BEKO Elektronik

Software Design Department

“ OLED Technology & Display Applications ”

Fatih Ünal & Hürriyet Keskin

February 6, 2008

Wednesday

Presentation Overview

- What is OLED ?
- OLED Components
- How OLEDs Emit Light ?
- Types of OLEDs: Passive and Active Matrix
- Types of OLEDs: Transparent, Top-emitting, Foldable and White
- OLED Advantages and Disadvantages
- Comparison of OLED and LCD
- OLED: A next generation display technology
- OLED TV
- OLED Market Potential
- Application areas of OLED technology
- Conclusion


UNIVERSAL DISPLAY
CORPORATION

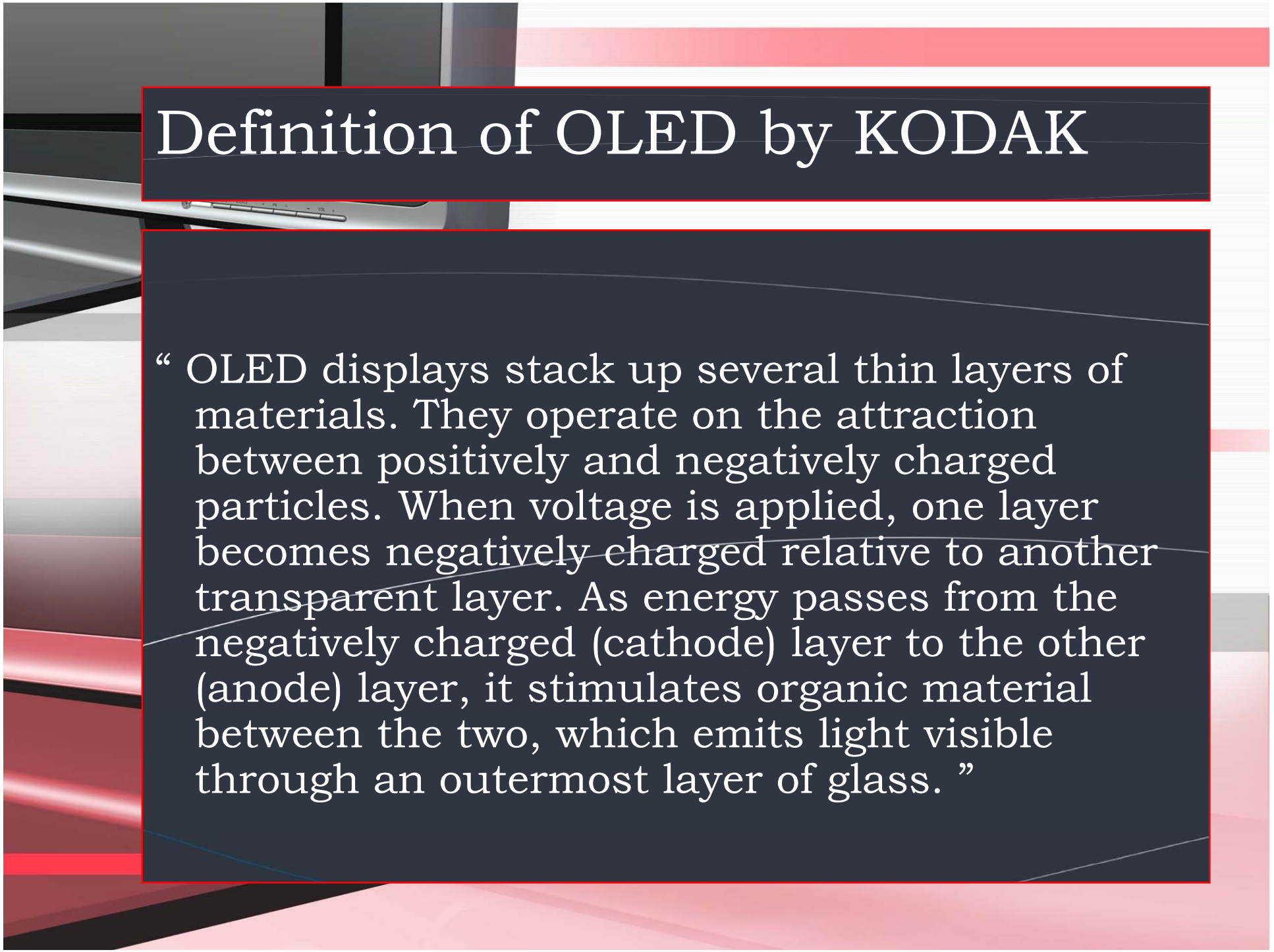

wise
view

What is OLED ?

