



Single Layer Color Cholesteric Liquid Crystal Display

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Outline

- Applications
- Color Technologies of Ch-LCD
- Development Results of ITRI
- Future Planning
- Conclusions

Mobile Phone



Slim & Light



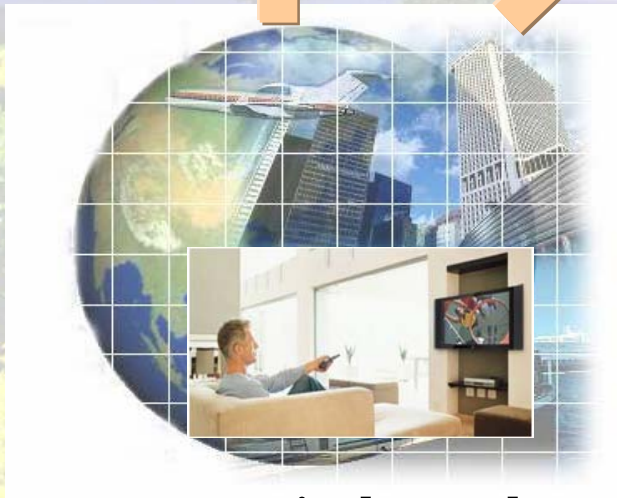
Rollable Display

Convenience



Digital Signage

Large area



Future Display Industry

**Ecology
(Energy Saving)**



E-paper

➡ Flexible Display is selected to meet the needs.



How Flexible Display Meet the Needs?

Approaches

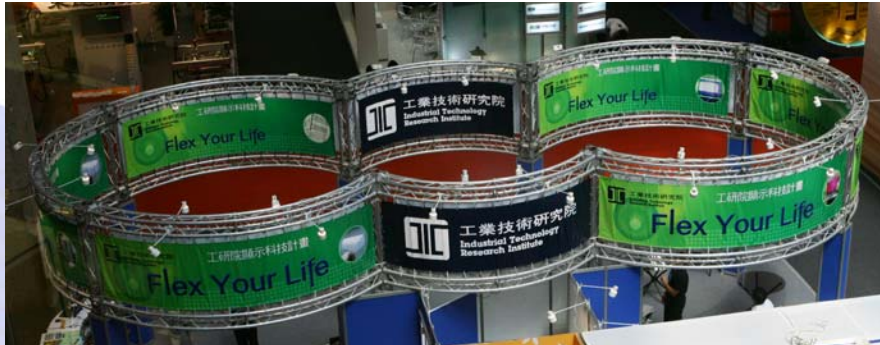
- Plastic Substrate →
- Rollable →
- R2R Process →
- Paperless/Bi-stable →

Needs

- Slim & Light
- Convenience
- Large area
- Ecology(Energy Saving)



