
High Resolution TFT-LCDs

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Research Worldwide



ThinkPad



- ◆ **Trackpoint III**
- ◆ **Integrated Infrared Links**
- ◆ **12.1" Active Matrix LCD**
- ◆ **MPEG-2 Video**
- ◆ **Mwave DSP**
- ◆ **V.34/28.8 Modem**

IBM TFTLCD Chronology



- ◆ **August 1986 - Joint R&D between IBM Japan, IBM Research and Toshiba Corp., 14" diagonal display fabricated**
- ◆ **March 1989 - 12 inch diagonal VGA TFTLCD demonstrated at Hanover CeBit**
- ◆ **August 1989 - Joint Manufacturing Agreement between IBM Japan and Toshiba Corp. Display Technologies Inc. formed.**
- ◆ **May 1991 - DTI TFTLCD's shipped in IBM products**

Current Standard Data Display Formats

UXGA 1600 x 1280 (or 1200)
(about 4X SVGA)

SXGA+ 1400 x 1050

SXGA 1280 x 1024
(about 4X VGA)

XGA 1024 x 768

SVGA 800 x 600

VGA 640 x 480

1.6X

2.6X

4.3X

4.8X

6.7, (6.2)X

Aspect Ratio: 4x3

4x3

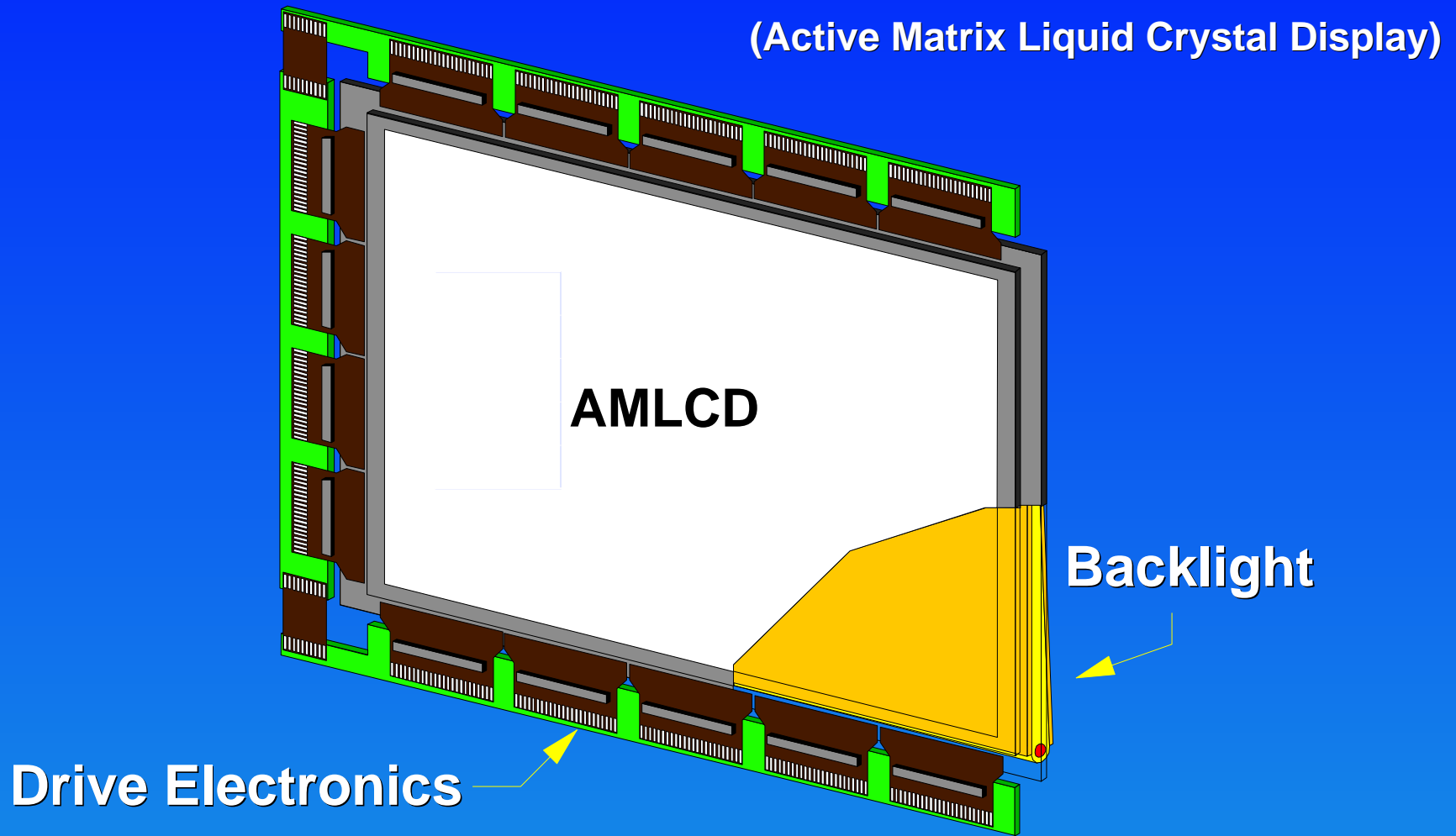
4x3

5x4

4x3

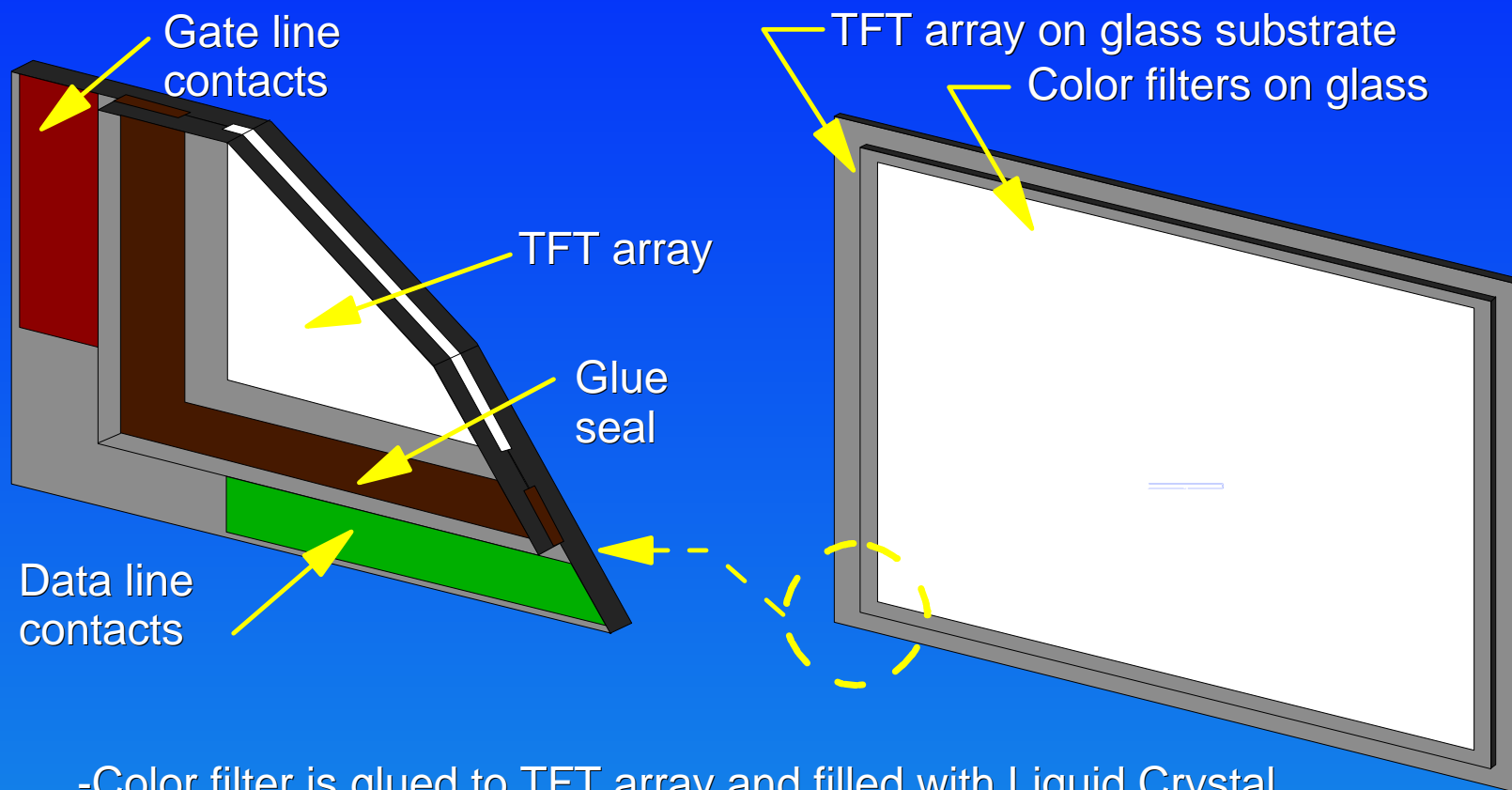
5x4, (4x3)

