RECENT ADVANCES IN DISPLAY TECHNOLOGIES

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Requirements

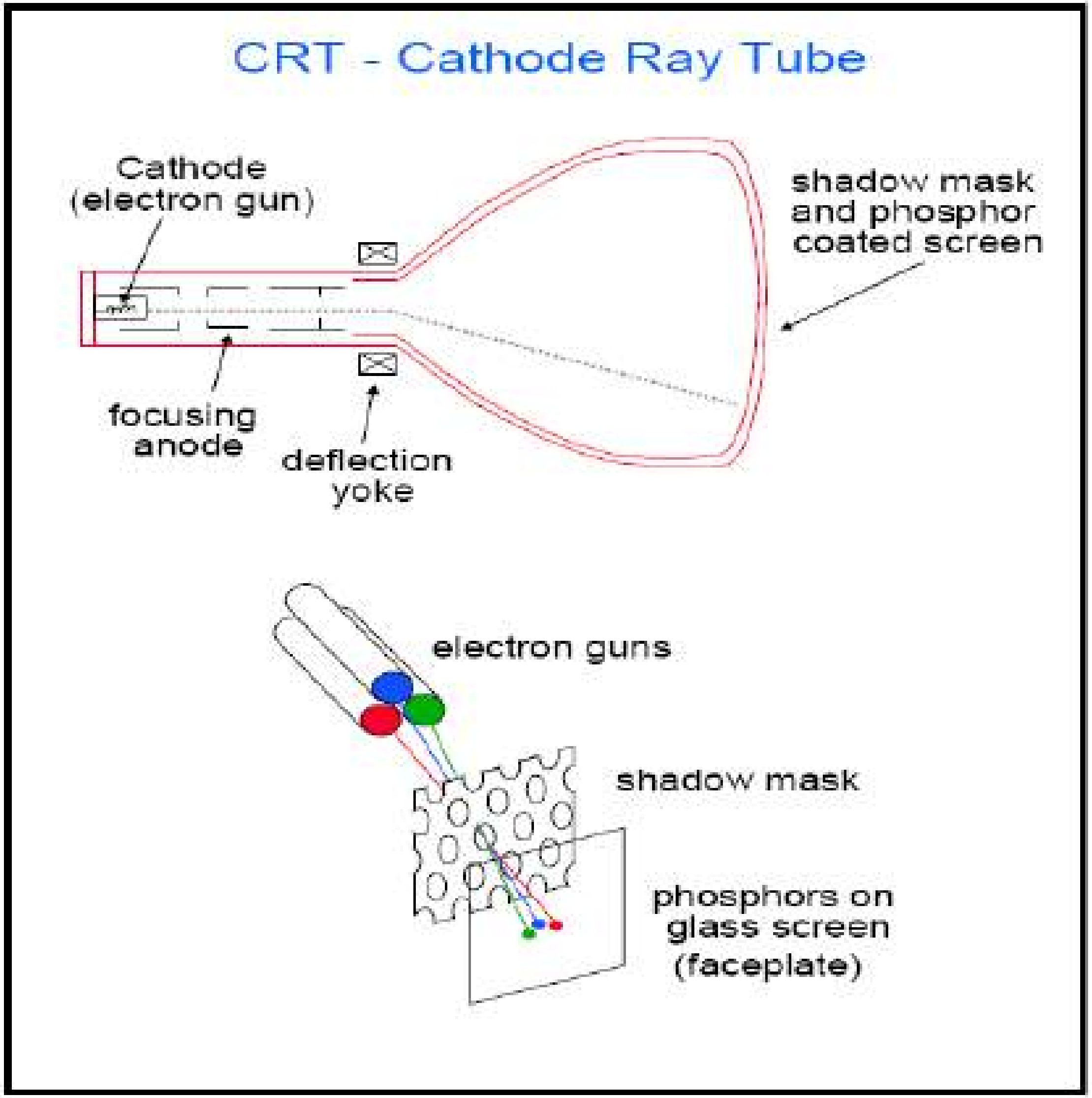
HIGH RESOLUTION
HIGH BRIGHTNESS
LARGE VIEWING ANGLE
HIGH WRITING SPEEDS
LARGE COLOUR GAMUT
HIGH CONTRAST
LESS WEIGHT AND SIZE
LOW POWER CONSUMPTION
LOW COST

TECHNOLOGIES

- CATHODE RAY TUBE (CRT)
- VACUUM FLOURECENT DISPLAY (VFD)
- FIELD EMISSION DISPLAY (FED)
- LIQUID CRYSTAL DISPLAY (LCD)
- PLASMA DISPLAY PANEL (PDP)
- ELECTROLUMINISCENT DISPLAY (EL)
- ORGANIC LIGHT EMITTING DIODE (OLED)

CRT

100 YEAR OLD WORKHORSE
CATHODOLUMINISCENT
BEAM SCAN DEVICE
LARGE VIEWING ANGLE
HIGH BRIGHTNESS
HIGH RESOLUTION
GOOD COLOUR GAMUT
BEST PERFORMANCE TO COST
BULKY HEAVY
UNIMPLEMENTABLE IN LARGE SIZES
OBSOLESCENCE
STILL ENJOYS 70% MARKET


CRT - Cathode Ray Tube
Cathode
(electron gun)
shadow mask
and phosphor
coated screen
focusing
anode
deflection
yoke
electron guns
shadow mask
phosphors on
glass screen
(faceplate)

VFD

- Earliest Flat technology
- Low Cost
- Good Luminance
- Excellent Viewing Angle
- Long Life
- Matrix Addressing
- Wire Emitters
- Cathodoluminescent
- Mechanical Complexity
- Low Resolution
- High Filament Power