Applications- Digital Signage



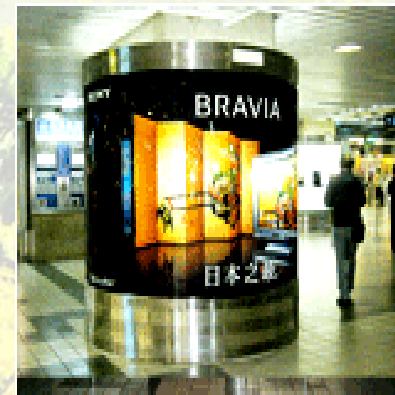
Restricted Color Signage



Printed Large Advertising Paper



Large Size Light Box



Curved Signage

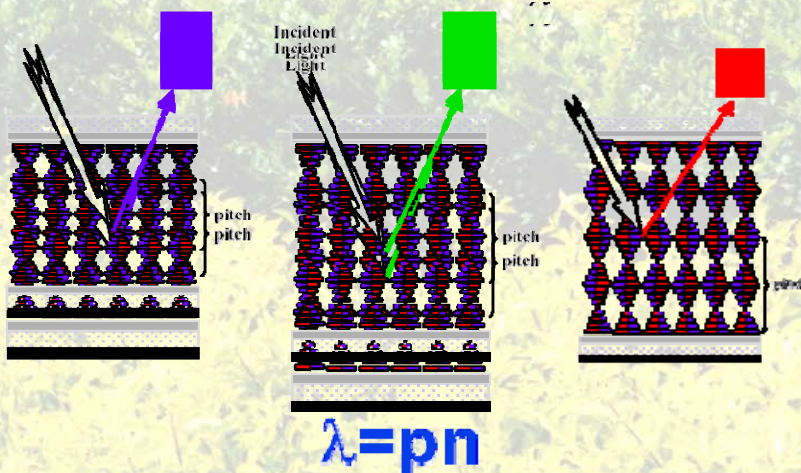
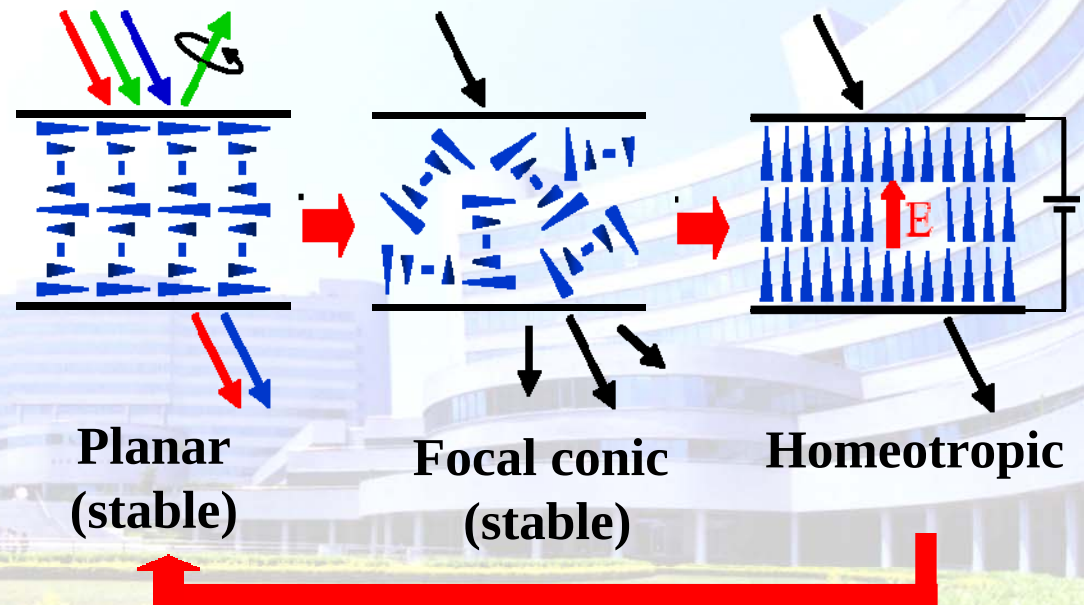
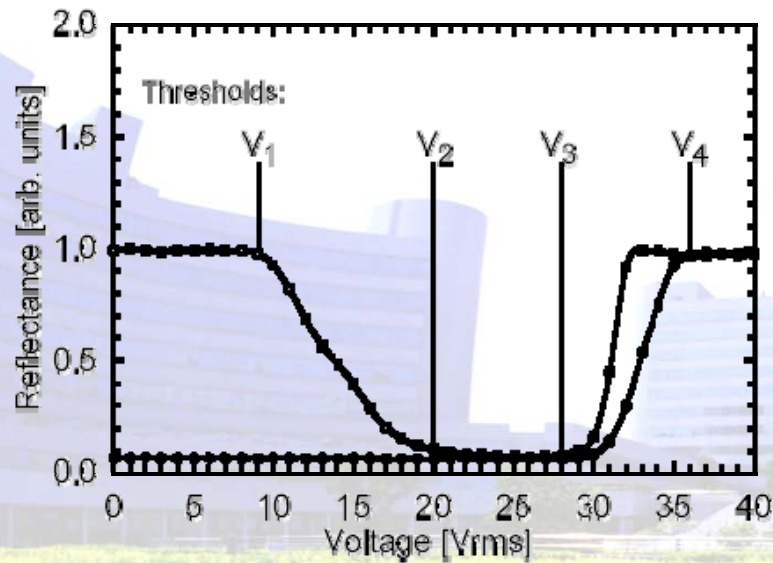
“Display” Your Room ?? The Killer Application??



The background of the slide is a photograph of the ITRI building, a large, modern, curved structure with many windows, surrounded by a lush green garden with yellow flowers in the foreground. The image is slightly faded to make the text stand out.

•Color Technologies of Ch-LCD

ChLCD Bistable Technique



Bi-stable:

- Low power consumption

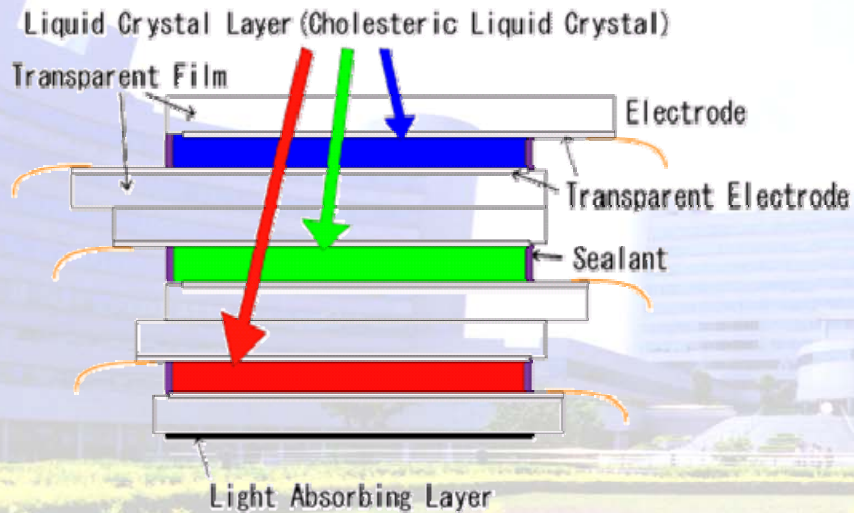
Simple structure:

- w/o CF, optical film
- No backlight
- Light/Thin



Stacked Layers Structure

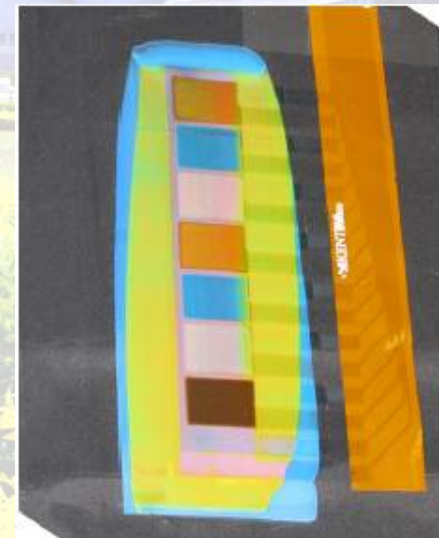
Fujitsu, 2007



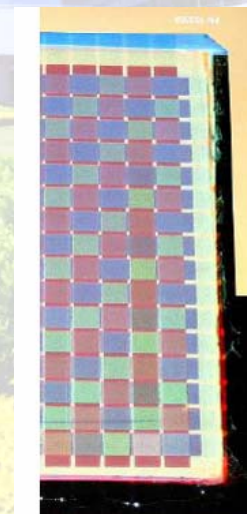
3-layer

KDI, SID 2007

shared electrode design



2-layer



3-layer

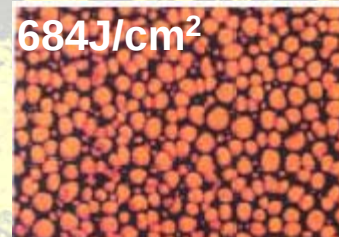
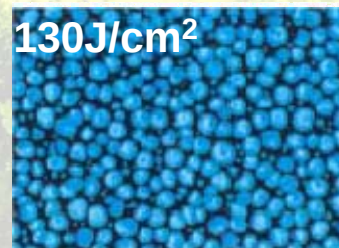
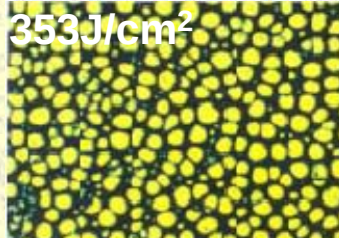
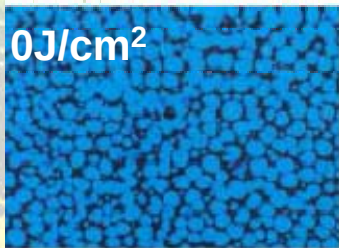
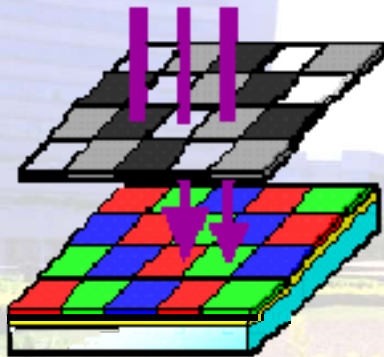
5 mil PET or rayon substrate

Single-layer Structure

KSU, 2003 SID DIGEST

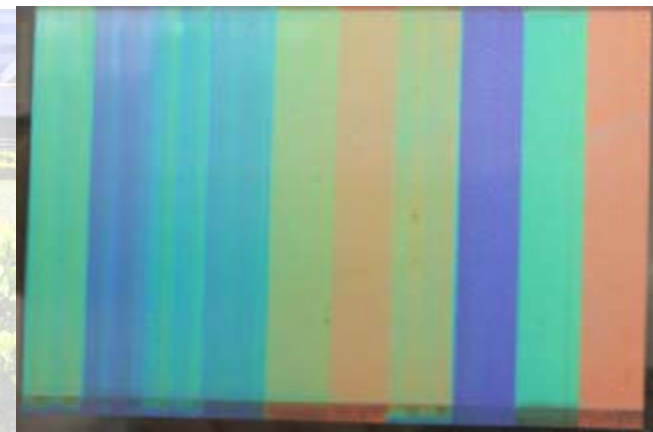
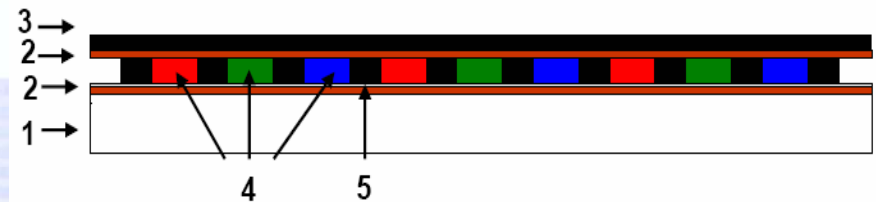
Photo-tuning+Encapsulation

Different UV doses



DTC/ ITRI, 2006 IDW

Ink Jet Printing ChLC

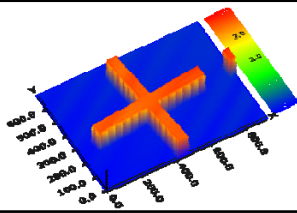
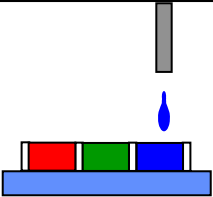
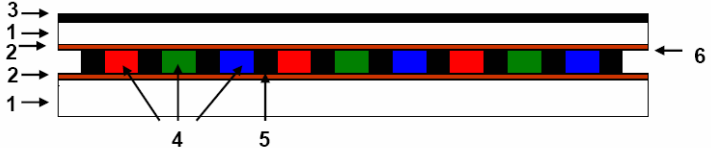
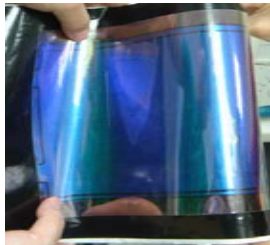
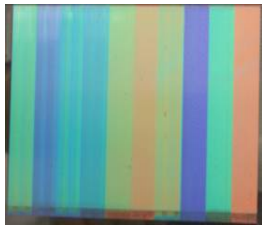


- Surface treatment
- Printing: material, color
- Protection layer
- Suitable for R2R process

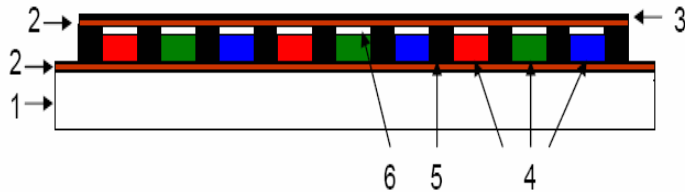
Comparison of ChLCD Technologies

Company	Kent Displays		Fujitsu	Eastman Kodak
Tech.	Single Substrate Ch-LCD	Encapsulated Ch-LCD by PIPS	Stacked color ChLCD	Single Substrate Ch-LCD
	USA		Japan	USA
Spec.	CR:45:1, R:37%	CR:40:1, R>40%	CR:4:1, R>30%	CR:27:1
	NA	■ 20x24pixels, 8dpi	■ 8 or 4096 colors ■ 768x1024(XGA) ■ A4/105ppi, A5/162ppi	R:27%
Structure				
Description	■ Coatable multicolor stacks, single sub. ■ screen-printing(E1)	■ Encapsulated ChLC ■ phase separation ■ full color stacked ChLCD	■ Three layers ChLCD ■ FLEPia A4 size 184.3x245.7mm2	■ Single-substrate self-assembled CH-PDLC via emulsion method
Product				
Reference	07 SID		2007	06 USDC