AMLCD Module

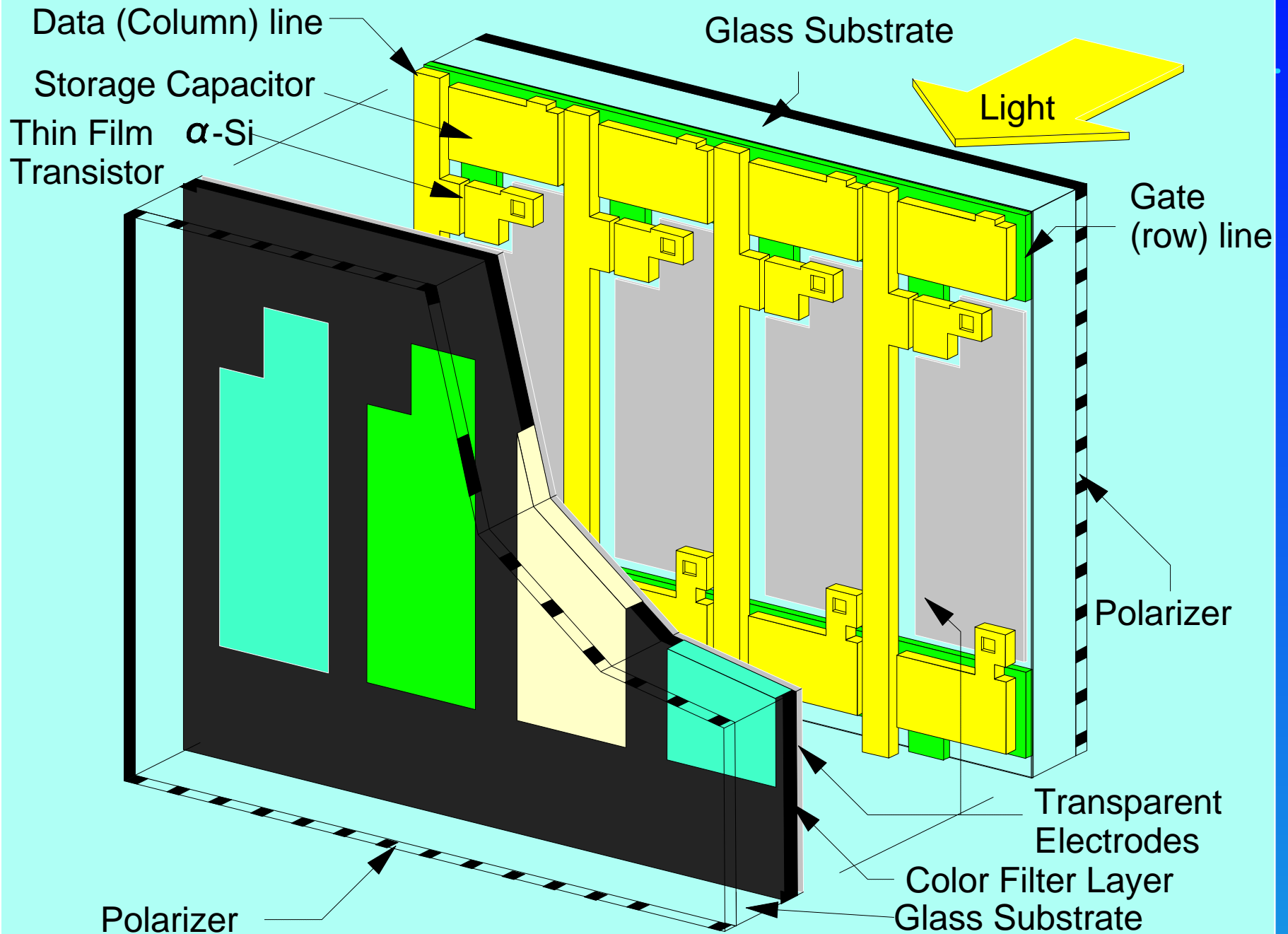


E. G. Colgan, IBM Watson Research, 3/96

Active Matrix & Color Filter on Glass

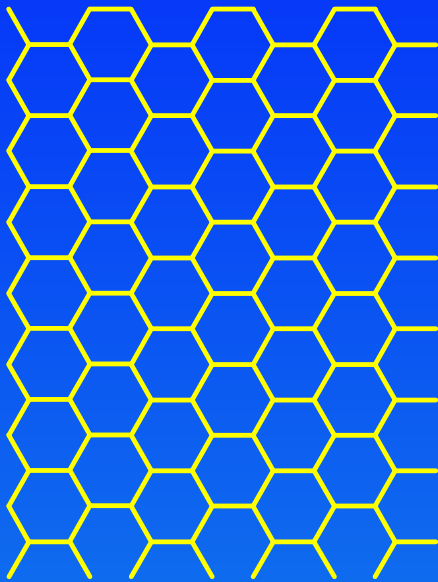


- Color filter is glued to TFT array and filled with Liquid Crystal.
- Thickness of L.C. layer determined by "spacer balls" sealed in with liquid crystal, typically about 5 μm in diameter.
- Polarizing films are laminated to the front & back after sealing.



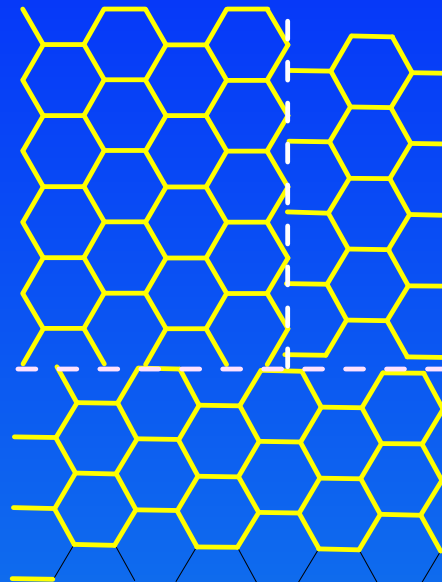
Amorphous Si Thin Film Transistors

Single Crystal Si



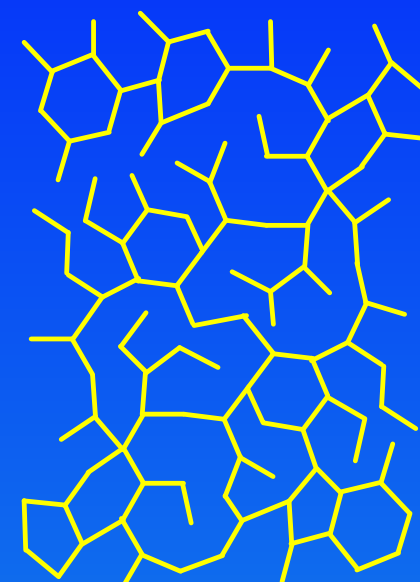
Electron Mobility: 1500

Polycrystalline Si



40-100

Amorphous Si

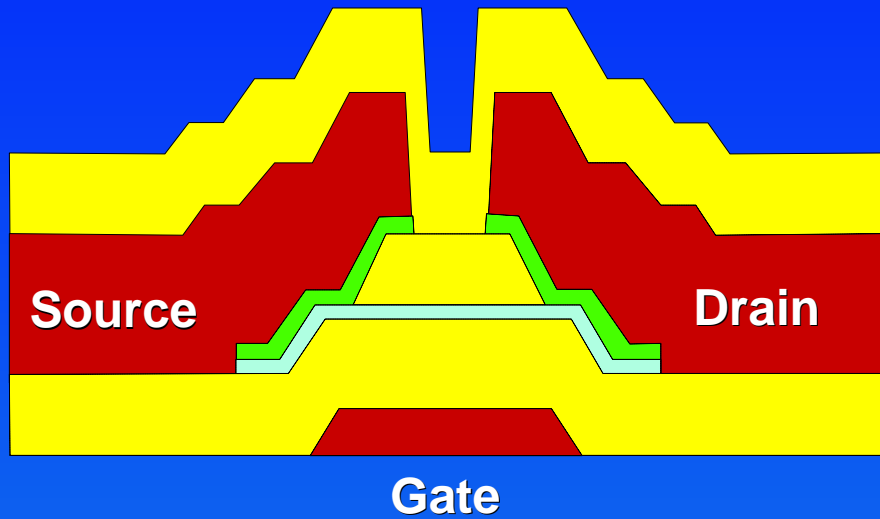


0.5-1.5 (cm²/V sec)

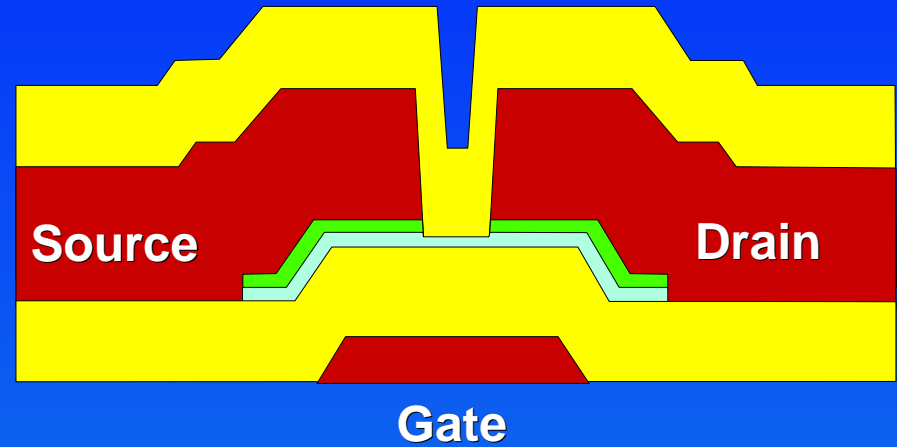
- ◆ Amorphous Si only has short range order
- ◆ Contains 5-20% Hydrogen, content & bonding important for electrical properties
- ◆ Can be deposited at 250-350 C, so inexpensive glass substrates can be used
- ◆ Resistivity decreases by 100,000X when illuminated due to photon induced free carriers