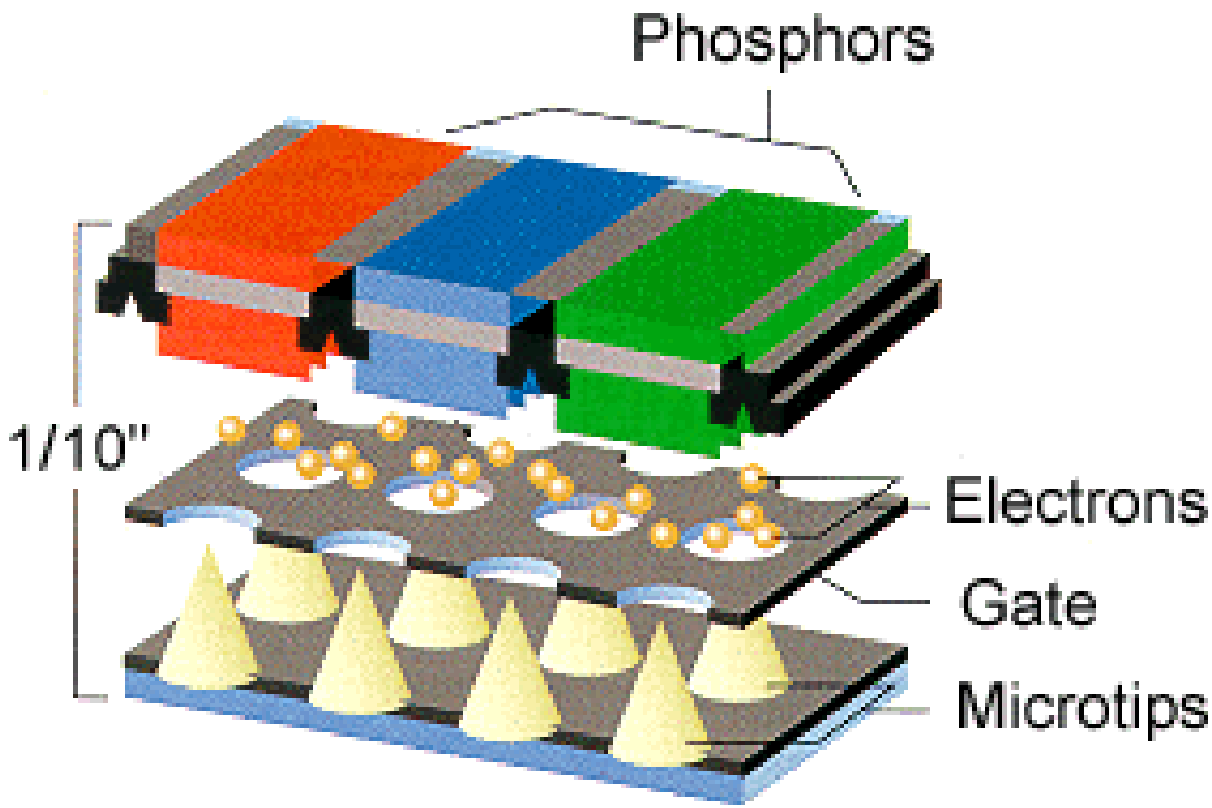
FED

- MATRIX DISPLAY
- LARGE VIEWING ANGLE
- HIGH BRIGHTNESS,HIGH RESOLUTION
- EXCELLENT COLOUR GAMUT
- TECHNOLOGY NOT MATURE

FIELD EMISSION

- SPINDT STRUCTURE
- MIM
- SURFACE EMISSION
- CARBON DIAMOND LIKE FILMS
- CARBON NANOTUBES

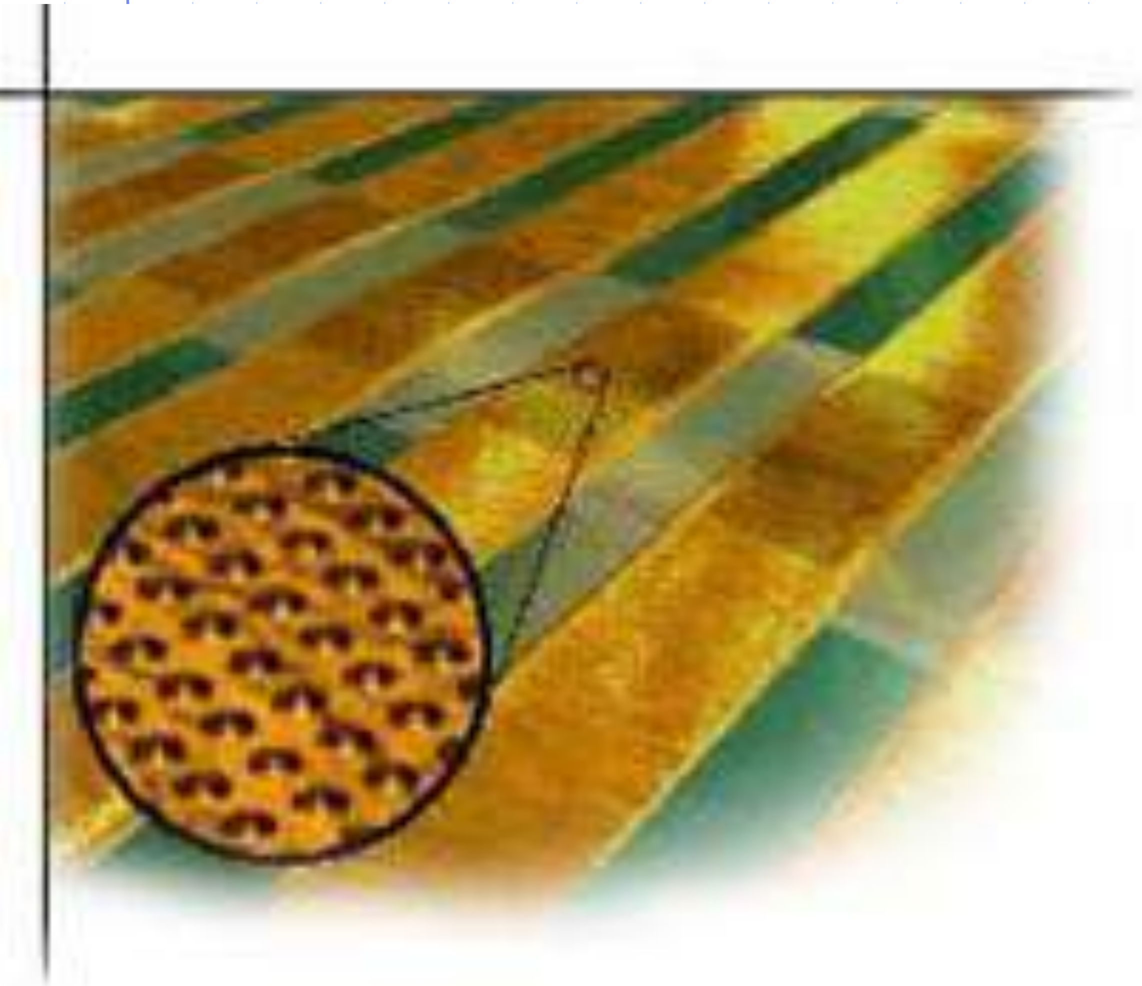
FED Principles



Field emission displays, electrons coming from millions of tiny microtips pass through gates and light up pixels on a screen.

This principle is similar to that of cathode-ray tubes in television sets. The difference: Instead of just one "gun" spraying electrons against the inside of the screens face, there are as many as 500 million of them (microtips).