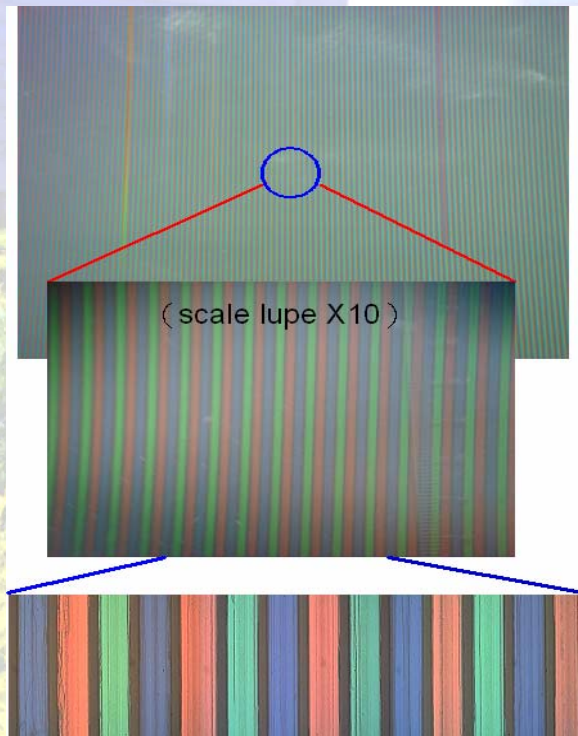
Development Results of ITRI

Company	ITRI	ITRI	ITRI	ITRI
Tech.	10.4" QVGA Monochrome PM Ch-LCD	4.1" Color PM Ch-LCD	10.4" Color Ch-LCD	Flexible 10.4" ChLCD
Spec.	CR>10:1	QVGA CR>10:1	QVGA (320xRGBx240)	QVGA (320xRGBx240)
	R>30%	R>30%	512 color	512 color
Structure				
Description	10.4" (320*240) monochrome Ch- LCD on PC substrates	Ink Jet Printing LC for single layer color ChL- CD	Pixelized vacuum filling of the ChLC	Pixelized vacuum filling Flexible technology
Product				
Reference	2006	06 IDW	07 ASID	07IDW

Single Layer Color Display on Glass



1. Substrate; 2. Electrode; 3. Absorption Layer; 4. Cholesteric Liquid Crystal
5. Bank; 6. Protective Layer



Picture of Panel

Specifications :

- Panel Size: 10.4"
- Substrate : glass(0.7mm)
- Display medium :
Red/Green/Blue Cholesteric LC
- Resolution : QVGA(320×RGB×240)
- Bank : 10um(H), 20um(W), 190um(Pitch)

Features :

- Single Layer color Ch-LCD
- Cost effective process: **Ink Jet Printing**
- Material saving process
- Low power consumption
- Reflective type display (without backlight)
- Simple structure (without polarizer)
- Passive Matrix Driving display

Applications :

E-Book, E-Paper, Signage...

Pixelized Vacuum Filling Tech. (PVF)

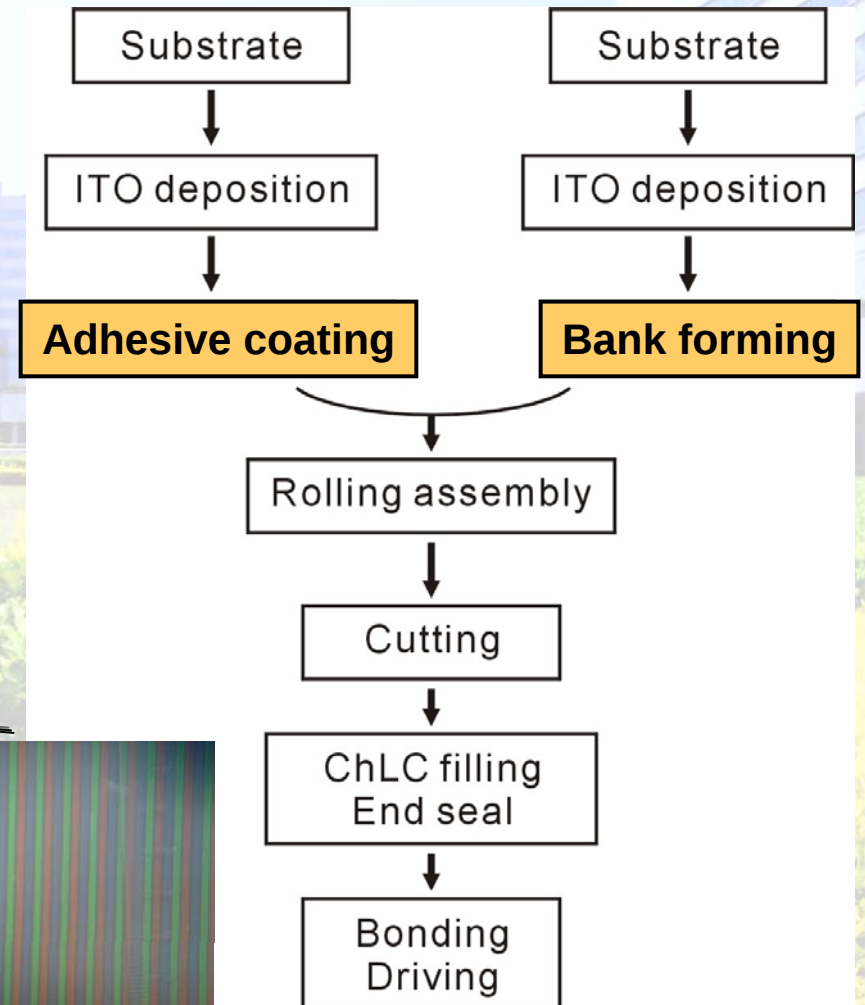
Structure design



1. Substrate; 2. Electrode; 3. Absorption Layer; 4. Cholesteric Liquid Crystal; 5. Bank; 6. Adhesion Layer



Process flow



PVF:

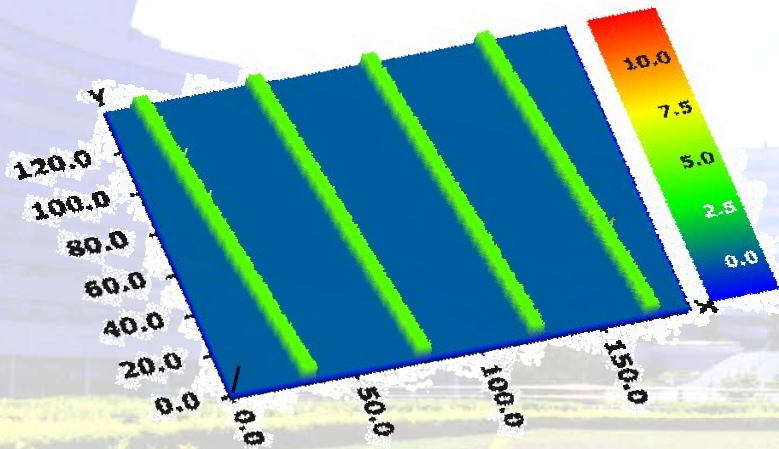
- Batch Type Process
- Traditional Cell Process Flow
- Novel End Seal Method





Bank Structure and Fabrication

Photolithography process



Molding process

Plastic substrate

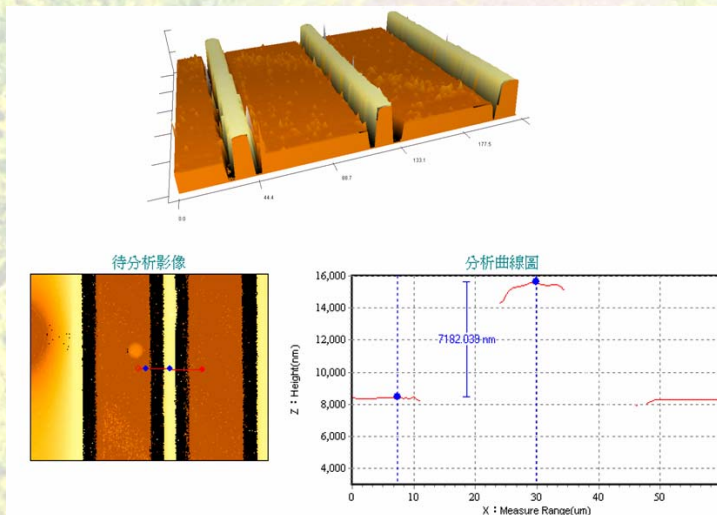
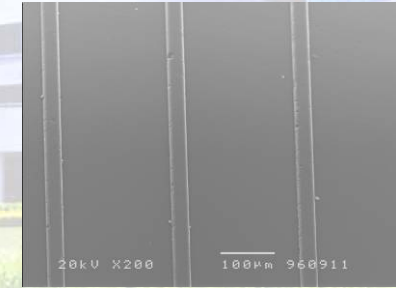
Sample size 10.4"

