Emissive and Non-Emissive Displays

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Agenda

- Introduction
- Types of Displays
  - LCD
  - Plasma Displays
  - OLED
  - FED/SED
- Comparison

Emissive Displays

- The image is produced directly on the screen
- Phosphors convert electron beams or UV light into visible light
- E.g.: Plasma-, FE-, SE-Displays

Emissive Displays

- Cathode Ray Tube (CRT)
- Field emission display (FED)
- Surface-conduction Electron-emitter Display (SED)
- Vacuum Fluorescent Display (VFD)
- Electroluminescent Displays (ELD)
- Light-Emitting Diode Displays (LED)
- Plasma Display Panel (PDP)
- Electrochemical Display (ECD)
- Organic Light Emitting Diode (OLED)

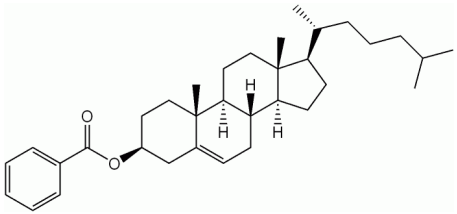
Non-Emissive Displays

- Light is produced <u>behind</u> the screen and the image is formed by filtering this light

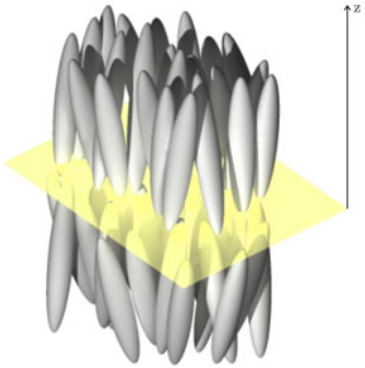
- E.g.: LC-Display (LCD)

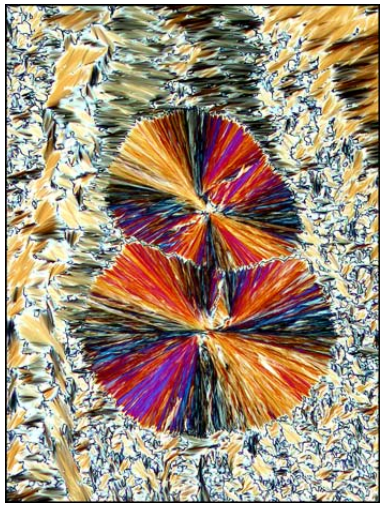
Liquid Crystal Display

- Liquid Crystal Display = LCD
- TFT-LCD = Thin Film Transistor = AMLCD (active matrix)
- Liquid organic crystals
  - Known since 1888
  - First application in 1968
  - Cholesteryl benzoate