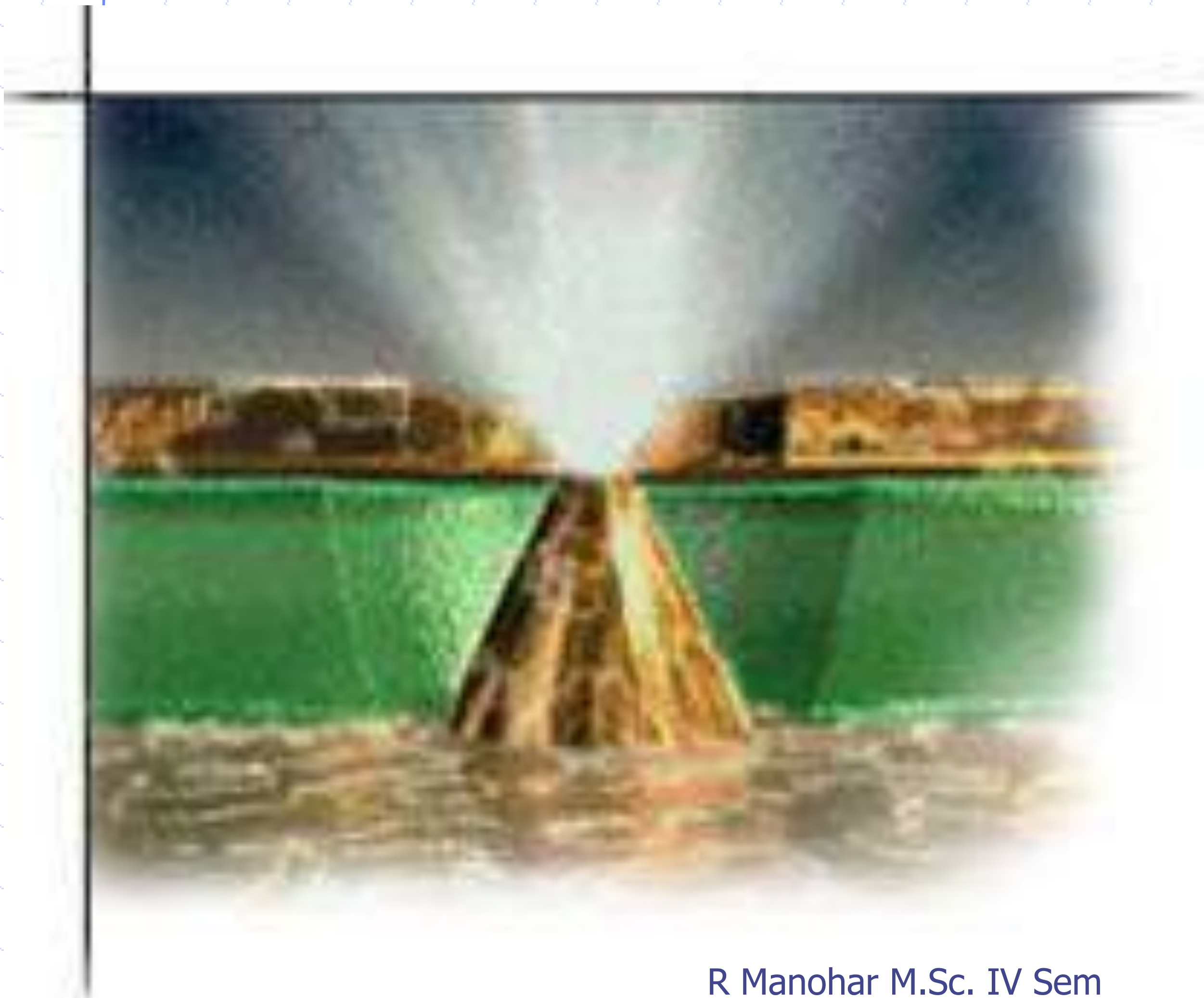
Cathode



The cathode/backplate is a matrix of row and column traces. Each crossover lays the foundation for an addressable
cathode emitters.

Each crossover has up to 4,500 emitters, 150 nm in diameter. This emitter density assures a high quality image through manufacturing redundancy, and long-life through low operational stress.

Emission



Emitters generate electrons when a small voltage is applied to both row (base layer) and column (top layer).

Pixels

Faceplate picture elements (pixels) are formed by depositing and patterning a black matrix, standard red, green, and blue TV phosphors and a thin aluminum layer to reflect colored light forward to the viewer.

FED advantages

Inherently high luminous efficiency

- No Response Time issues
- CRT-like Colour Gamut
- Lower Power Consumption
  - Cold Cathode Emission
  - Distance between cathode and screen ~0.2–5mm
- Flat Panel Technology
  - Matrix Addressed – No DY
- Capital investment for manufacturing VLS TV with printable CNT FEDs - 1/10th of LCD
- Cost advantage over LCD could be 40%

Technology	Luminous Efficiency (Lm/W)
CRT (at 30KV)	3
PDP	0.8
LCD	3
OLED / PLED	5
FED at 8 KV	7

FED Technology Roadblocks

- Spindt type FED
  - Yield problems – Tip wear off, high vacuum
  - High cost of submicron technology for Spindt type emitters
  - High Voltage Breakdown due to electron bombardment and spacer charging
  - Phosphor decay in case anode is at low voltage to counter the above problem
  - Backscatter from anodes at high anode voltages leading to cross talk

EL

- The structure consists of two thin layers of dielectric with phosphor sandwitched between them. A thin Al layer on the top and thin ITO layer on the bottom completes EL.When voltage of order of 200V is applied the resultant high electric field (1MV/cm) tunnels electrons through dielectric on to phosphor. The high energy of electrons impact the colour centres to emit visible light.
- High brightness, high resolution,
- Blue phosphor improvement required
- High voltage switching
- High purity materials
- Small sizes
- Expensive

LCD

- Most mature flat panel technology
- Major share of FPD market
- Poor intrinsic viewing angle
- Requires backlight
- Inefficient
- Slow
- Effected by Temperature and sunlight

Liquid Crystal Display (LCD)

Discovered in 1888 by Austrian botanist Friedrich Reinitzer. RCA made the first experimental LCD in 1968.

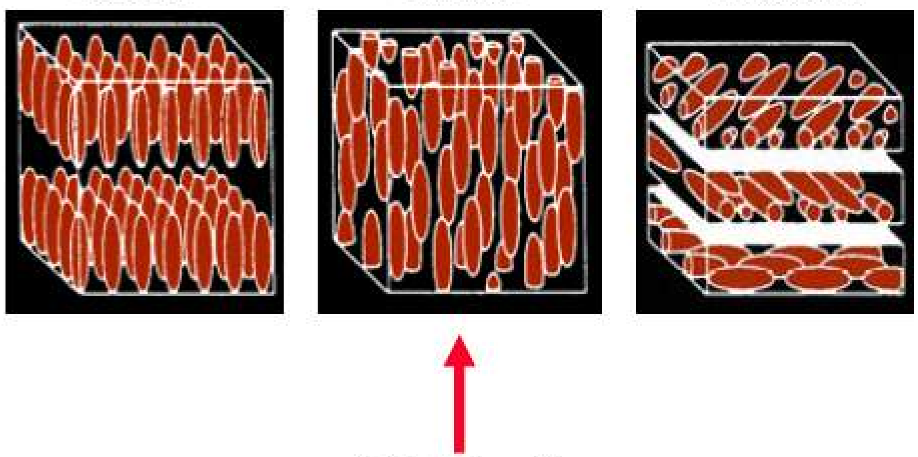
Liquid Crystals are used to make thermometers and mood rings because heat changes absorbance properties.

http://computer.howstuffworks.com/lcd2.htm

Liquid Crystal Display (LCD)