Transistor Types

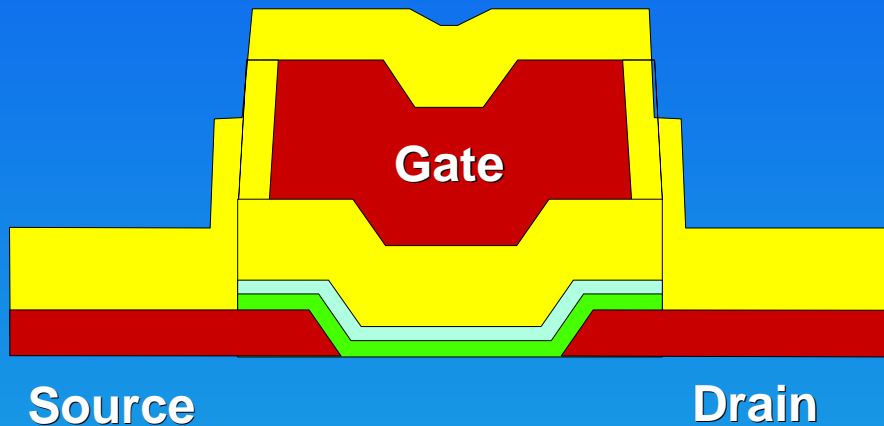
Inverted-Staggered: Trilayer



Inverted-Staggered: Back-Channel Cut



Top Gate-Staggered



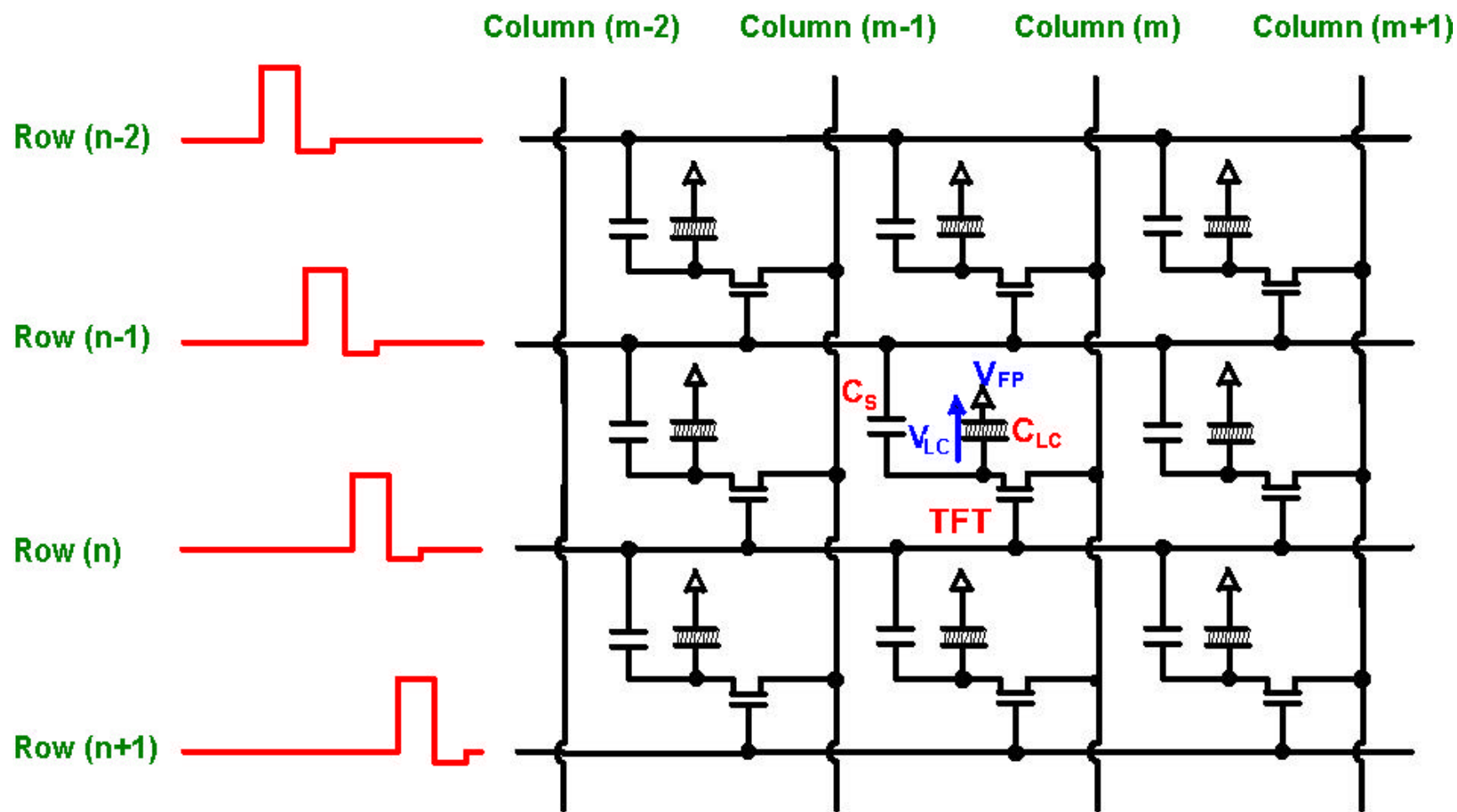
Gate or Data Metal

Gate or Passivation Dielectric

Intrinsic α -Si:H

n+ α -Si:H

Cs-on-Gate-Array Driving Scheme



Liquid Crystal Cell Assembly Process

TFT Array Substrate

Cleaning

Apply Polyimide & Bake

Rub Polyimide & Clean

Color Filter Substrate

Cleaning

Apply Polyimide & Bake

Rub Polyimide & Clean

Apply Glue Seal

Spray Spacer Balls

Align & Cure Glue