- Organic Light Emitting Diode (OLED)
- Composed of thin films of organic molecules that create light with the application of electricity.
- Provides crisper, brighter display. Refresh rate is almost 1000 times faster than LCD's. Video images will be more realistic.
- Uses less power than light emitting diodes (LEDs) and liquid crystal displays (LCDs)

What is OLED ?

- R&D facilities on OLED technology proceed rapidly and in the future OLEDs will be used widely on TVs, home and office lighting, billboard displays.
- Flexibility that enables folding up, roll-up shape-free. Only a quarter-inch thick.
- First used by KODAK scientists in 1987.

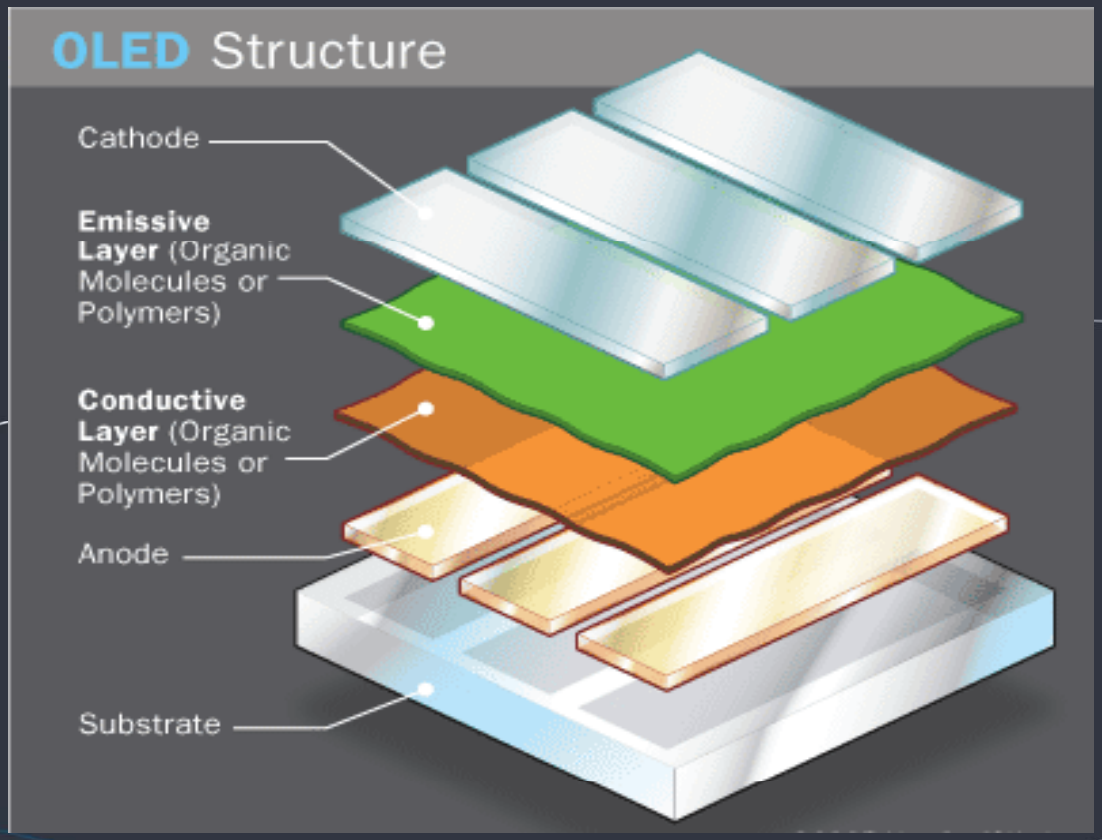


Definition of OLED by KODAK

" OLED displays stack up several thin layers of materials. They operate on the attraction between positively and negatively charged particles. When voltage is applied, one layer becomes negatively charged relative to another transparent layer. As energy passes from the negatively charged (cathode) layer to the other (anode) layer, it stimulates organic material between the two, which emits light visible through an outermost layer of glass. "