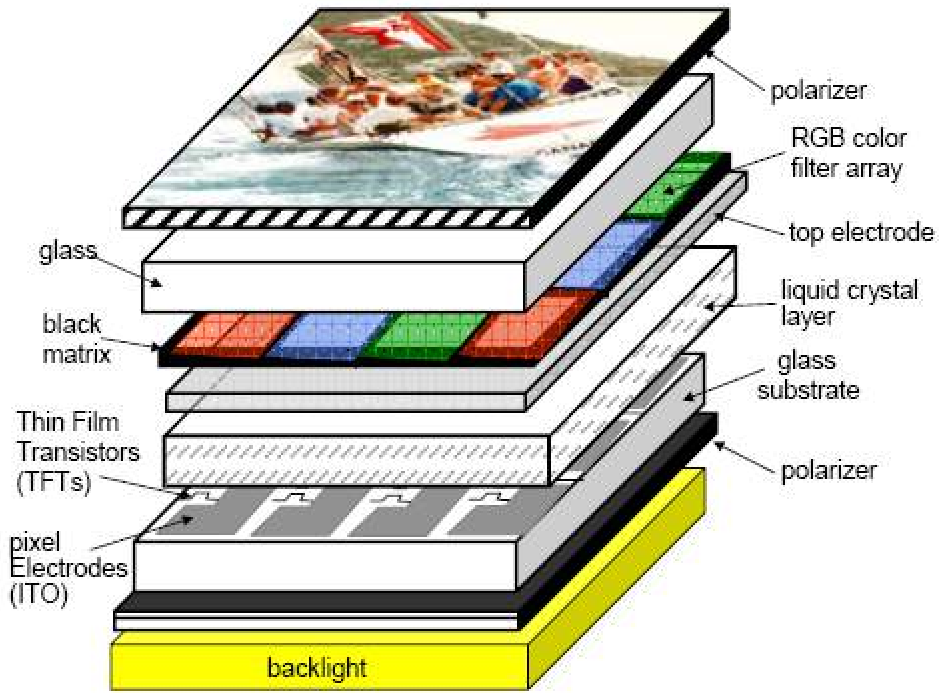
- Liquid crystals (LC) are complex, organic molecules
  - fluid characteristics of a liquid and the molecular orientation order properties of a solid
  - exhibit electric, magnetic and optical anisotropy
- Many different types of LC optical configurations
  - nematic materials arranged in a twisted configuration most common for displays
- Below are shown three of the common LC phases

Smectic Nematic Cholesteric

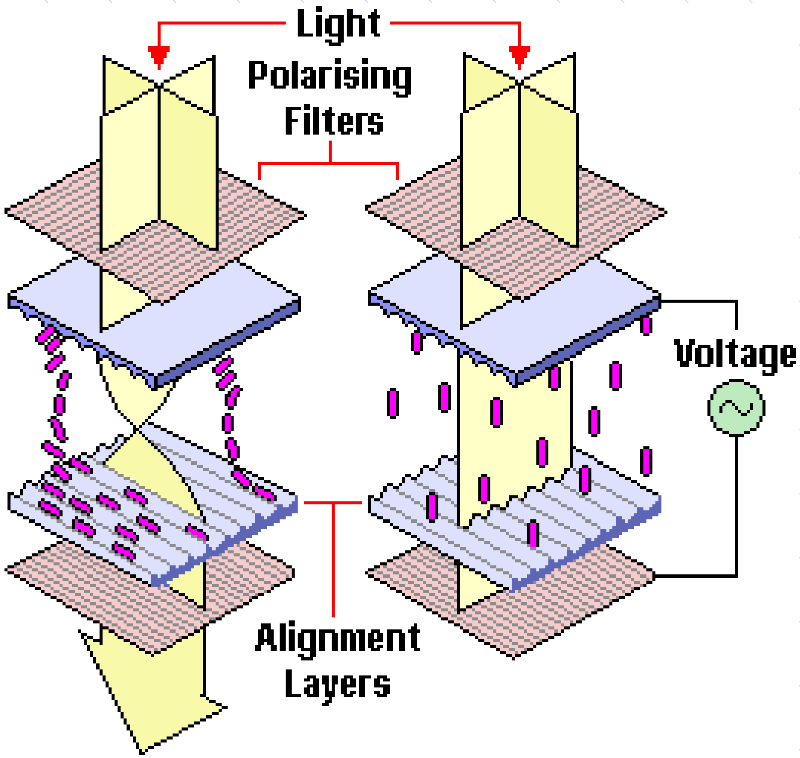


Twisted Nematic
= most common
for displays

LCD System


polarizer
RGB color filter array
top electrode
liquid crystal layer
glass substrate
polarizer
glass
black matrix
Thin Film Transistors (TFTs)
pixel Electrodes (ITO)
backlight

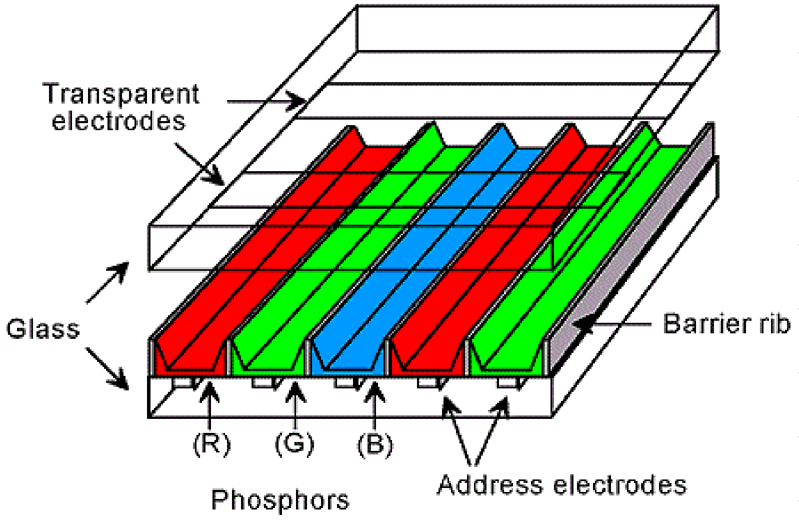
LCD



- There are many modes operation
- B VA RT
- TN 90 deg twist H P S
- STN 270 deg twist H P S
- IPS in plane switching P VG P
- MVA multidomain vertival alignment P G G
- OCB optically self compensated birefringence G G VG

PDP

- Large Displays >32”
- High Resolution
- High Brightness
- Good Contrast
- Good Colour gamut
- Large viewing angle
- High Speed
- Presently High Cost



PLASMACO 60” AC PDP

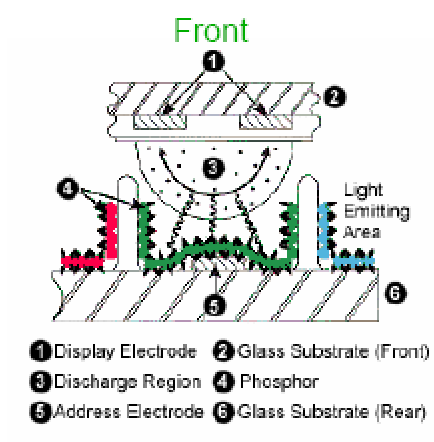
Gas Plasma

Plasma = a gas made up of free-flowing **ions** and **electrons**.