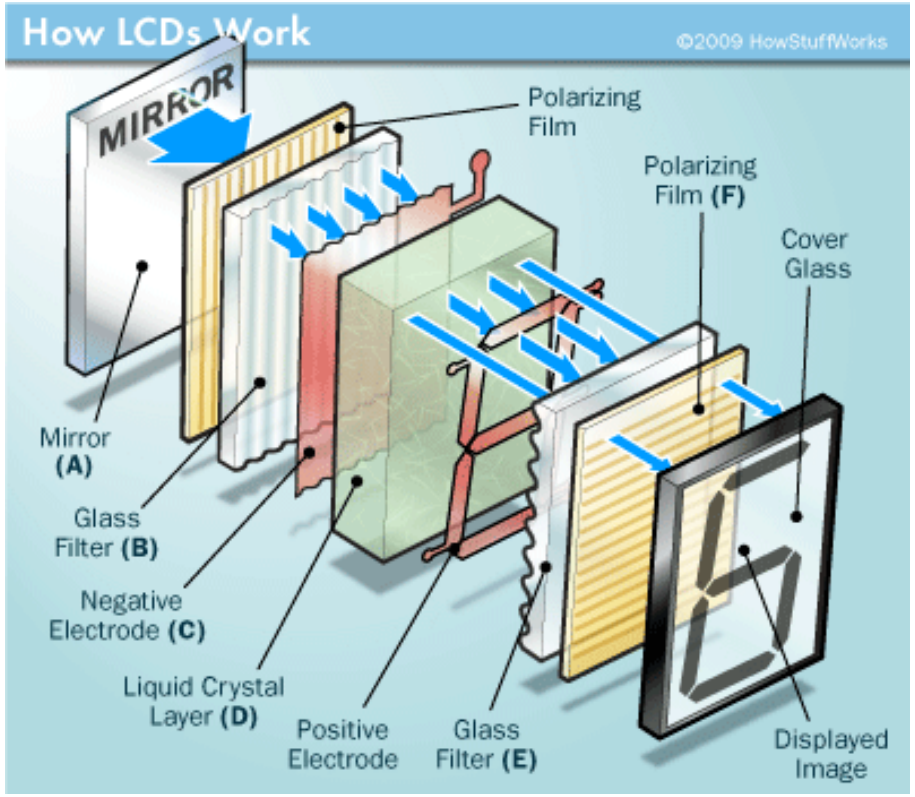


- Optical anisotropy





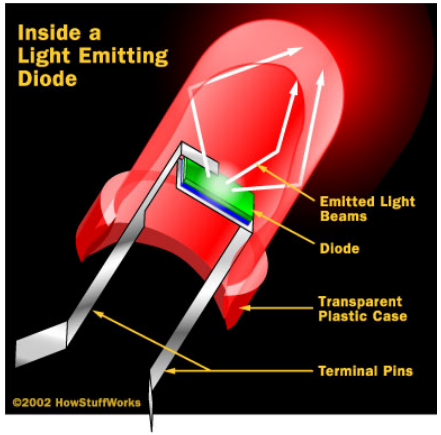
Working Principle LCD



Light Sources for LCDs

- CCFL = Cold Cathode Fluorescence Lamp

- White LED



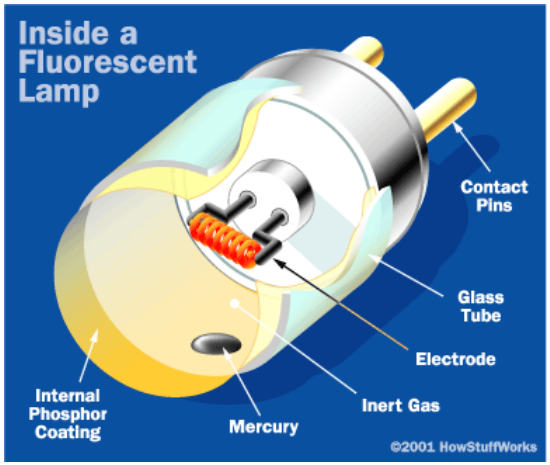
- RGB LED

CCFL

- First CCFL was developed by Georges Claude in 1909
- Low pressure fluorescence lamp
- Edge lit backlight
- Emits white light
- Electrodes remain cold during operation

Working Principle CCFL

- Low pressure glass tube filled with Hg/Ar, Hg/Ne or Ne