PMMA Bank

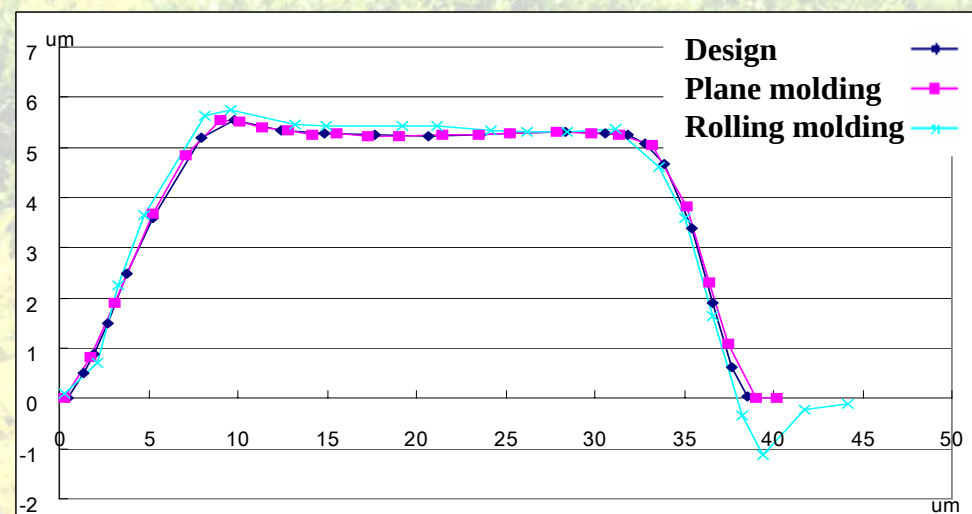
Ni Roller



Bank



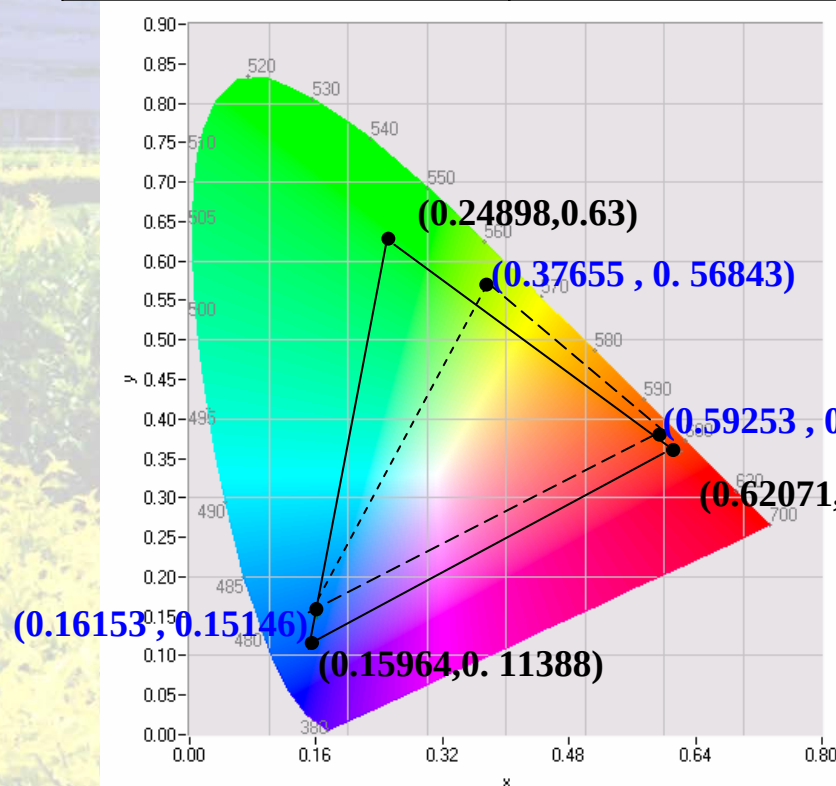
Bank Structure





Color Performance

ChLC	455 nm (B) $\Delta\lambda = 49$ nm	528 nm (G) $\Delta\lambda = 53$ nm	666 nm (R) $\Delta\lambda = 61$ nm
Host (5016+110)	2.13464	2.38304	1.99535
Dopant	0.12820	0.12214	0.08229
(D/H+D)*100 (%)	5.6454	4.8755	3.9993
CIE (x,y)	(0.15964, 0.11388)	(0.24898, 0.63)	(0.62071, 0.35705)



--- Merck

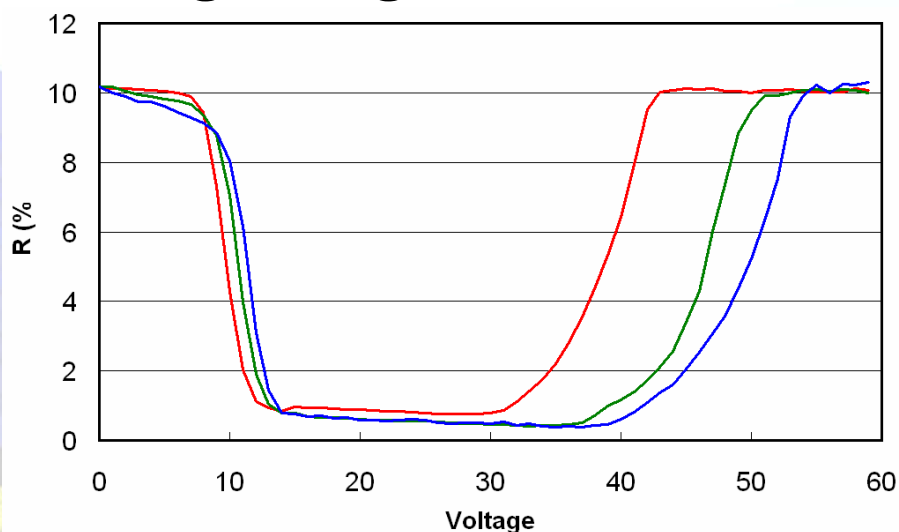
— ITRI-ChLC

NTSC % of ITRI (MCL)
ChLC : 69.18%



Optical & Electrical Property of ChLCD

Driving voltage



Contrast:

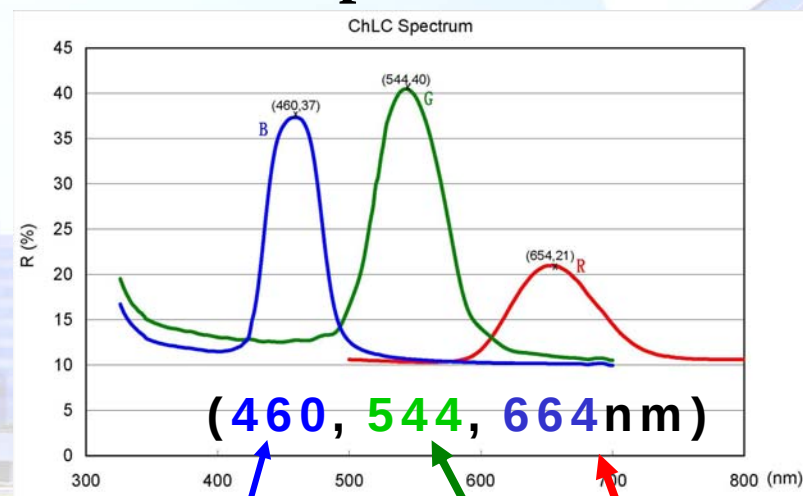
Red: 12
Green: 16
Blue: 13

Reflection:

Red 18%
Green 23%
Blue 8%

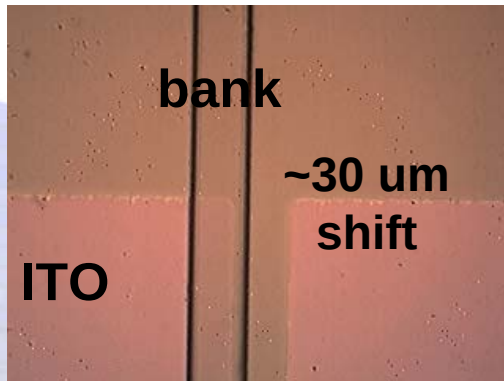
(EZ contrast)

Reflective Spectrum



Process Issues & Solutions

Substrate (PC) deformation:

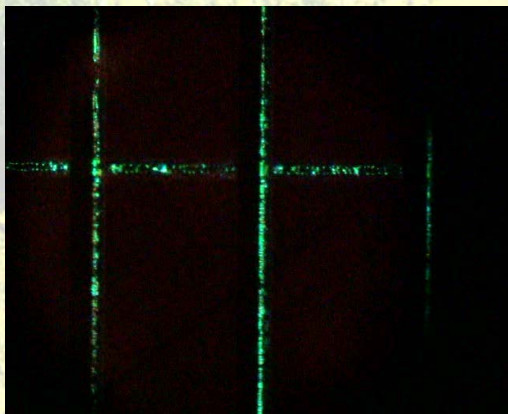


Process modify

- Deformation history
- Structure design
- ITO gap



Light leakage



dark state

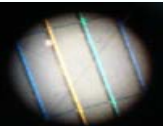
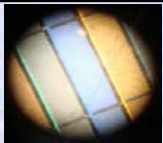
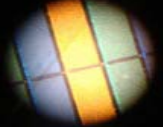
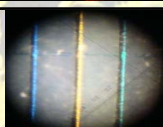
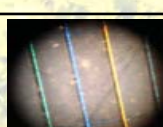
No light leakage



dark state



ChLCD Driving Voltage and Frequency

Voltage	Frequency (Hz)	Result
$\pm 50V$	0.5	
	10	
	50	
	100	
	200	
50V	0.5	
	100	

■ Bipolar driving voltage better than uni-polar voltage

■ driving frequency ≥ 100 Hz can get better driving result

10.4" Single-layer Color ChLCD

Display on glass



Flexible display



- Size: 10.4"
- Driving: PM
- Reflection >8%
- Resolution: QVGA 320xRGBx240
- Gray scale: 8 gray levels
- Color: 3 bits color
- CR >10
- Bending < 30mm