Gas Plasma Display = An array of cells (pixels) composed of 3 subpixels: red, green & blue. An inert (inactive) gas surrounding these cells is then subjected to voltages representing the changing video signal; causing the gas to change into a plasma state, generating ultra-violet light which reacts with phosphors in each subpixel. The reaction generates colored light.

Gas Plasma Displays

Emissive rather than transsmitive



Step 1: Address electrode causes gas to change to plasma state.

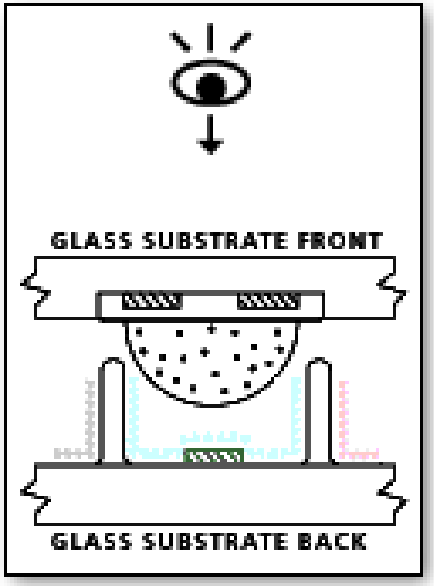
Step 2: Gas in plasma state reacts with phosphors in discharge region.

Step 3: Reaction causes each subpixel to produce red, green, and blue light.

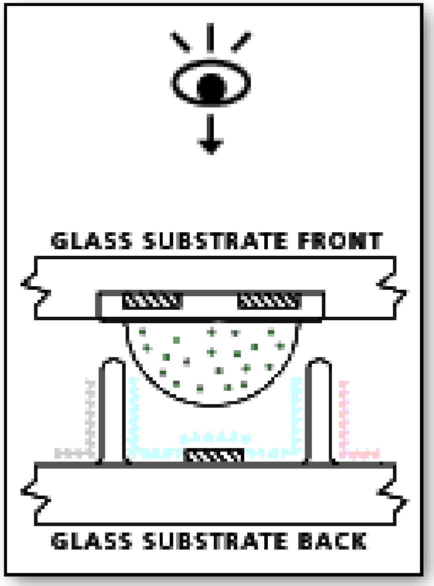
http://www.audiosound.com/whatisplasma.html

http://www.avdeals.com/classroom/learning_resources.htm

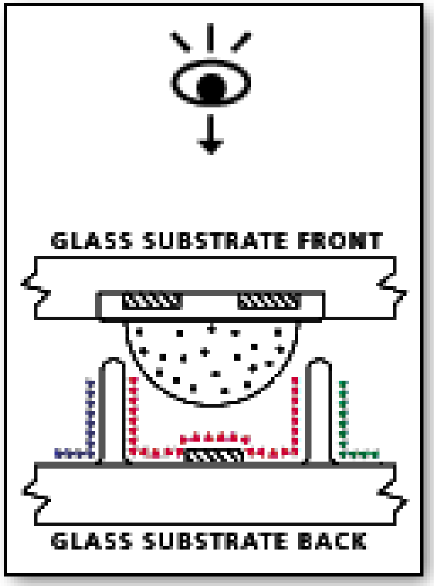
PDP Working



Address electrode causes gas to change to plasma state.

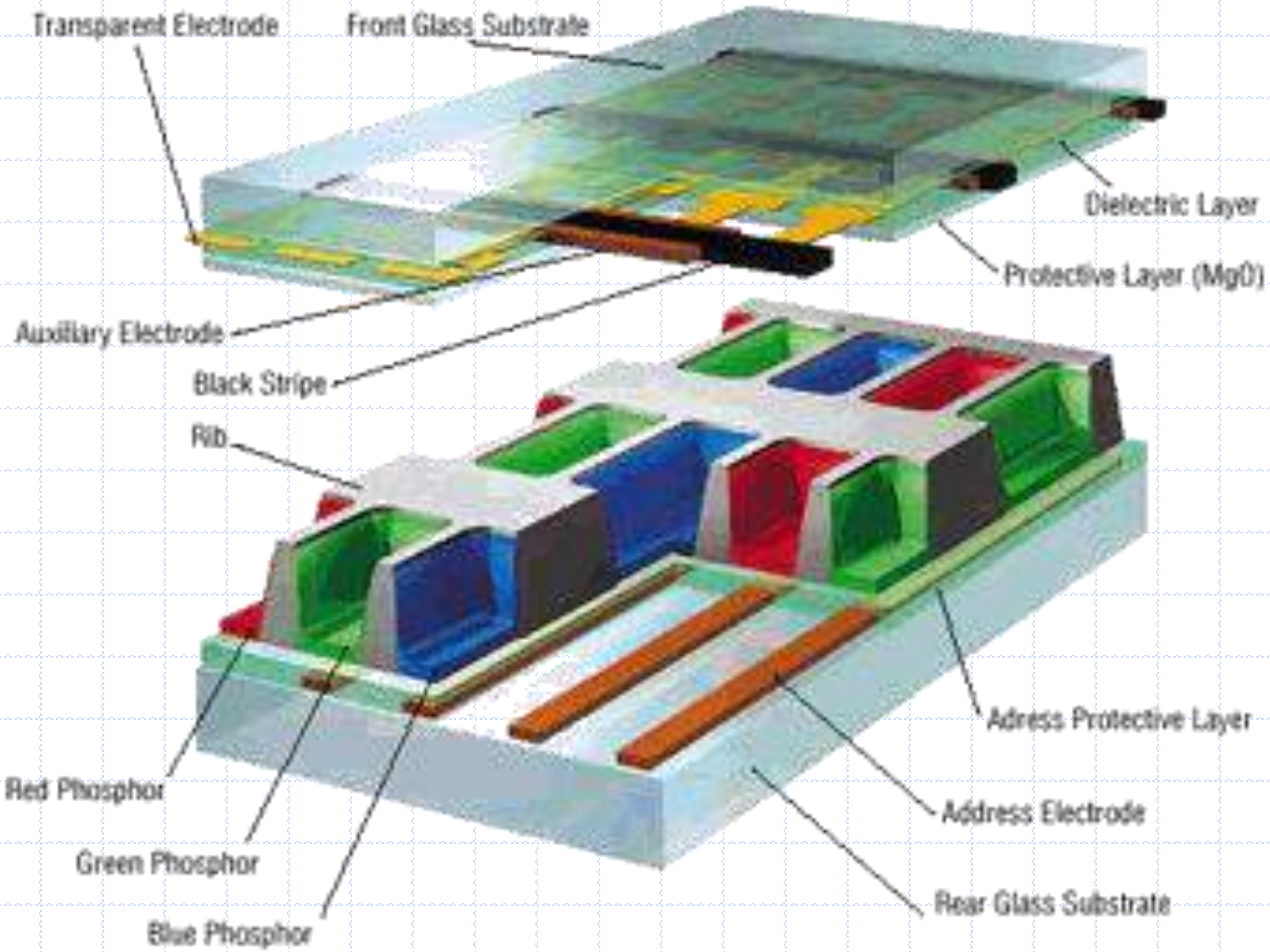


The plasma emits UV in discharge region which impinges on the phosphor



Reaction causes each subpixel to produce red, green, and blue light.