  - 185, 254 nm and 74 nm
- Phosphors transform UV light into white light
  - BAM($BaMgAl_{10}O_{17}$:Eu), LAP($LaPo_4$:Ce,Tb), YOX(Y_2O_3:Eu)
- Color temperature: 2700 - 6500 K depending on mixture
- Activation: $MeCO_3 \rightarrow MeO + CO_2$ (Me = Ca, Sr, Ba)
- Operation: $W + 6\ BaO \rightarrow Ba_3WO_6 + 3\ Ba$



LEDs

- White LED
  - Blue LED with converter phosphor: YAG:Ce
  - Edge lit backlighting

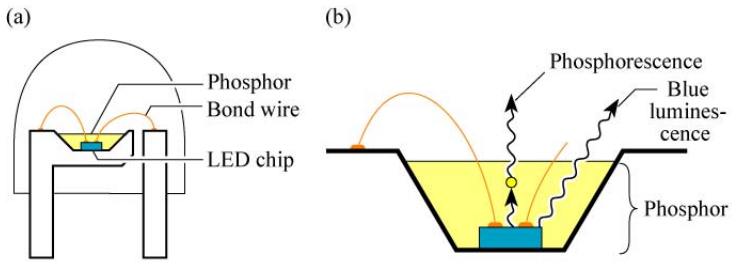
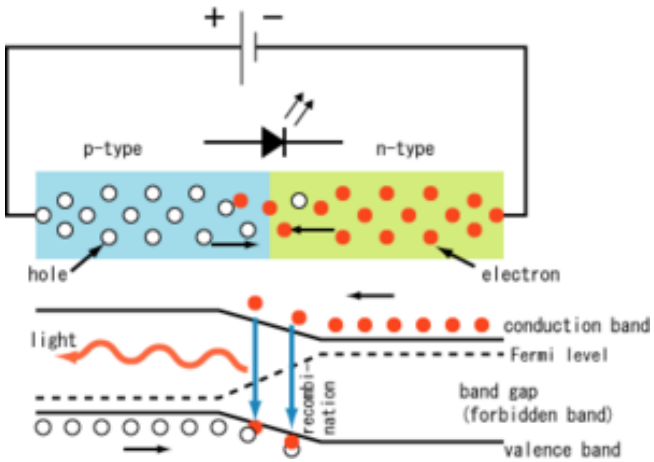