Fill with Liquid Crystal

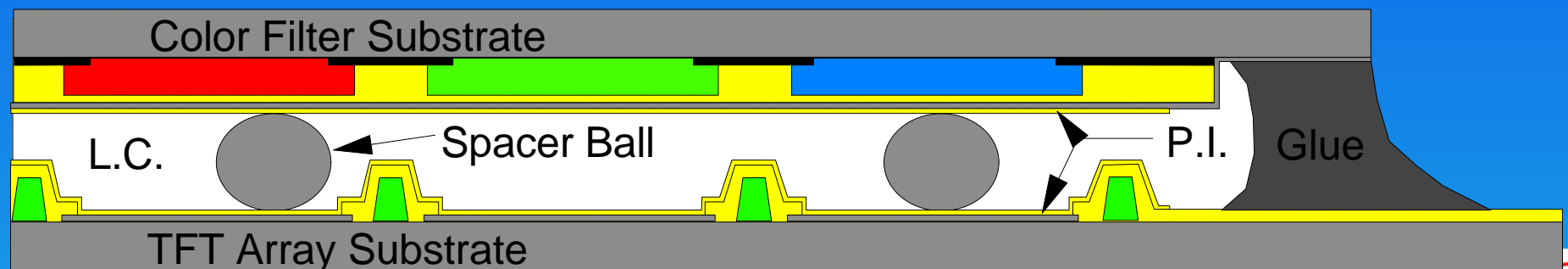
Seal Fill Hole

Scribe & Break

Inspection & Test

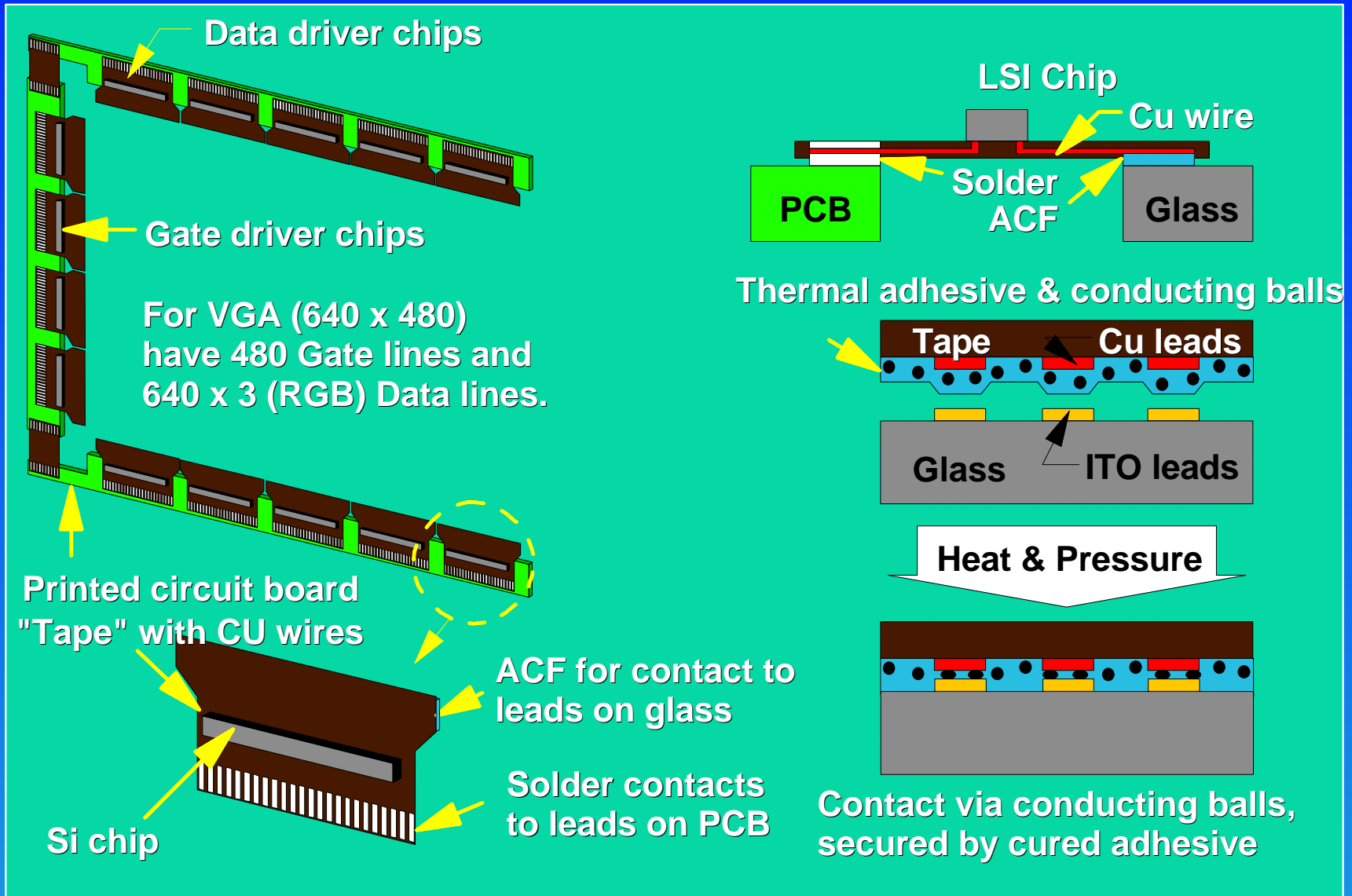
Clean & Apply Polarizer

Not to scale

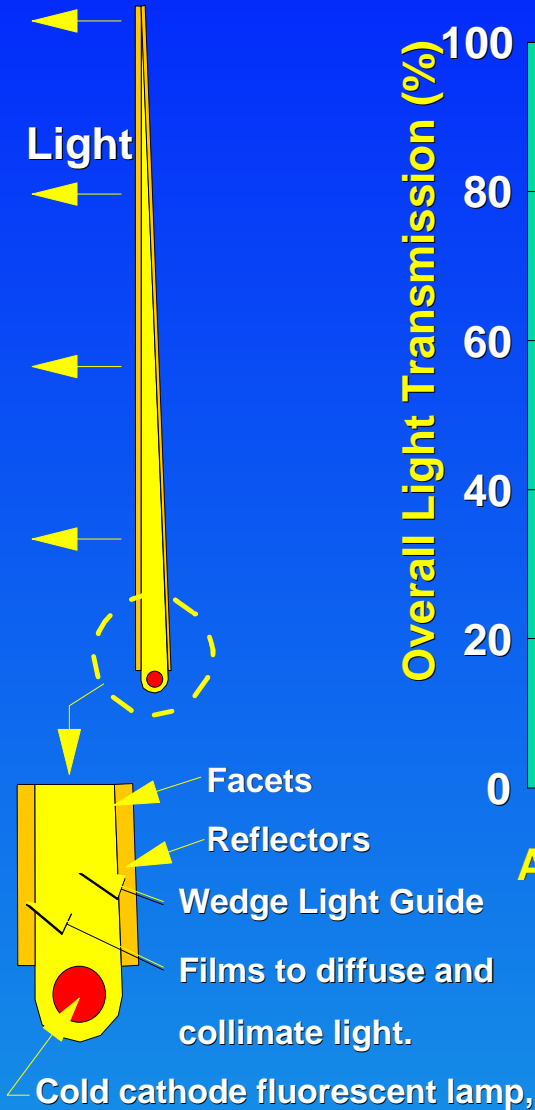


Drive Electronics

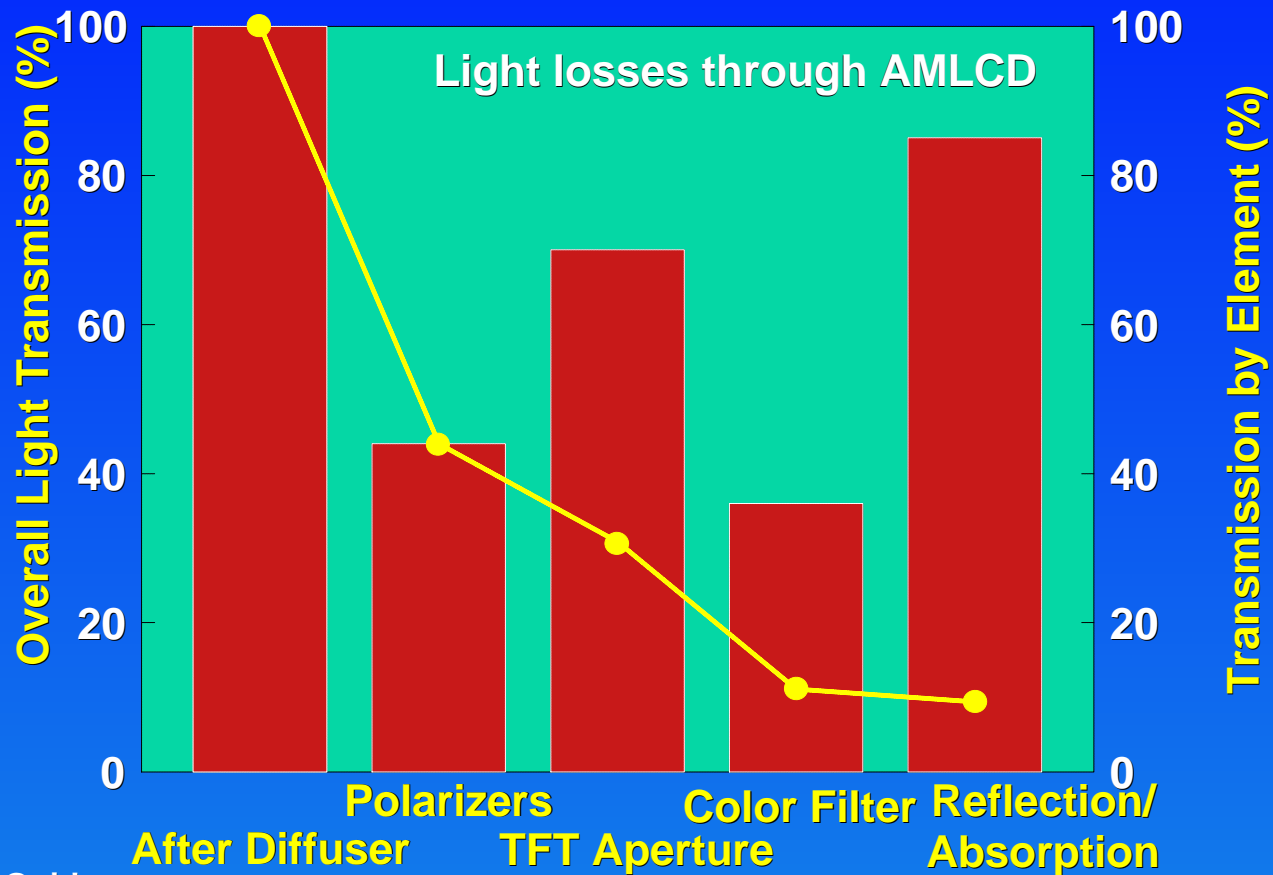
"TAB" (tape automated bonding) packaging, ACF pitch about 75 μm .



Back Light



2-3 mm dia., 3 spectral band.



-Approximately 10% of light used.

-Back light includes an "inverter" which transforms low voltage DC to high voltage AC to power the fluorescent lamp.