Structure of a PDP



Plasma vs LCD

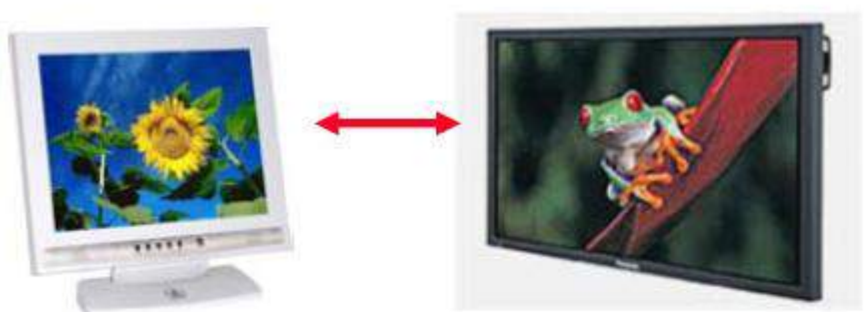
Advantages Of Plasma Displays Over LCDs

- Viewing angle of Plasma: 160 degrees+, ~ 90 degrees vertically vs. LCDs: up to or less than 160 degrees horizontally.

- Size much larger Plasma 32-61 inches vs LCD 2-28 inches.
- Plasma is Emissive (internal) vs LCDs are Transmissive (External backlight).

- Switching speeds: Plasma <20ms (video rates) vs LCDs>20ms (may have image lag at video rates)

- Color technology: Plasma uses Phosphors (Natural TV colors) vs LCDs use Color Filters (Not the same color system as TV).



Plasma vs CRT and DLP

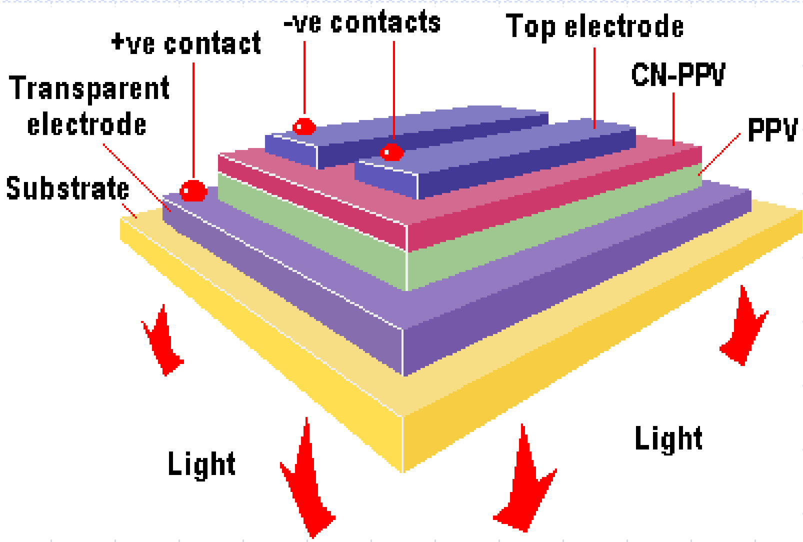
Advantages Of Plasma Displays Over Regular TV's

- 4" thick, and can be hung on a wall
- Much larger picture
- Higher color accuracy
- Brighter images (3 to 4 times brighter)
- Better resolution
- High-definition capability
- 16:9 aspect ratio vs. standard 4:3
- Can be used as a monitor for a PC or Mac
- Images don't bend at the edge of the screen
- Reflections from windows or lights are minimized
- Wider viewing angles
- Not effected by magnetic fields

Advantages Of Plasma Displays Over Projection Monitors

- Ideal for any room, even rooms where space may be limited
- 4" thick, and can be hung on a wall
- Can be used as a monitor for a PC or Mac
- Higher color accuracy than most PTV's
- Brighter images than most PTV's
- Better resolution than most PTV's
- Wider viewing angles , not stuck sitting in a sweet spot
- DLP and LCD rear projectors need bulb replacement every 4 to 5000 hours (cheap initially but more expensive in the long run).

OLED

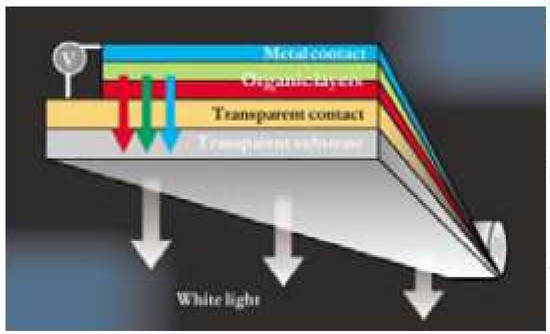


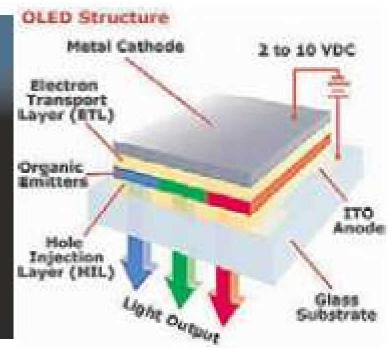
- Most promising technology
- Already in small sizes
- No inherent size limit
- Conformal displays
- Large viewing angle
- High resolution
- High Speed
- Good colour gamut
- Lifetime issues to be solved
- Great threat to LCD 2008?

Organic Led Displays (OLED)

An electronic device made by placing organic thin films between two conductors (Anode & Cathode). When electrical current is applied, a bright light is emitted.