Fig. 21.7. (a) Structure of white LED consisting of a GaInN blue LED chip and a phosphor encapsulating the die. (b) Wavelength-converting phosphorescence and blue luminescence (after Nakamura and Fasol, 1997).

E. F. Schubert
Light-Emitting Diodes (Cambridge Univ. Press)
www.LightEmittingDiodes.org

- RGB LED
  - 3 LEDs per pixel
  - Full backlight



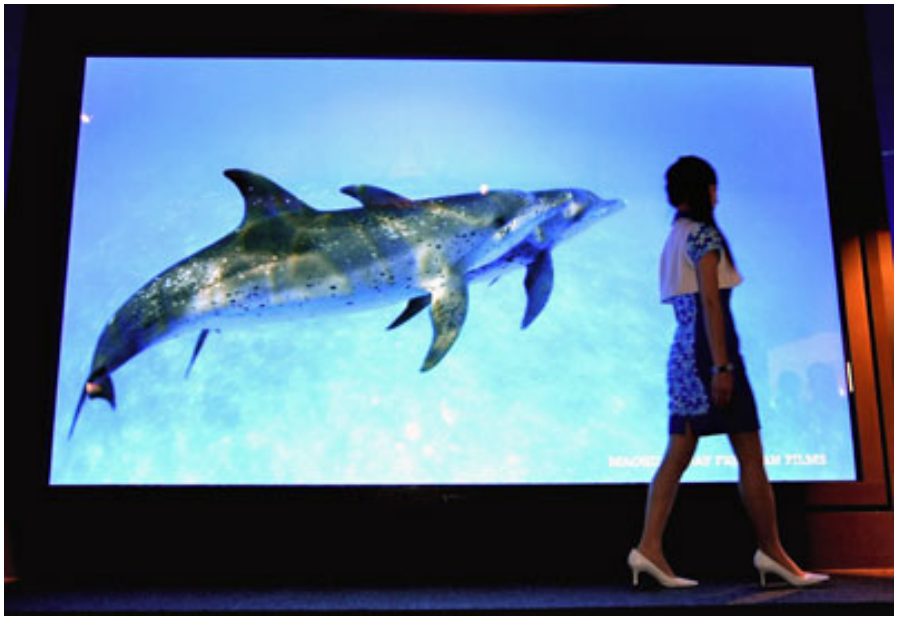
LCD

- Pros:
  - Lightweight construction
  - Thin panels
  - Low energy consumption

- Cons:
  - Quality of image depends on viewing angle
  - Low response times

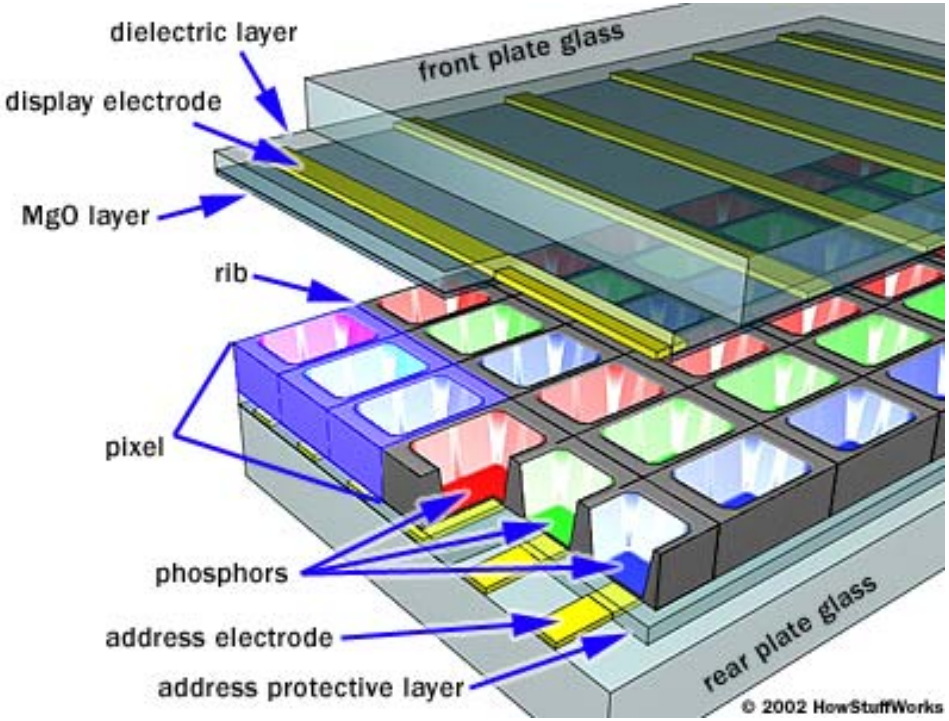
PDP

- PDP = Plasma Display Panel
- „Production“ of light in every pixel
- Plasma as the „source of light“
- Large displays/TV sets possible



Working Principle PDP

- First displays in 1929
- Working pressure: 200-300 mbar
- Ne with 10-15% Xe
- Plasma emits UV-light



Mechanisms

$Xe + e^- \rightarrow Xe(^3P_1) + e^-$

$Xe(^3P_2) + e^-$

Xe^{**}

$Xe^{**} \rightarrow Xe(^3P_1) + hv(828nm)$

$Xe(^3P_2) + hv(823nm)$

$Xe(^3P_1) \rightarrow Xe + hv(147nm)$

$Xe(^3P_1) + Xe + M \rightarrow Xe_2^* + M$

$Xe_2^* \rightarrow 2\,Xe + hv\ (150nm\ or\ 172nm)$

Phosphors for PDPs

Color	Chemical Composition
Blue	$(Y,Gd)(V,P)O_4$ $BaMgAl_{10}O_{17}:Eu$
Green	$Zn_2SiO_4:Mn$ $BaMgAl_{10}O_{17}:Eu,Mn$ $BaAl_{12}O_{19}:Mn$ $(Y,Gd)BO_3:Tb$
Red	$(Y,Gd)BO_3:Eu$ $(Y,Gd)_2O_3:Eu$ $(Y,Gd)(V,P)O_4:Eu$

PDP

- Pros:
  - Large displays
  - Good color rendering
  - Thin panels
  - No dependence on viewing angle
  - Brigthness