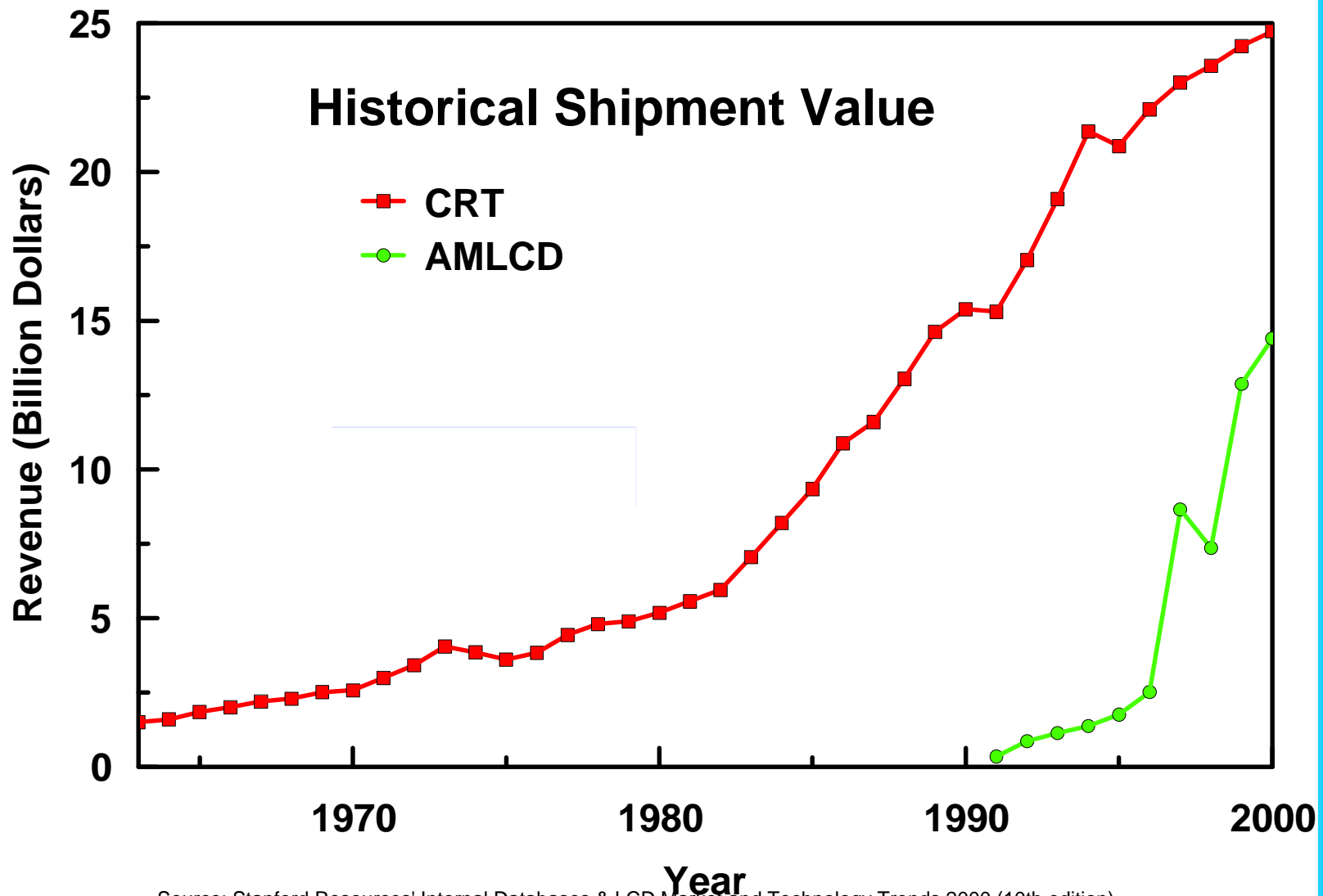
High-Resolution AMLCD Business

Presentation 2/2/2002

IBM Corporation

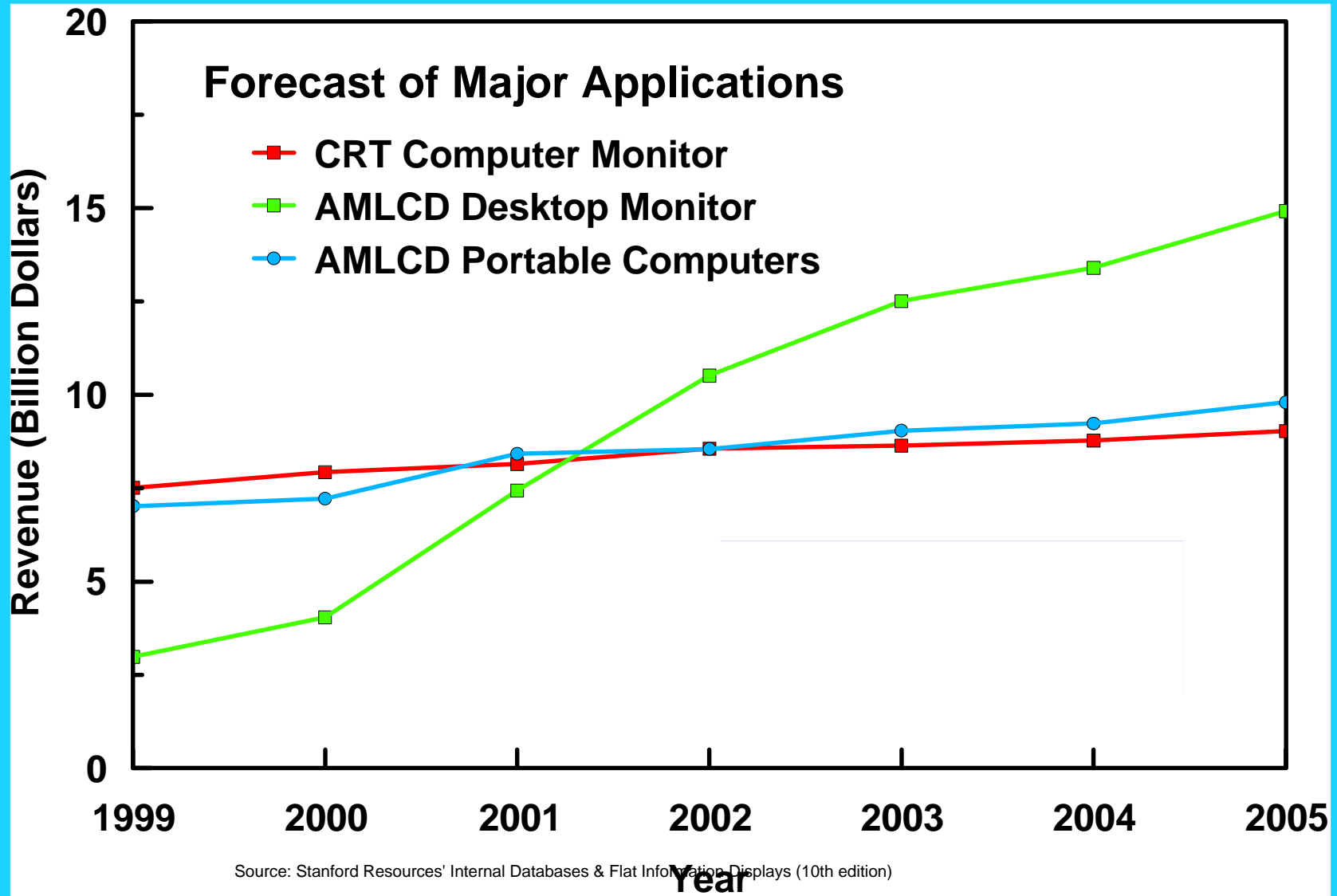


Historical Display Revenue



Source: Stanford Resources' Internal Databases & LCD Market and Technology Trends 2000 (10th edition)

Forecast Display Revenue



History of High-Resolution TFT AMLCDs

<u>Year</u>	<u>Size</u>	<u>Resolution</u>	<u>ppi</u>	
1996	10.4 inch	SXGA (1.3Mpixel)	157	IBM
1998	11.3	UXGA (1.9Mpixel)	177	NEC
1998	20.8	QXGA (3.1Mpixel)	123	IBM
1998	16.3	QSXGA (Roentgen, 5.2Mpixel)	202	IBM
1998	20.0	QUXGA (7.7Mpixel)	200	TOSHIBA
1999	9.4	UXGA (1.9Mpixel)	211	NEC
2000	22.0	QUXGA-W (Bertha, 9.2Mpixel)	204	IBM

Form Factor Design



22.2"-QUXGA-W AM-LCD Prototype (Bertha)

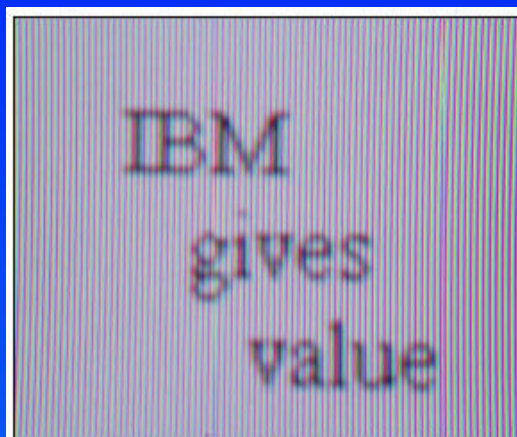


- **First Customer Shipment in September 2000:
LLNL (Lawrence Livermore National Labs)**

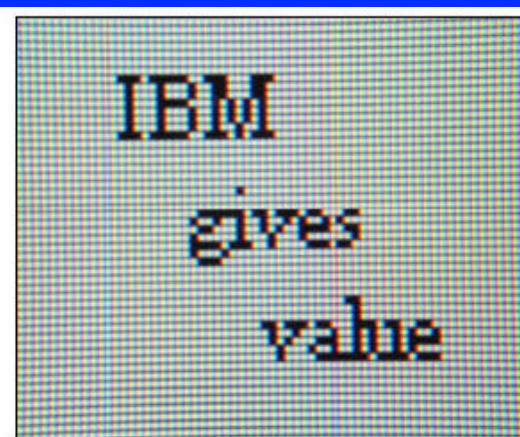
High Resolution & High Image Content (1)

■ Superior Text quality

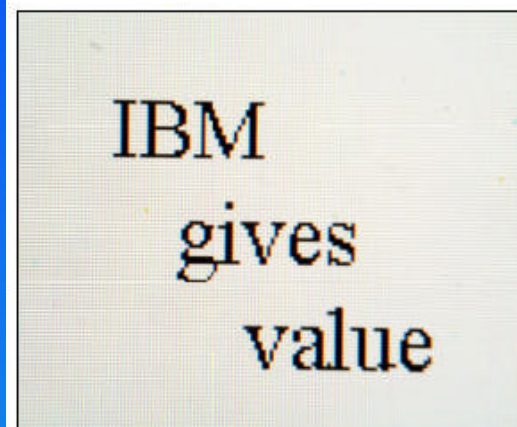
- ▶ 'blockiness' & pixelation effects have virtually disappeared
- ▶ even very small point sizes (e.g. 6 point) is clear & legible



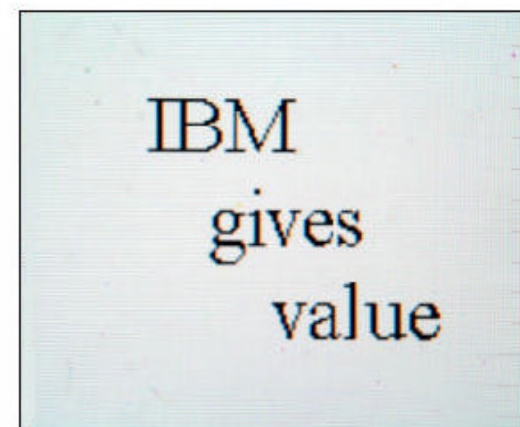
CRT 0.25 mm dot pitch



83 ppi, 12.1" SVGA



150 ppi



200 ppi

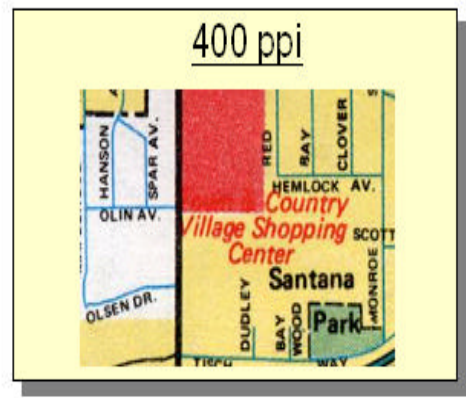
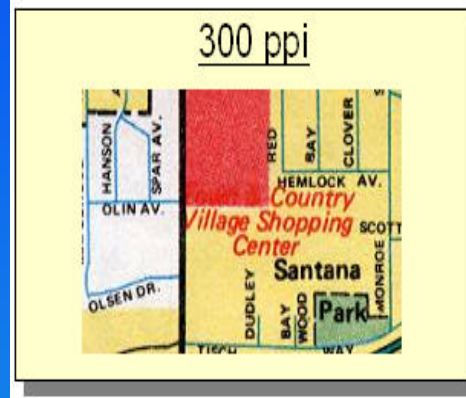
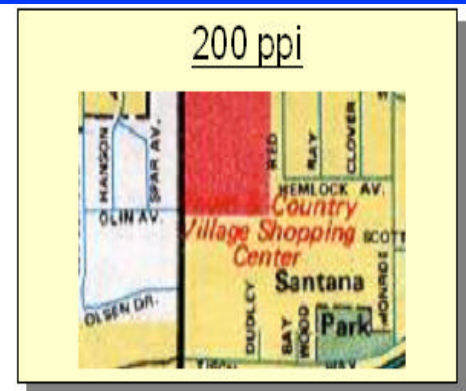
Times New Roman at 10 pts. : IBM gives value