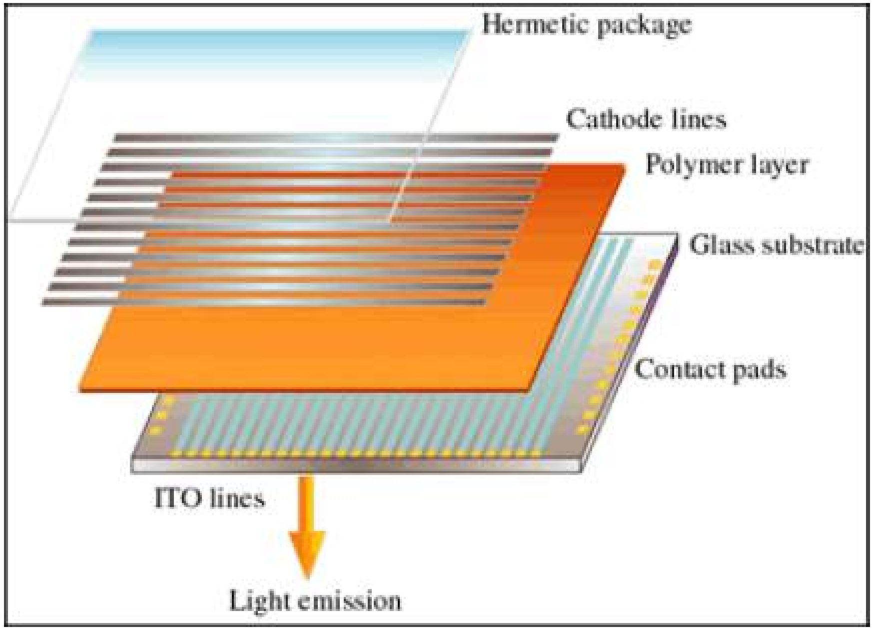
This phenomenon is called **electro-phosphorescence.**





- Can be very thin (organic layers less than 0.1mm).
- Simple to manufacture - In Polymer OLEDs the organic material can be quickly and easily applied to a substrate.

OLED Structure is Simple

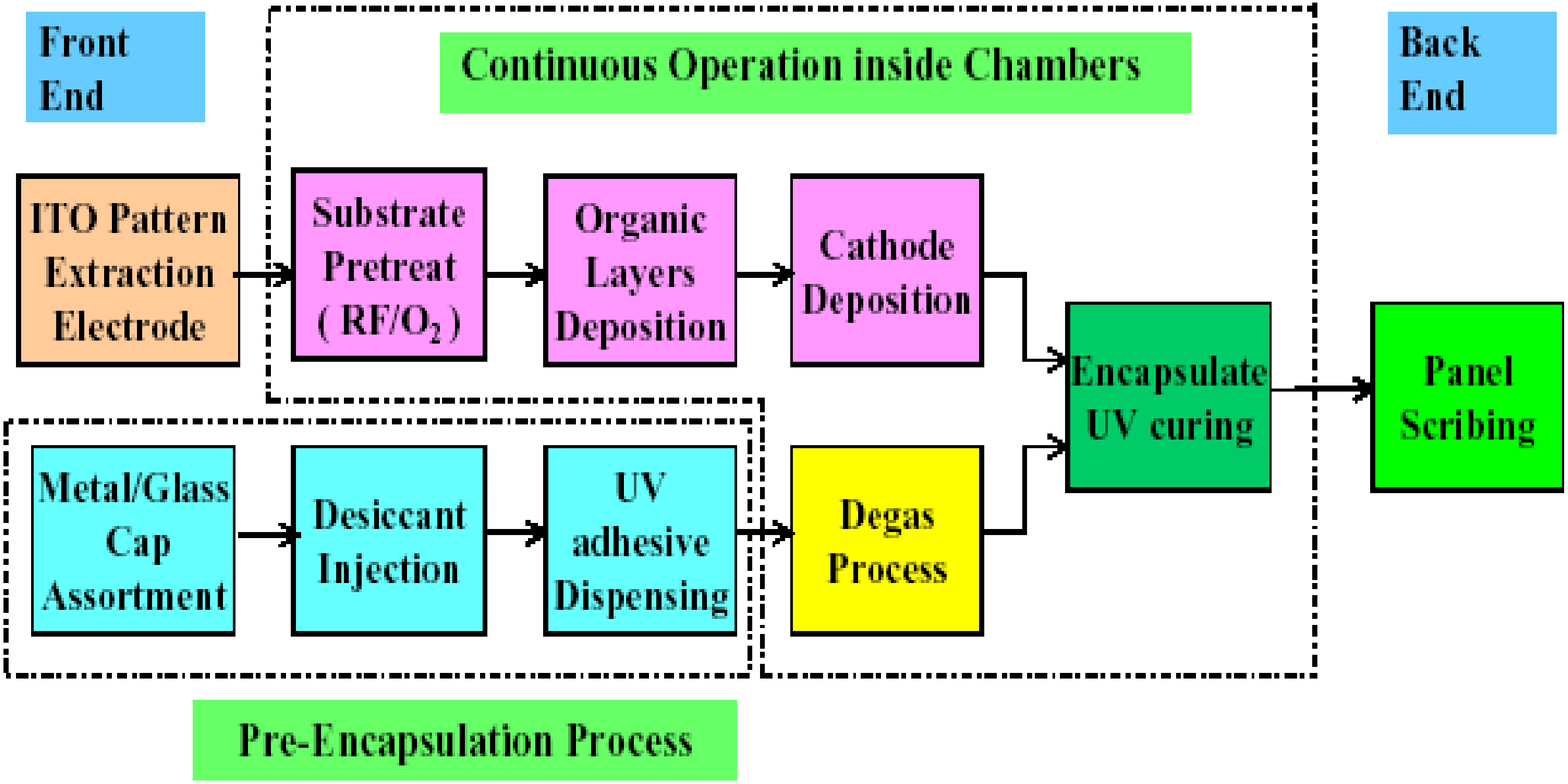


- No backlight (low power)
- Simpler to manufacture
- Very fast switching times
- Lifetime issues

OLED advantages

- Colour Gamut comparable to CRT, with potential to get better – Striking visual appeal
- Thinner – No backlight
- Less Expensive than LCD due to lesser components
  - White + Color Filter route takes away some of this advantage
- Potential for printing in manufacturing.
- Flexible and Conformal Displays

OLED Process



OLED Roadblocks

- Materials
  - Small molecule lifetimes still not OK for TV applications, although robust for mobile phones
  - Polymers struggling with material stability
- Manufacturing
  - UHV process not easily scalable to larger Mother Glass. Currently, manufacturing restricted to 370 x 470mm
  - Printing (Polymers) still in R&D stage
- Active Matrix Back plane
  - Incompatible with the existing a:Si technology
  - LTPS technology (considered suitable for current driven devices) suffers from uniformity problems and restricted to displays < 8”

