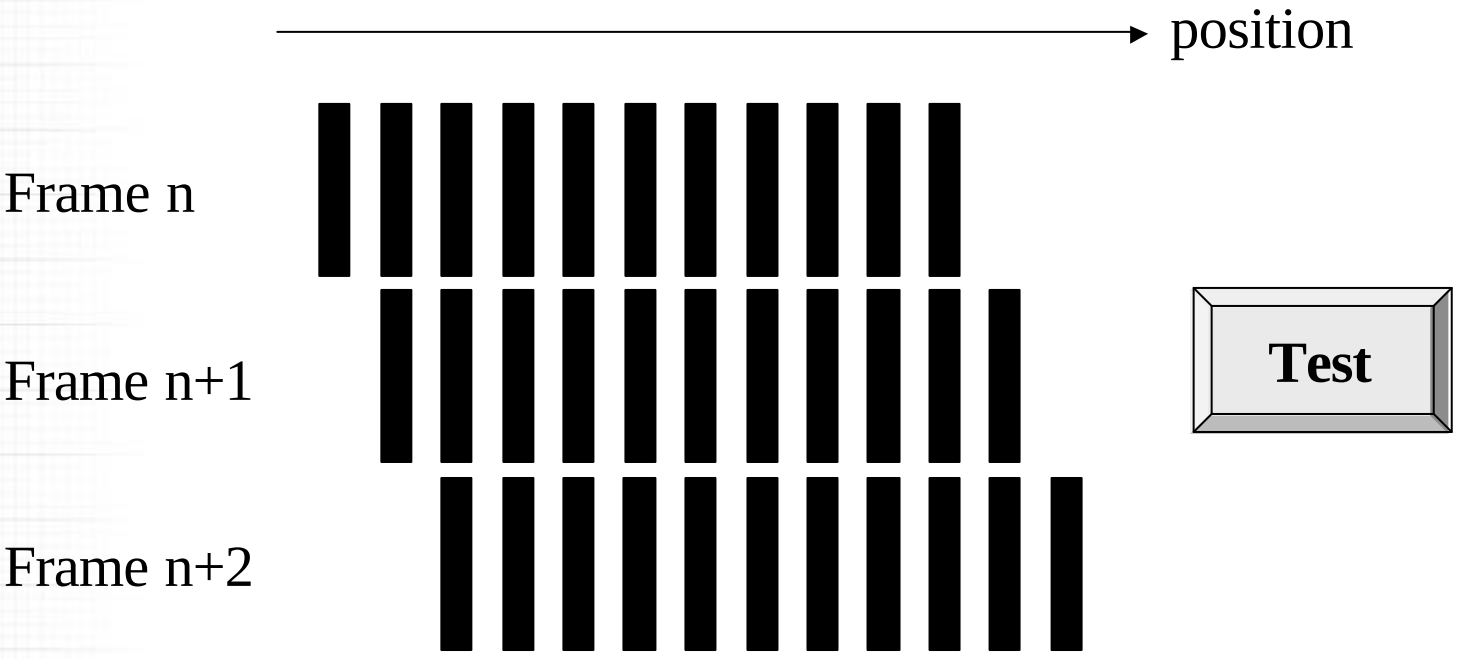


AMLCD
(hold type)

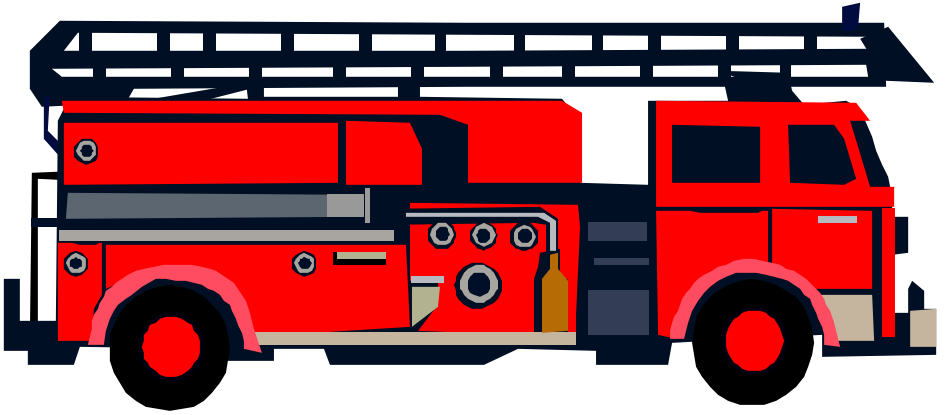


CRT
(impulse type)