OLED Components

A semiconductor device 100-500 nanometers thick. (200 times smaller than a human hair)



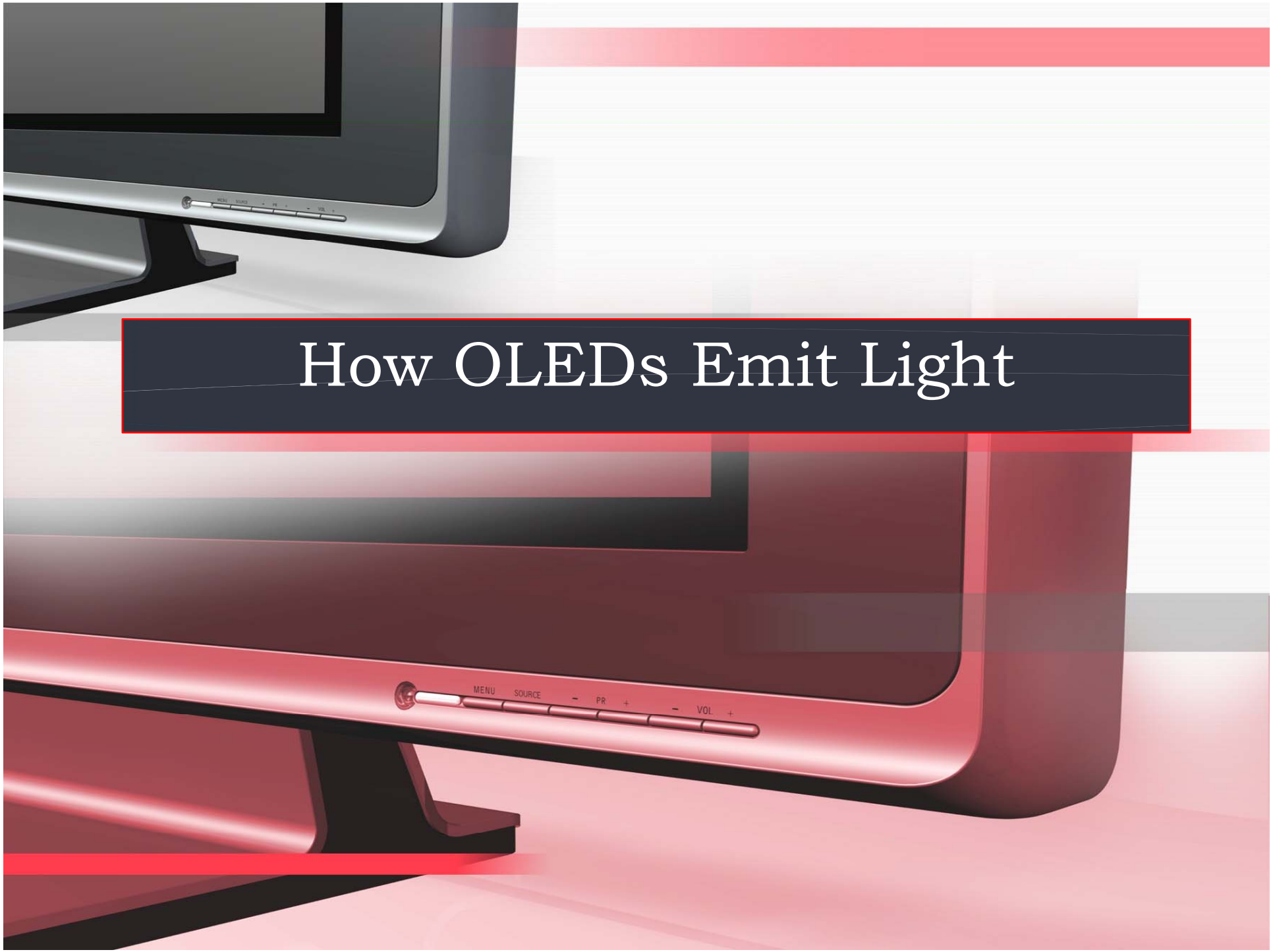
OLED Components

- Substrate (plastic, glass, foil): Supports the OLED
- Anode: Transparent. Removes electron when current is applied.
- Organic layers: Made of organic molecules, polymers.
  - Conducting layer: transports “holes” from the anode.
  - Emissive layer: transports electrons from the cathode, light is made here.