- Cons:
  - High costs
  - Power consumption

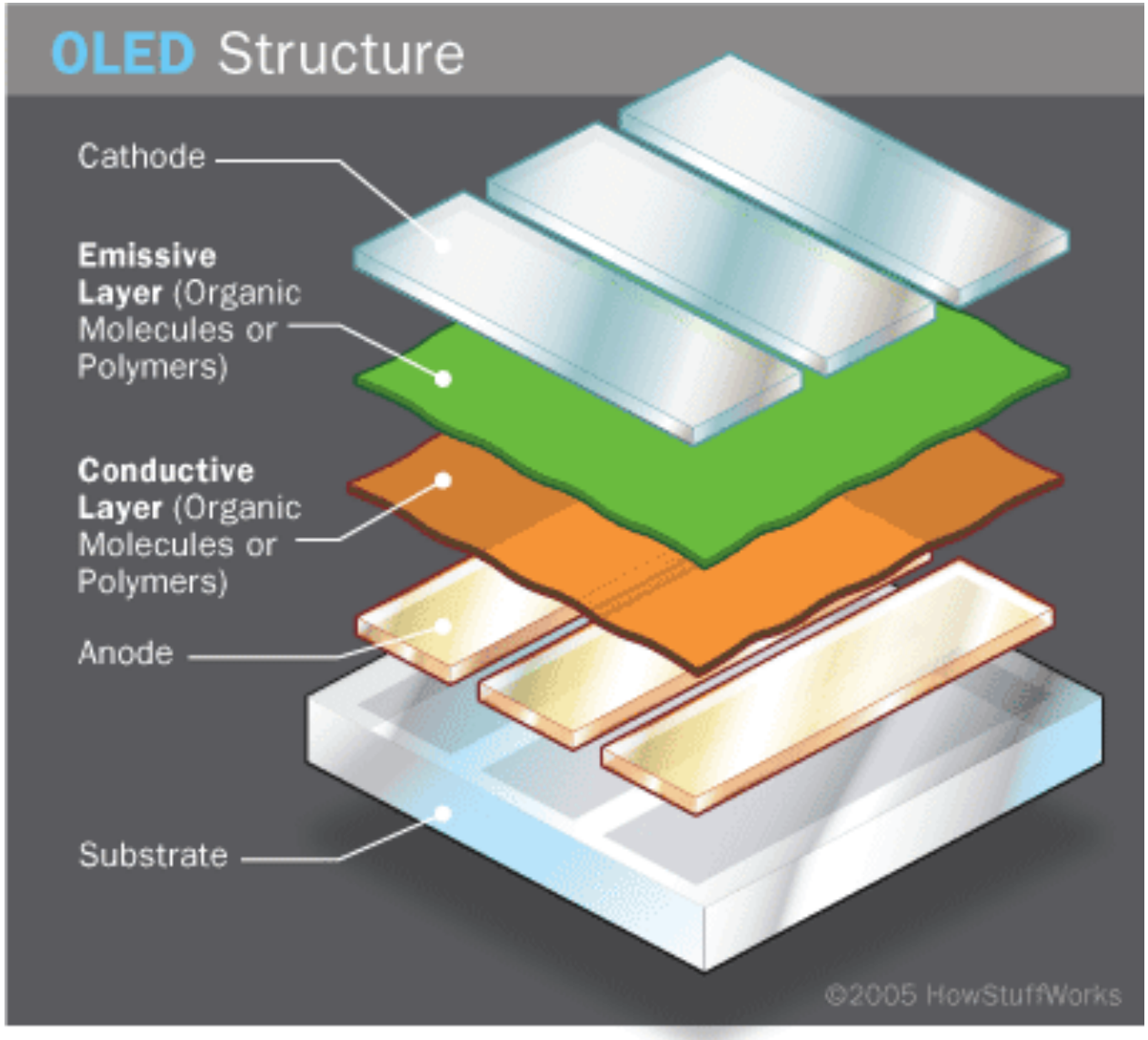
OLED

- OLED = organic light emitting diode
- Development started in 1980s and was lead by Kodak
- There are different OLEDs used for displays:
  - *Passive-matrix* OLED → less efficient → suited for small screens (2- to 3-inch)
  - *Active-matrix* OLED → very efficient using TFT

  → large displays, electronic signs
  - *Transparent OLED* → >70% transparency

  → Laptop, Head-up systems

OLED Structure

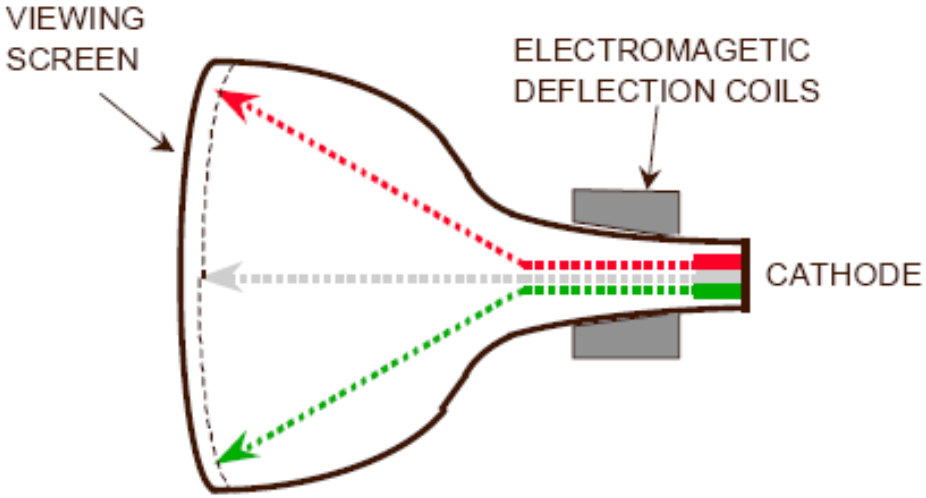


OLED

- Pros:
  - Thinner, lighter and more flexible than LED, LCD and Plasma
  - Brighter than LED because organic layer is a lot thinner than the corresponding emitting layer in the LED
  - Much less power due to unnecessary backlighting
  - Large fields of viewing
- Cons:
  - Liftetime (blue has only a lifetime of 14,000 hours)
  - Manufacturing is expensive
  - Air sensitive – Water can easily damage OLEDs