Hold Type Display



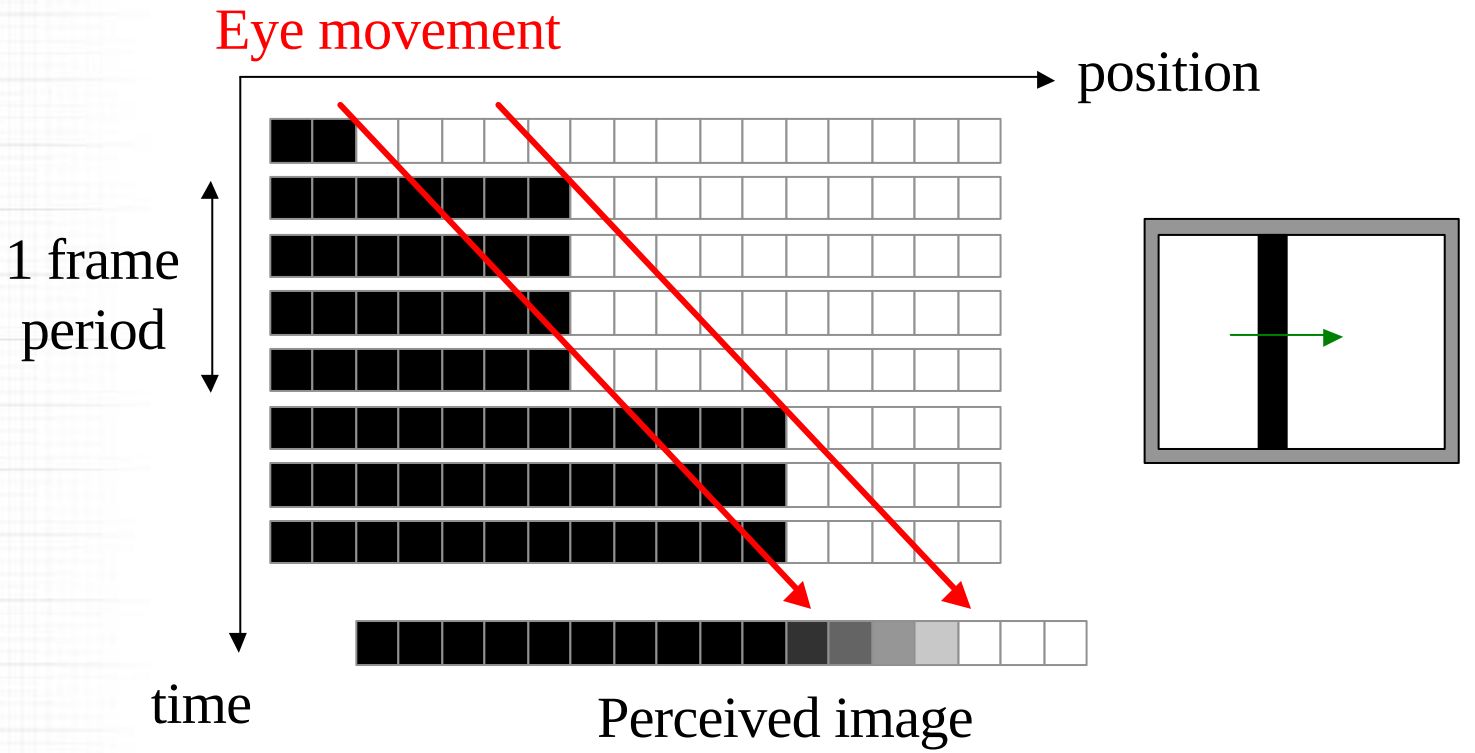
Hold Type and Impulse Type Display



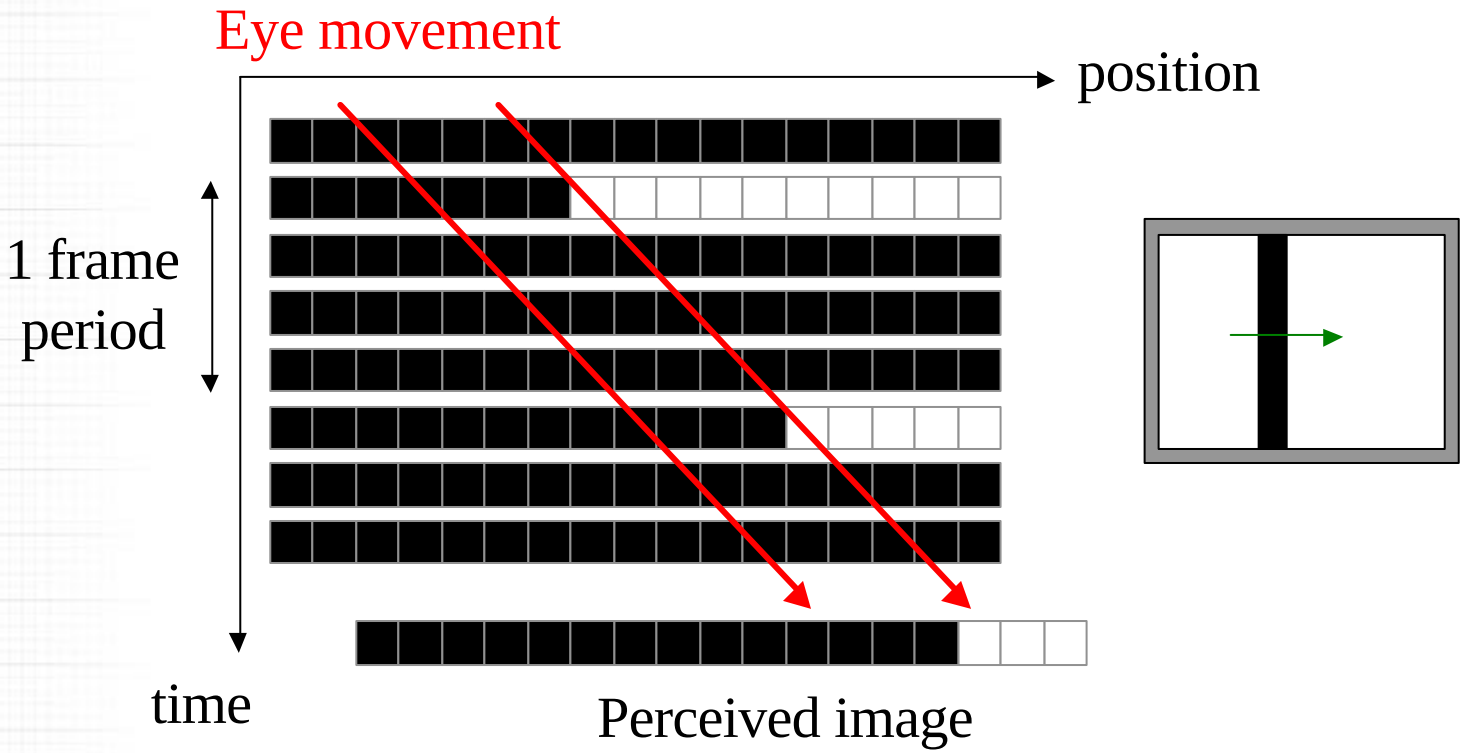
Hold Type

Impulse Type

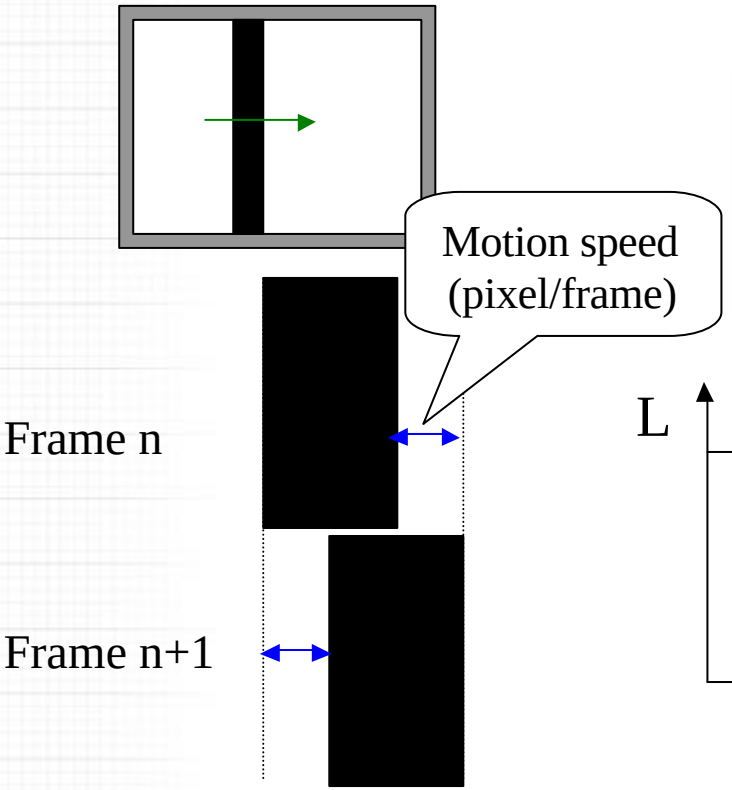
Hold Type Display

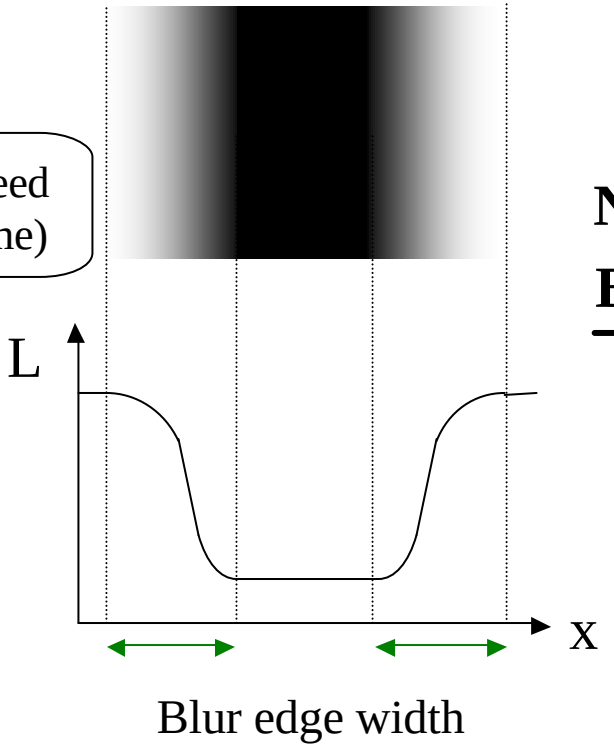