High Resolution & High Image Content (2)

- Superior Image quality

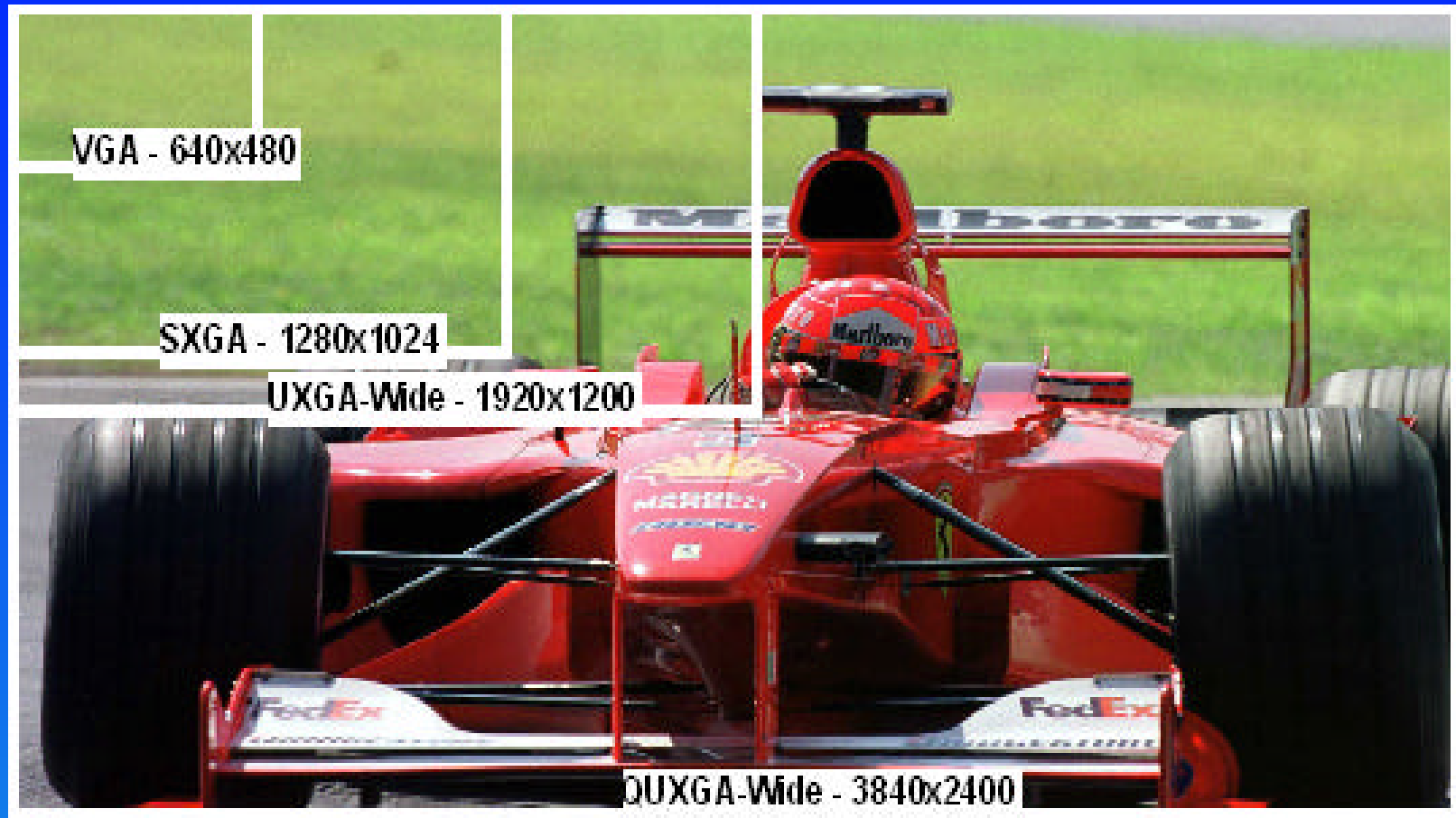
- ▶ Pictures sharp as original photographs
- ▶ finest details visible

- Ideal for Cartography



Based on images from
Seiko Epson

High Resolution & High Image Content (3)



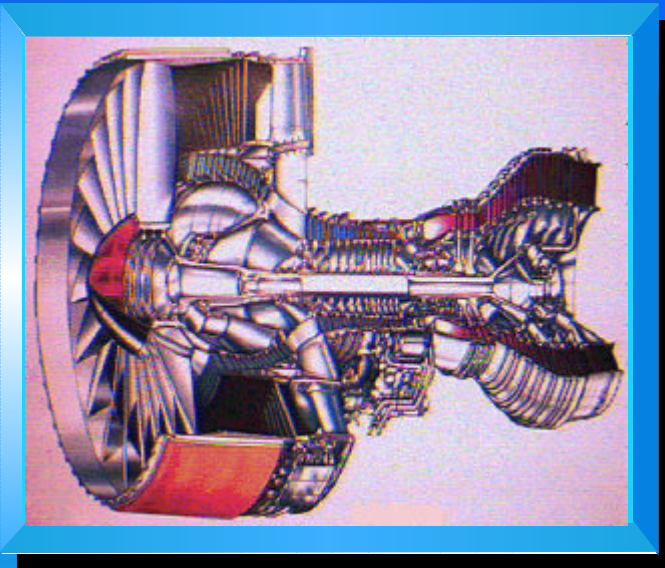
- More of the Image Data is visible at a given Pixel Density (Quality)

Digital Imaging - Visual Computing

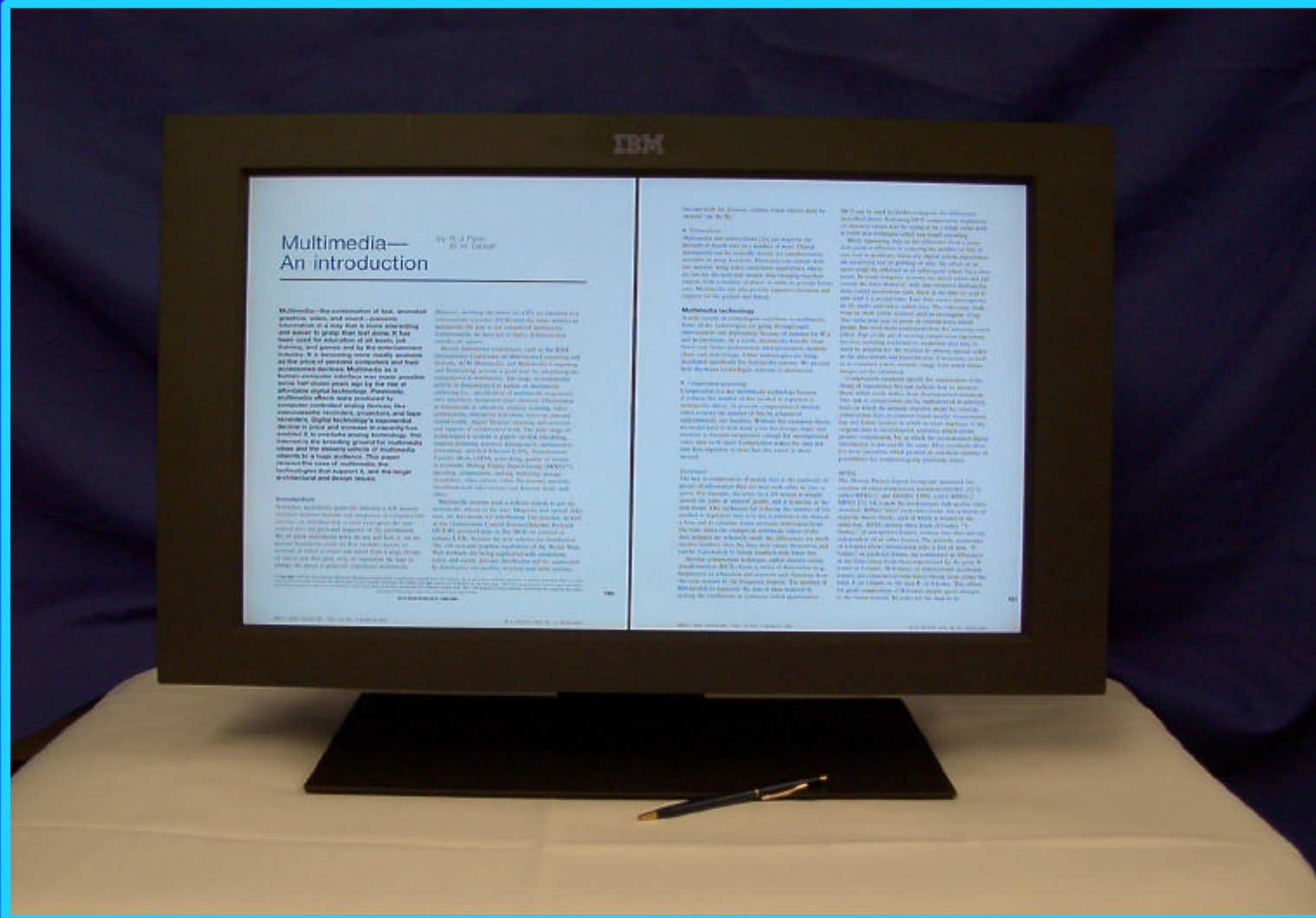


High Quality Image becomes
more Common !!!