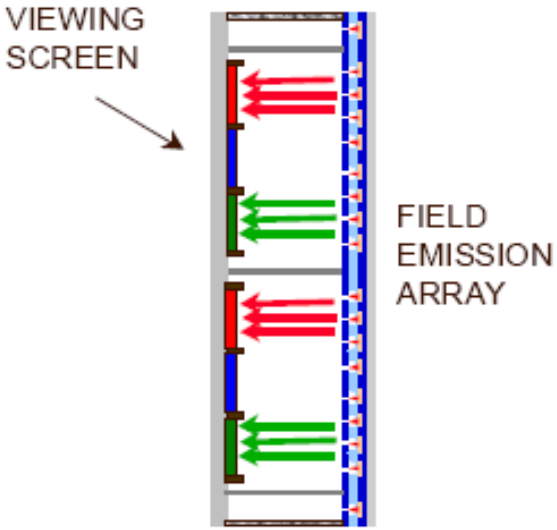
What is an FED?

Cathode Ray Tube (CRT)



Three hot cathodes produce electrons which are scanning in vacuum across a multicolor viewing screen to create an image

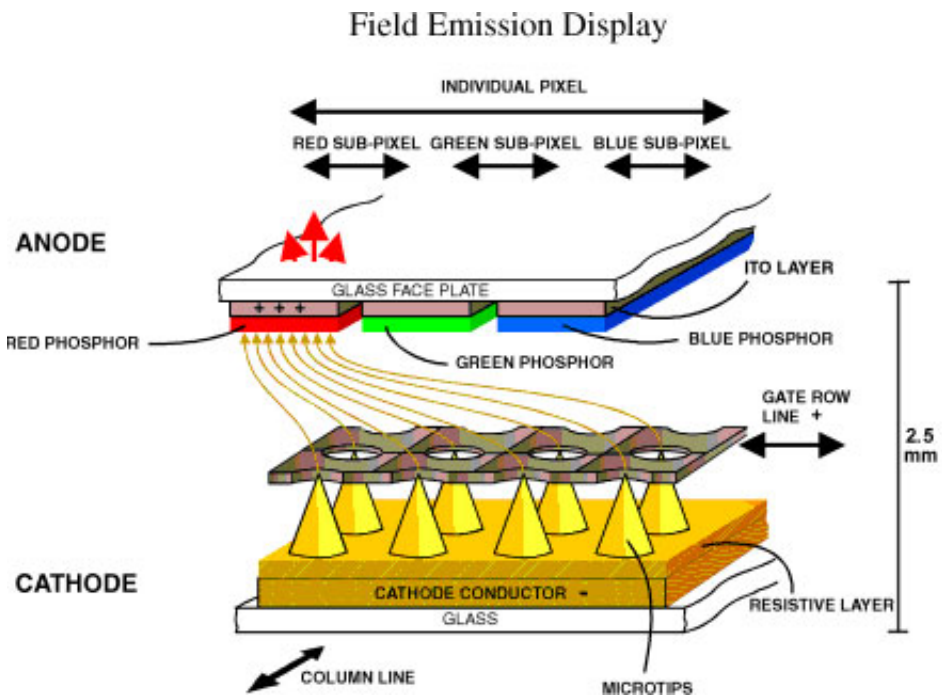
Field Emission Display



Electrons from millions of tiny cathodes travel in vacuum to a muliticolor viewing screen to create an image

Concept of FED

- First concentrated efforts in 1991 by Candescent in cooperation with Sony; 2009 Sony gave up production due to a lack of capital but there are still some Japanese Companys working on it
- Current between CNT`s and metal mesh producing the electrons and controlling them (large field electron source)
- Electrons reaching the phosphor layers and excite them
- Phosphors emit different colours
- Three sub-pixel add up to one pixel