Impulse Type Display



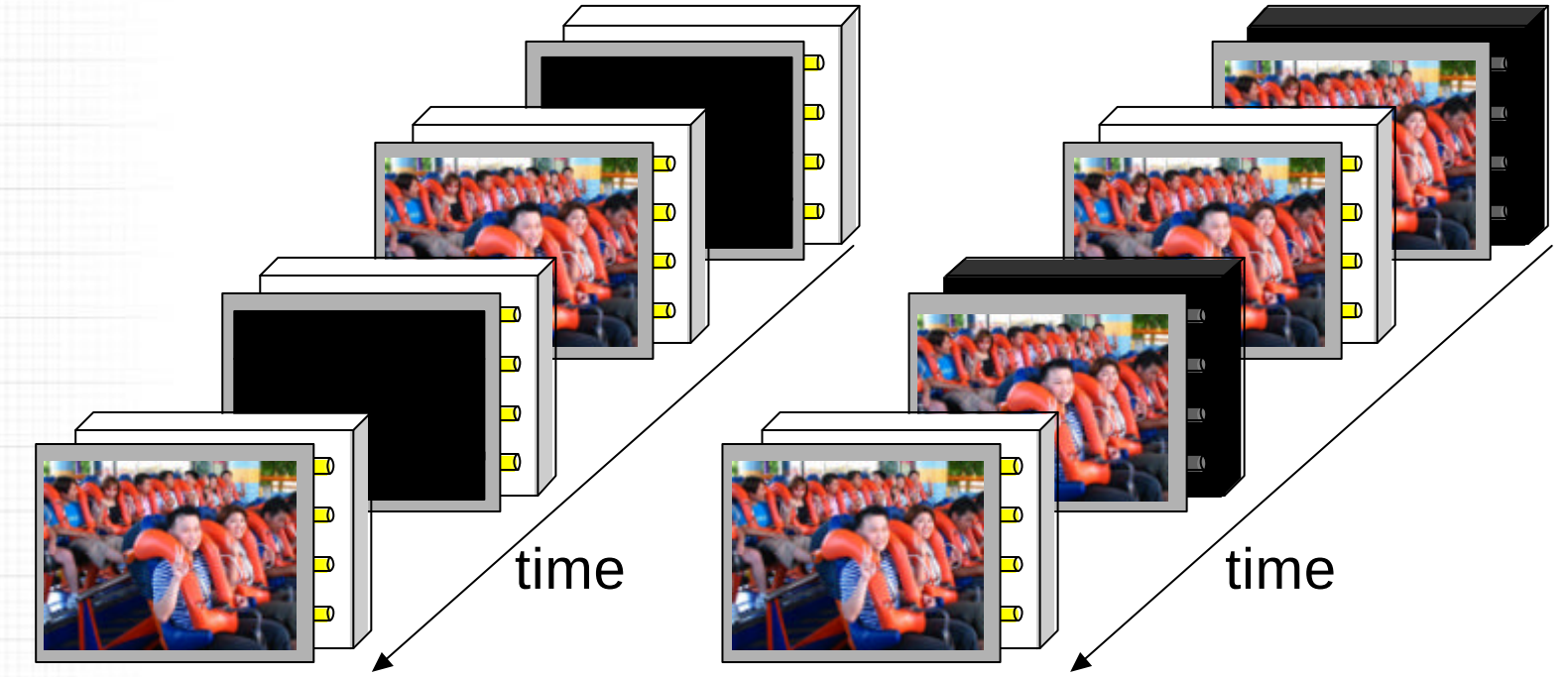
Normalized Blur Edge Width



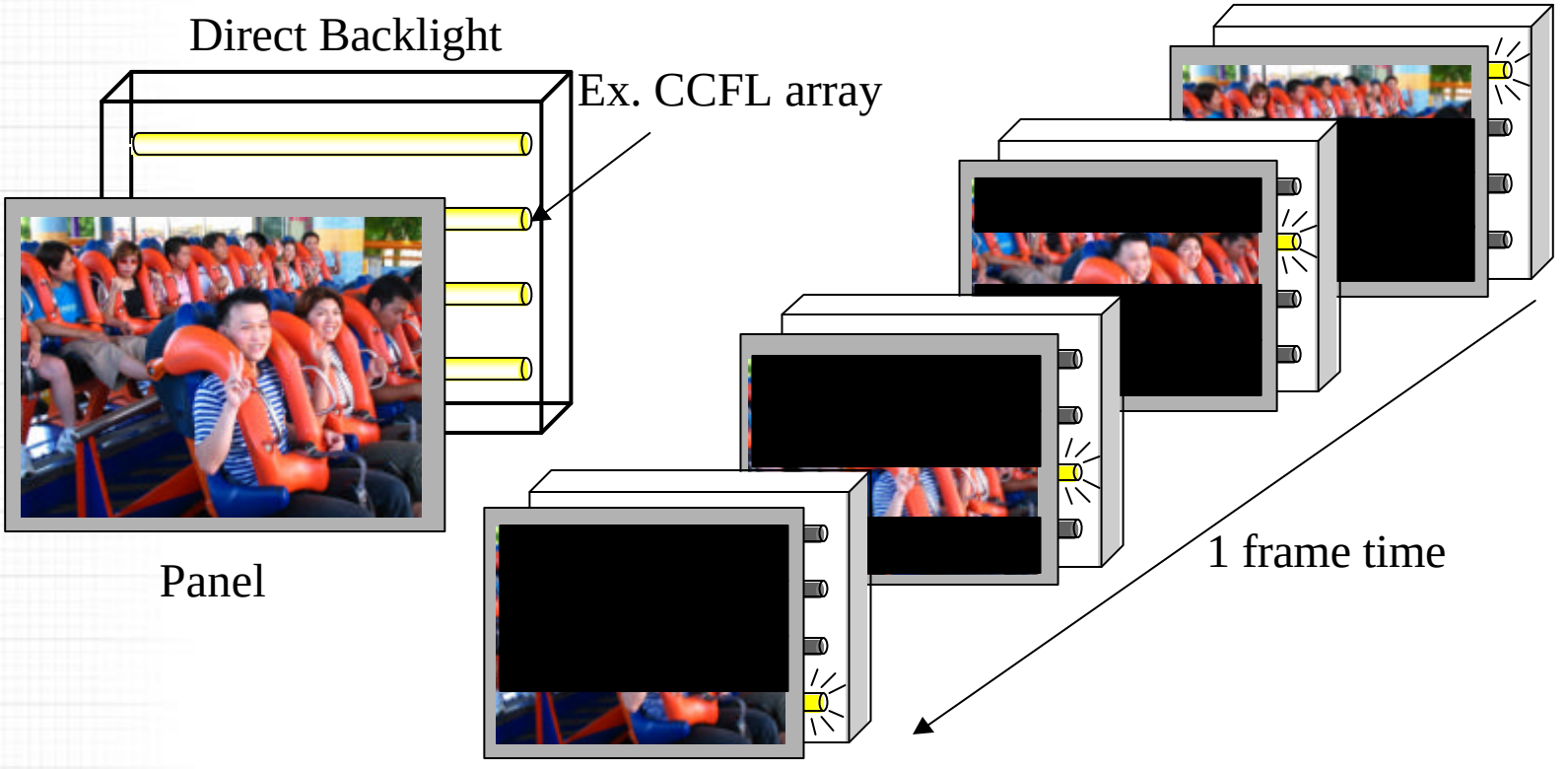


$$\text{N-BEW} = \frac{\text{Blur edge width}}{\text{Motion speed}}$$

Black Insertion and Flash Backlight



Scan Backlight



Simulation

original

Improvement by Pseudo Impulse

hold type and slow response

pseudo impulse and fast response

High Frame Rate / High Definition LCD

Resolution: 1920x1080
Frame rage: 120Hz

小結

- Slow response of LC and mismatching between display and human visual perception are the main causes of blur motion images on LCDs.
- Slow response of LC can be improved by fast response liquid crystal and over drive technology
- The mismatching issue can be improved by pseudo-impulse technologies
- Continuous investment in research and development will make the overall performance and image quality of LCD TVs to surpass that of CRT TVs soon

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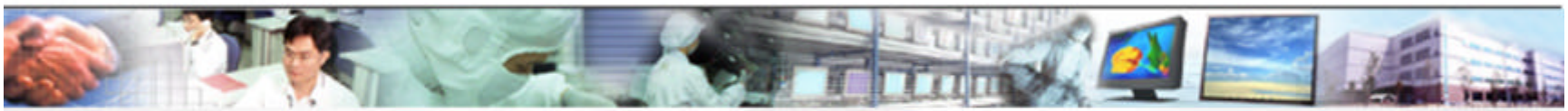

Fast response technology

Thank you

for your attention

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