- Medical Radiology & Diagnostics
- CAD/CAM, Industrial Design
- Digital Imaging, Satellite Mapping
- Financial Analysis
- e-Commerce, On-Line Catalogue
- Education, Libraries
- Digital Museum
- Video Processing

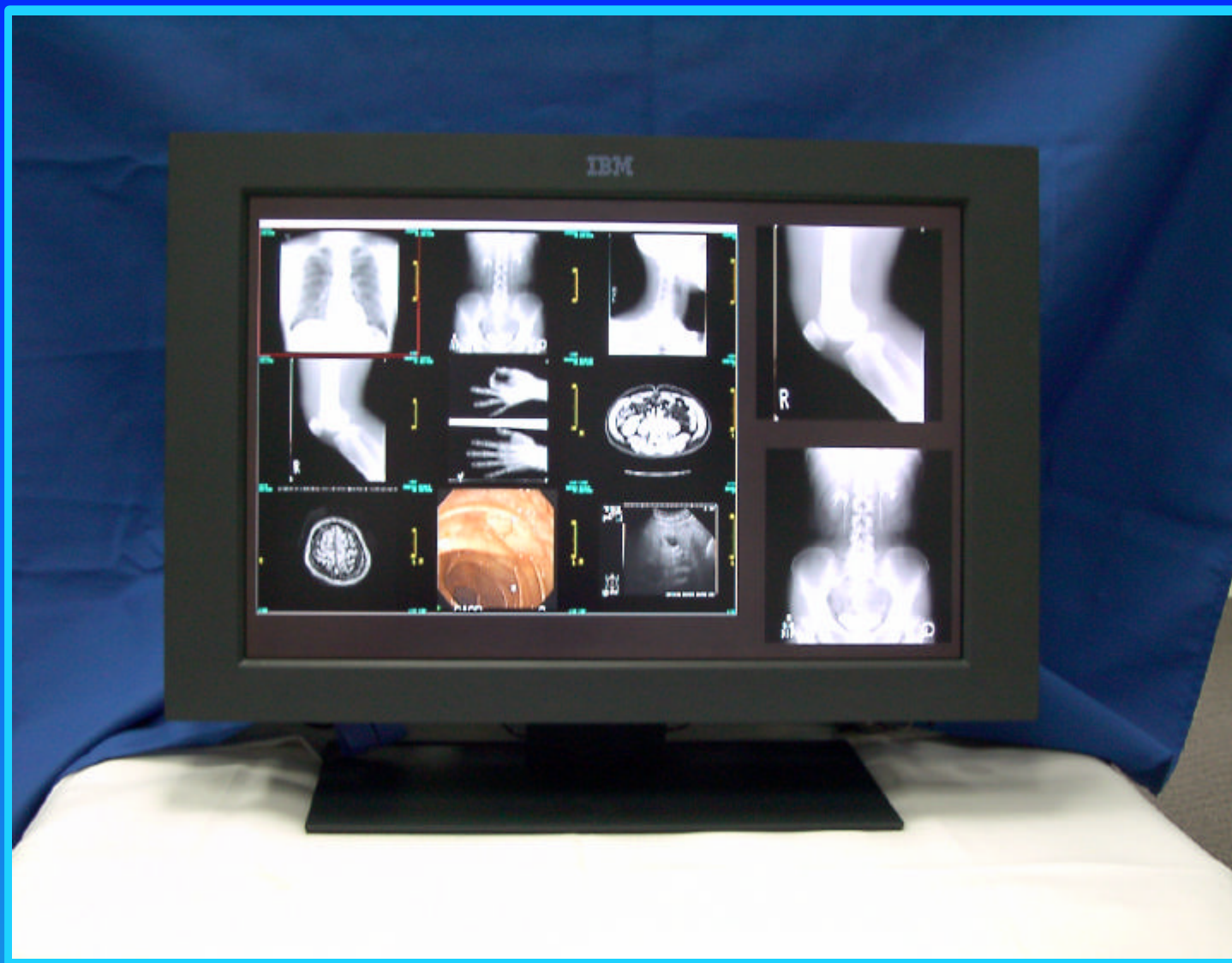


Pre-Press & Soft-Proofing



- 16:10 aspect ratio and 22" diagonal enables view of 2 full A4 or Letter format sheets

X-Ray and Mammography Imaging



Bertha Characteristics

Columns x Rows	(3840 x 3) x 2400
Resolution	204 ppi
Aperture Ratio	28%
Viewing Angle	>170° (Dual Domain IPS)
Contrast Ratio	400:1
Driver Chips	24-bit/pixel (16.7M colors)
Input Data Rate @60Hz	1.8 GByte/sec
Luminance	235 cd/m²
Total Power Consumption	<111 W (Dot inv.)

Key Manufacturing Technologies

Presentation 2/2/2002

IBM Corporation



DTI



IBM TFTLCD Manufacturing



- ◆ 1991 - 2x10.4" VGA, Phase 1, 300x400mm
- ◆ 1993 - 4x10.4" VGA, Phase 2, 360x465mm
- ◆ 1994 - 16.1" SXGA, Phase 1, 300x400mm
- ◆ 1995 - 4x10.4" SVGA, Phase 2, 360x465mm
- ◆ 1996 - 6x12.1" SVGA, Phase 3, 550x650mm

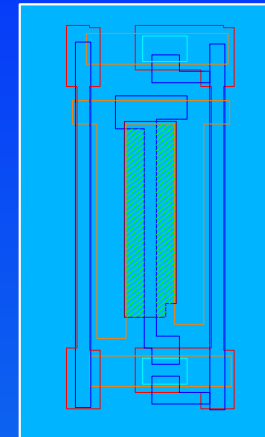
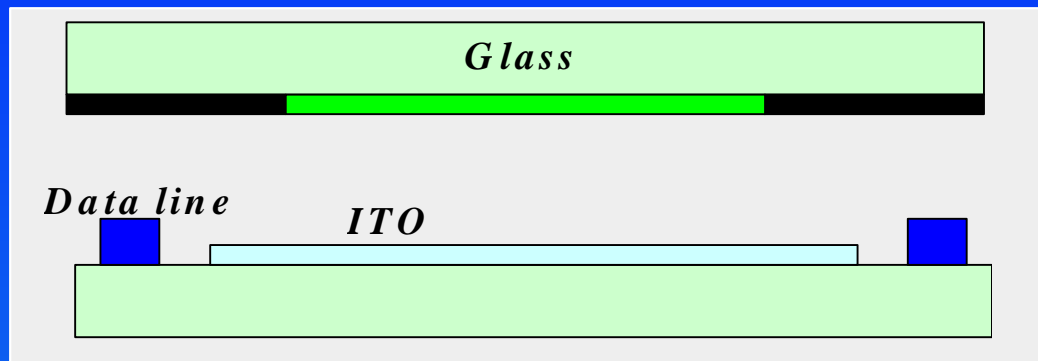
Yasu Site



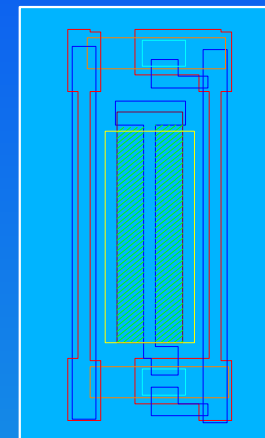
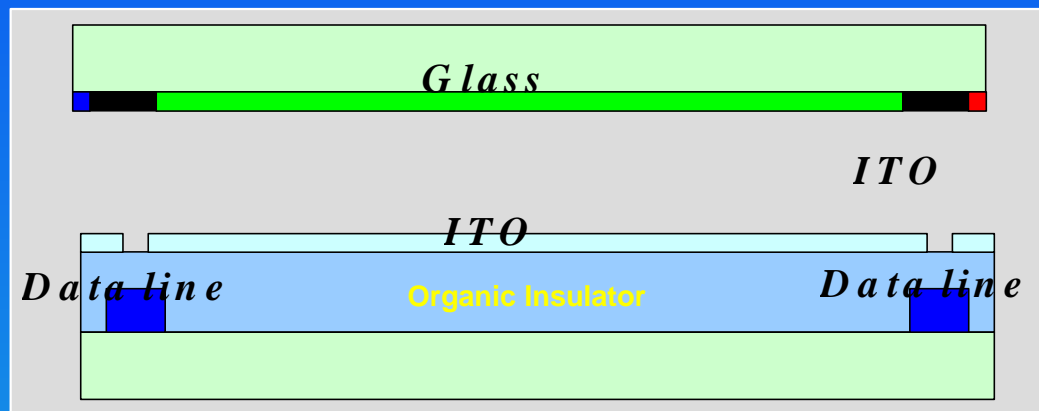
High Resolution Process - HRP Structure

HRP allows to layout signal lines and ITO vertically while keeping distance between signal line and ITO which makes wider aperture ratio instead of traditional horizontal layout.