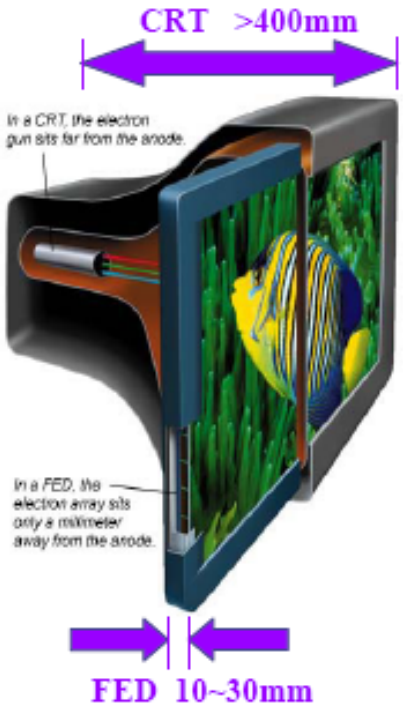


Field Emission Display (FED)

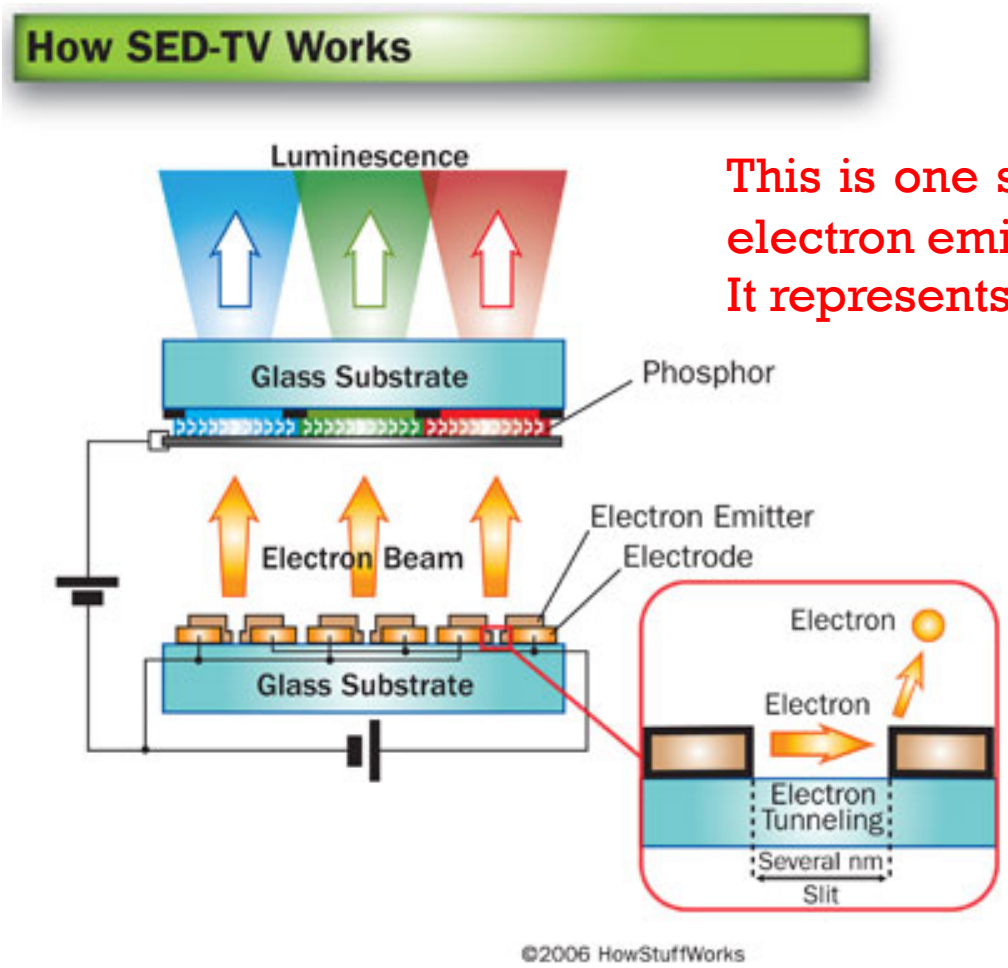
- Pros:
  - More efficient than LCDs
  - No backlighting system and extra active matrix like TFT → very thin displays
  - High image quality
  - High response time
- Cons:
  - Production problems due to the high reliability (vacuum)
  - Acceleration current not high enough to excite phosphors
  - Contamination and damage in processing

SED

- SED = Surface-conduction Electron-emitter Display
- Emerging technology, Co-developed by Canon and Toshiba; 2010 Canon has halted further development
- Is based on the idea of Cathode Ray Tubes (CRT)



Canon SED-Tv



This is one surface-conduction electron emitter (SCE).
It represents one pixel.