10.4" Single-layer Color ChLCD

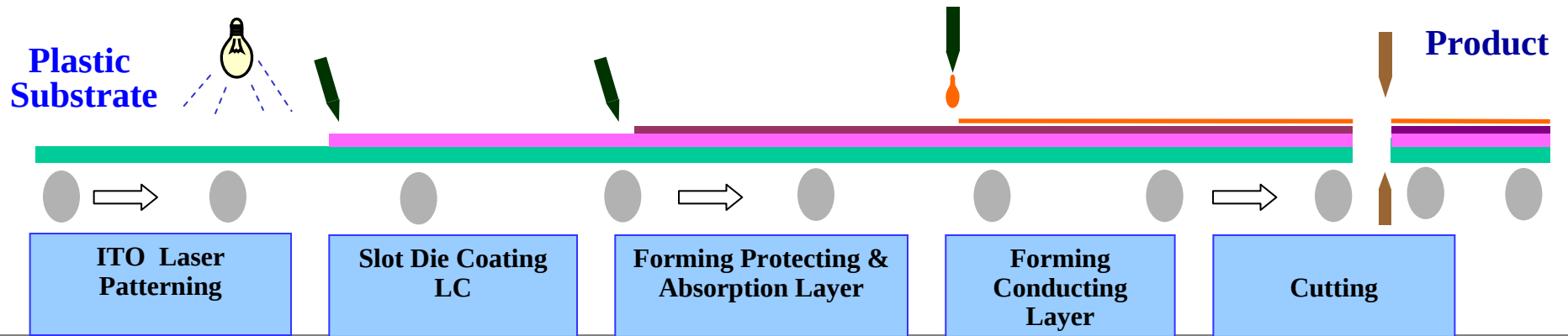




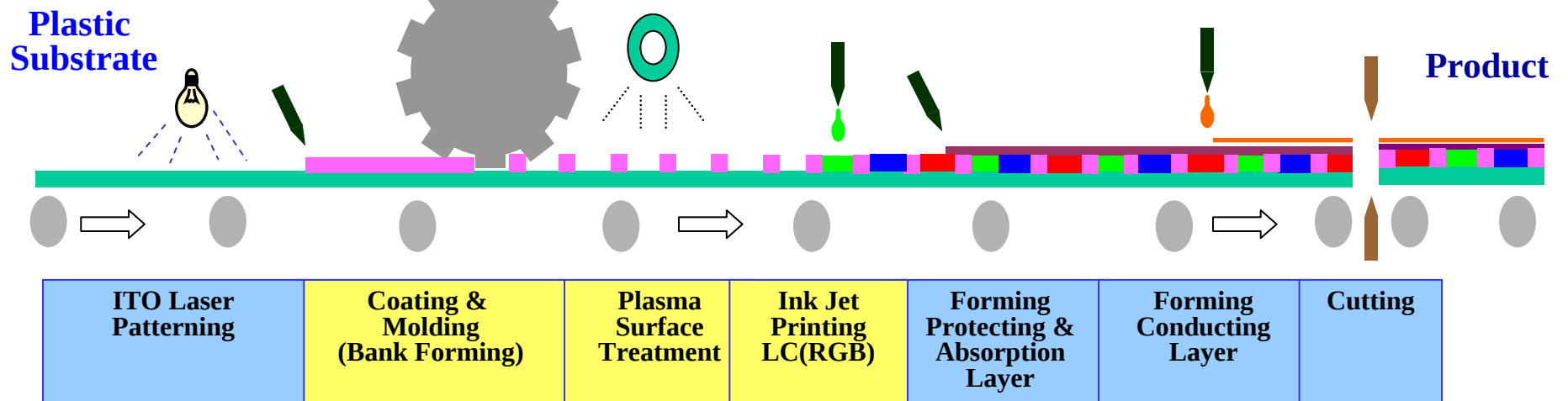
Future Planning

R2R Ch-LC Process Pilot Line

Monochrome

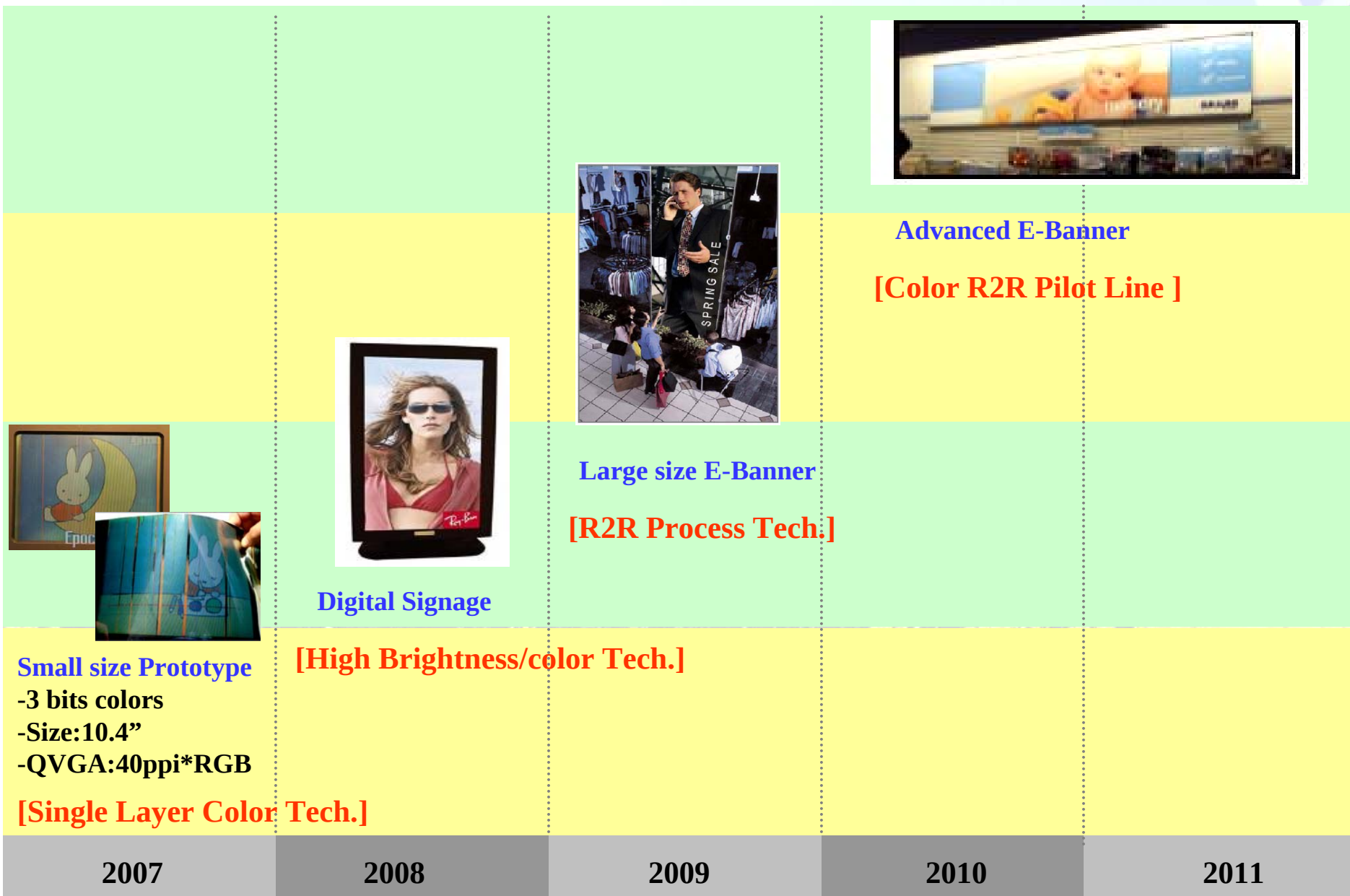


Color R2R





Product Concept Roadmap





Integration in ITRI

DTC :

- Panel design/ integration
- Large size driving system
- R2R Ink Jet Printing

MSL/CMS/ITRI south :

- Defect inspection tech.
- R2R embossing tech.
- R2R process

Color R2R Ch-LC

MCL / EOL :

- LC material tech.
- IJP color display material
- High reflective LC
- Flexible bonding tech.



Industrial Cooperation

Panel/System Makers :

1. Mass production analysis
2. Driving System
3. Product spec. /design

Material Suppliers :

1. Conducting materials
2. Dark layer/ Protection layer
3. Bank material
4. LC material

Equipment Suppliers :

1. Ink Jet Printing
2. Roll Coater

Integrated color R2R cooperation project :

1. Panel /System Makers
2. Material Suppliers
3. Equipment Suppliers

2008

2009

2010

Conclusions

- The single layer design simplifies the fabrication process.
- The 10.4" flexible, color, bi-stable display is realized by the PVF technique.
 - Resolution QVGA, CR>10, 3 bit color, voltage<60V, bending<30mm more than 10000 times
- Other topics on flexible bi-stable Ch-LC display
 - Brighter, Better Color, Lower driving voltage, Larger size, Higher resolution, R2R process.



Thank you for your attention!