■ Conventional Structure

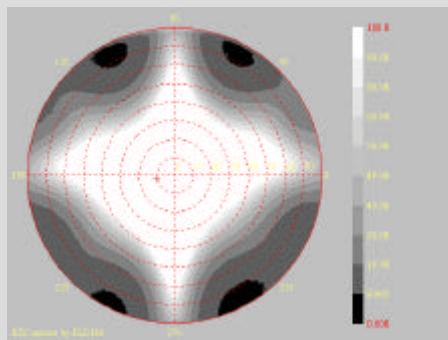
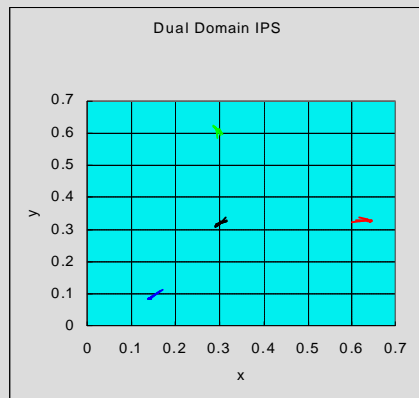
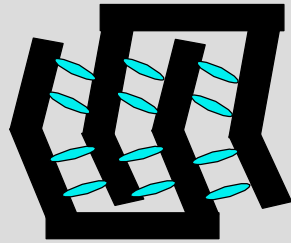


■ HRP : High Resolution Process

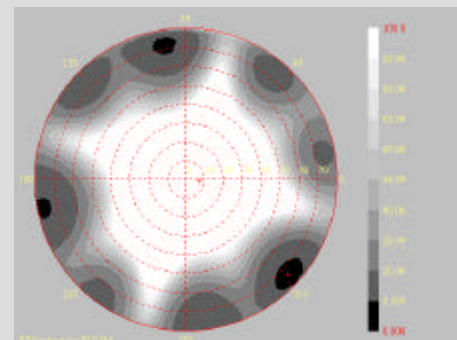
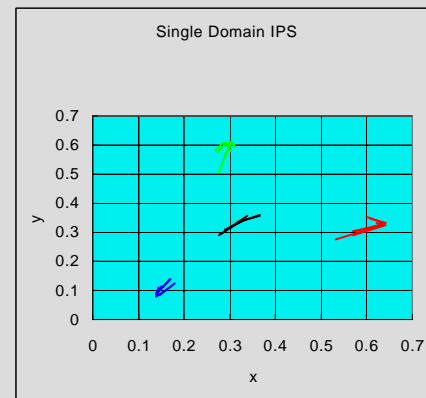
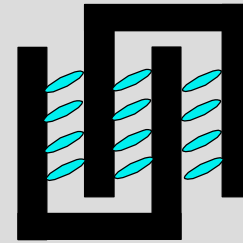


IPS with Dual-Domain Structure

Dual Domain



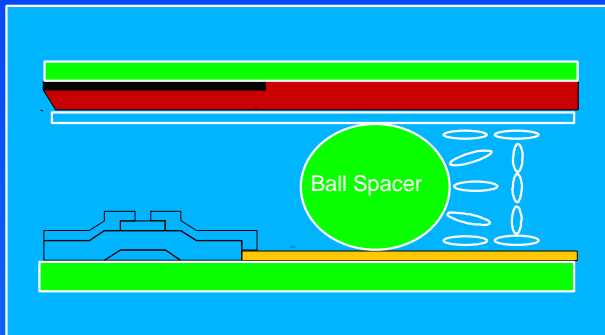
Single Domain



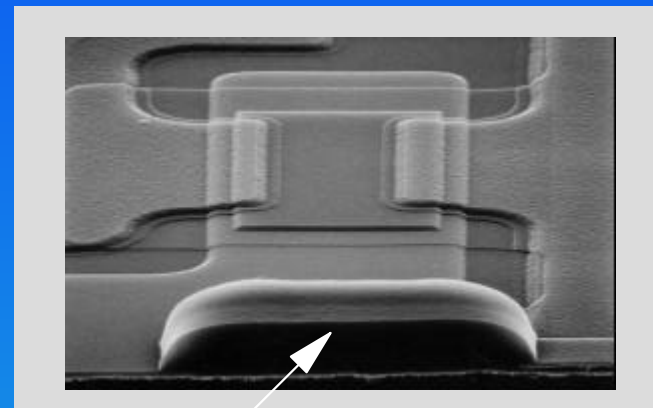
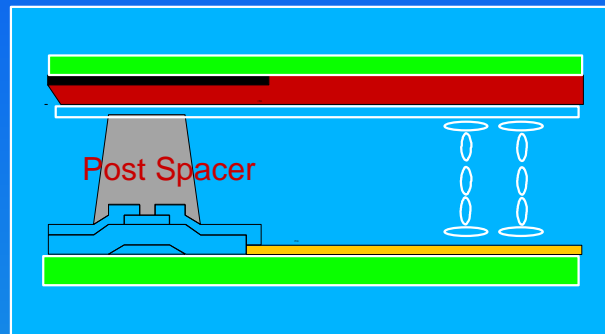
"Post Spacer" Technology

In conventional structure, light leakage around spherical spacers causes contrast deterioration. Post-Spacer technology replaces the spacers traditionally used in LCD with a permanent spacers, providing a more rigid panel construction, preventing light leakage to provide better contrast ratio.

■ Conventional Structure

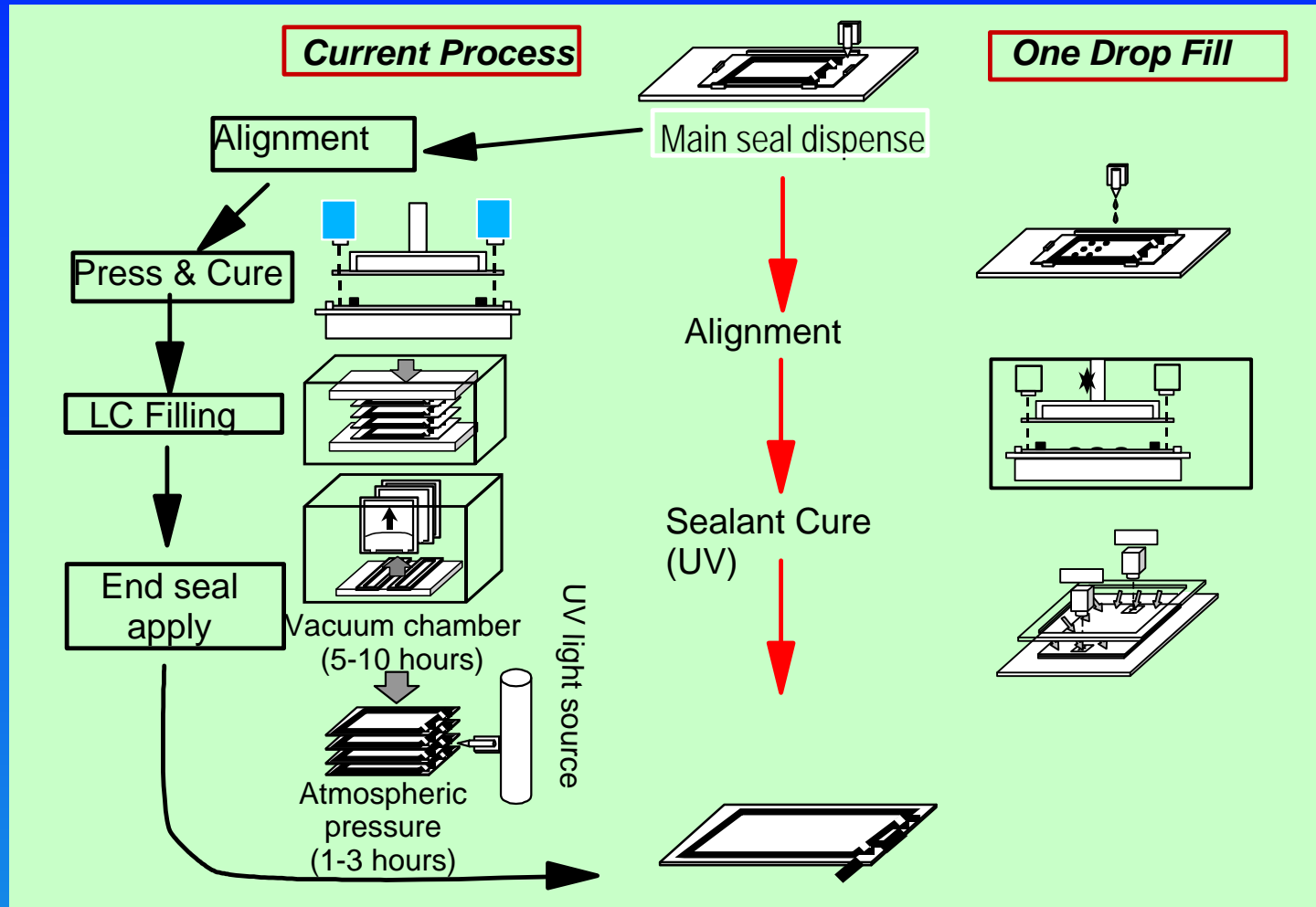


■ Post Spacer



Spacer Fabricated on TFT Substrate by Photolithographic Process

"One Drop Fill" Cell Process Revolution



9.2Mpixel Display Product (6/26/01)



- General Availability in Japan since 7/6/2001
- http://www.ibm.link.ibm.com/usalets&parms=H_101-178

Conclusion

- 9.2Mpixel Display Product announced 6/26/01
- Available as IBM Product T220 but also OEM
- High-Resolution LCDs will replace Desktop CRTs
- Work needed mainly on the system level to deliver the bandwidth to ultra-high-res. displays
- **IBM delivers Digital Flat Panel Display Technology beyond Capabilities of CRTs**