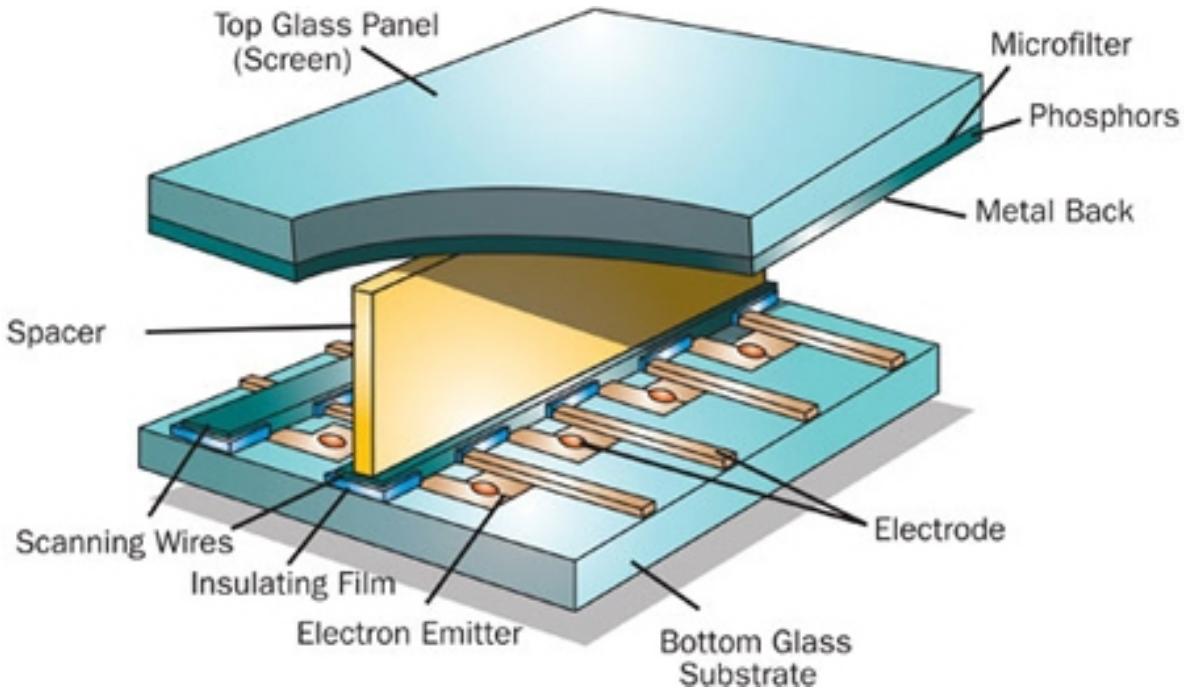
1. Electrons emitted in vacuum by tunneling due to potential difference (10 V) between the two electrodes

2. Electrons are accelerated by a high electric field towards the positiv charged screen, which is coated with phosphors

3. The phosphors get excited by the electrons and emit visible light

How a SED-TV Works

- Millions of SCEs are arranged in a matrix and each one controls the red, green and blue aspect of one pixel of the picture
- Parts which are not used to create pixels are black, resulting in a high contrast
- Microfilters improve color accuracy and cut down on reflected light



SED

- Pros:
  - Thin and lightweight
  - High efficiency
  - Exellent color and contrast potential
  - Wide viewing angel
  - Unlike CRTs, SEDs permanently display the entire image

- Cons:
  - Unknown life expectancy
  - Potential for screen burn-in
  - **High manufacturing costs**

Overview Technical Data

	CRT	LCD	LCD LED	OLED	Plasma	FED/SED
Contrast	500:1	50,000:1	3,000,000:1	> 1,000,000:1	2,000,000:1	20,000:1
Brightness [cd/m^2]	300	500	300	600	1000	400
Viewing angle [degree]	180	170	170	> 170	170	180
Size [inches]	< 40	108	108	80	150	27
Set depth [mm]	400	20	2,6	0,05	7-18	
Response time [ms]	5	10-25	10-25	0,01	< 8	< 2
Power consumption	High	Low	Low	Very low	Medium	Low

New Display Technologies

- Quantum Dot Display (QDLED)
- Laser Phosphor Display (LPD)
- Organic Light Emitting Transistor (OLET)
- Nanocrystal Display
- Thick-film dielectric electroluminescent (TDEL)
- Inferometric Modulator Display (IMOD)