PROJECTION DISPLAY

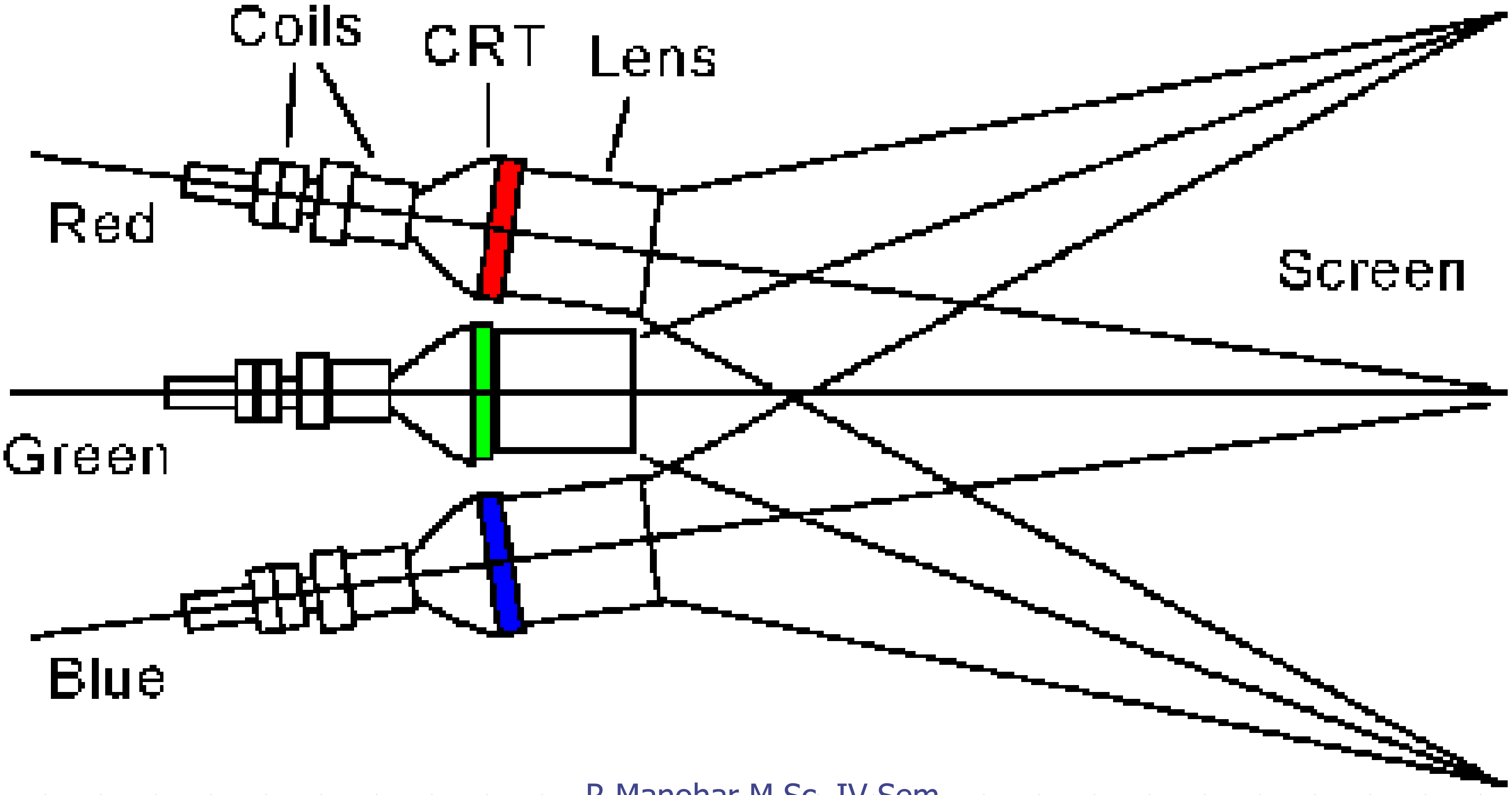
Classification:

Front projection
Rear projection

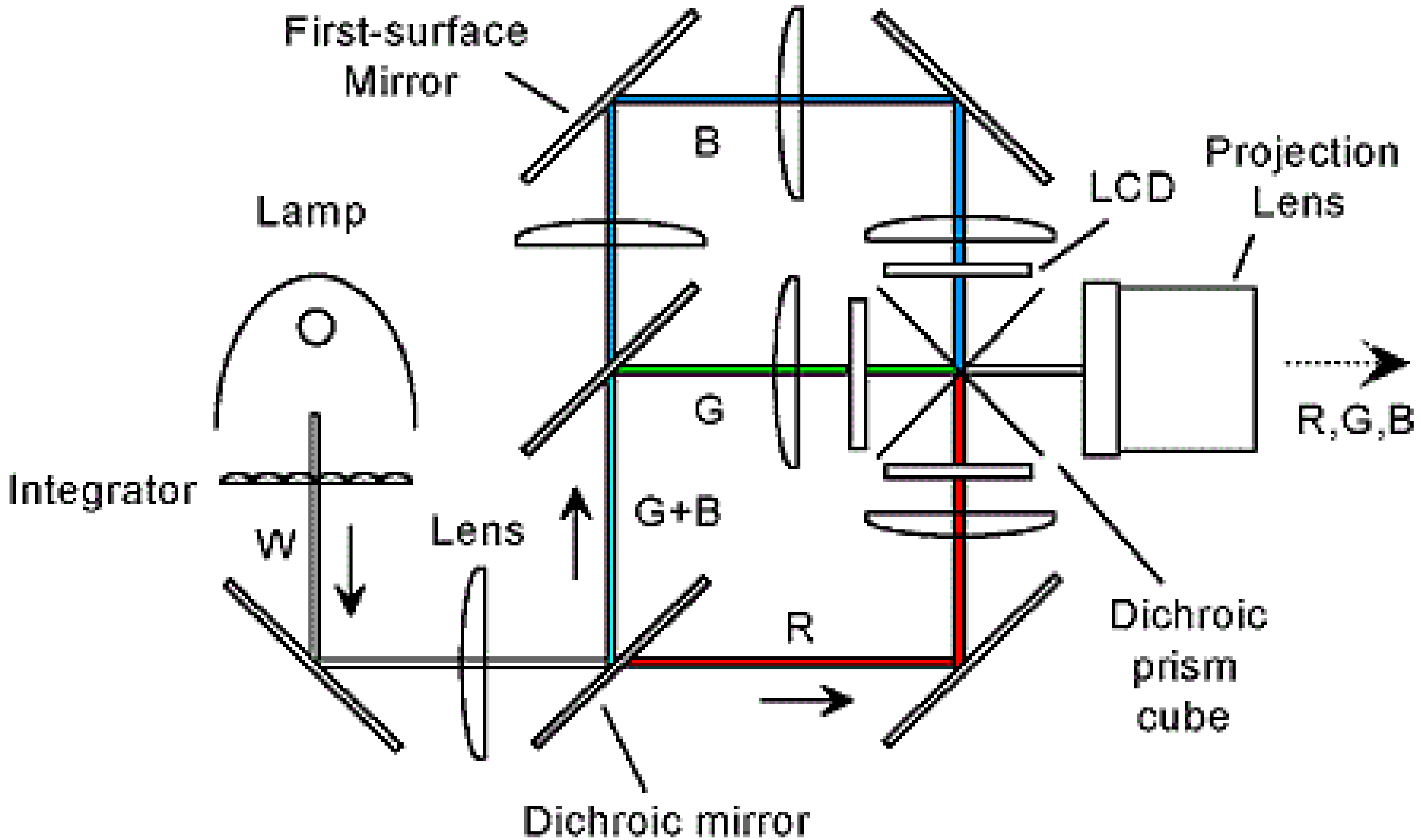
Technology:

CRT	-	Emissive
LCD	-	Transmissive / Reflective
DLP/DMD	-	Reflective
GLV	-	Diffractive
LCOS	-	Reflective

Rear Projection CRT



Rear Projection LCD / LCoS



Thank you