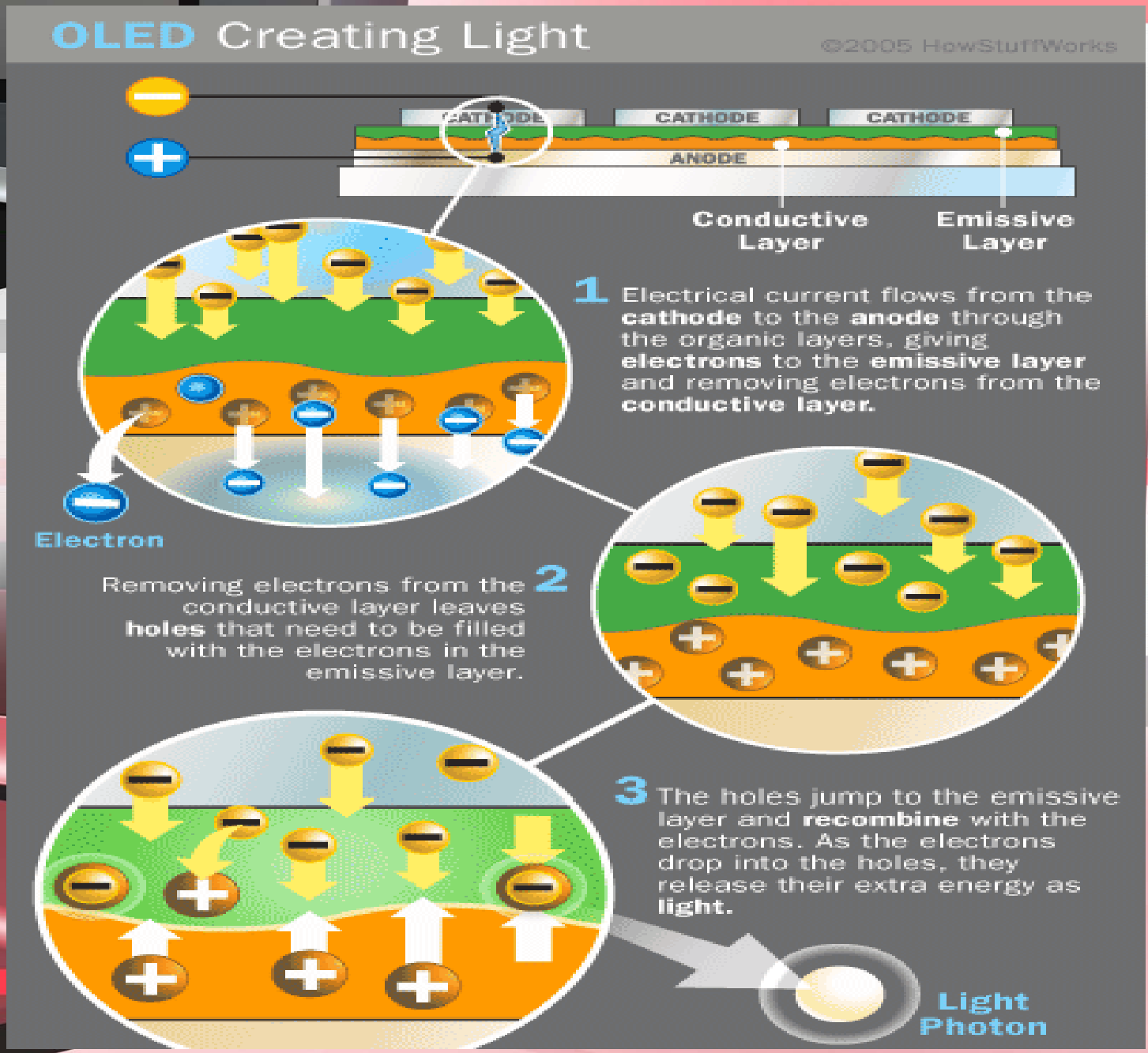
OLED Components

- Cathode: may or may not be transparent. İnjects electrons when a current flows through the device.

Inkjet technology is widely used when making OLED, OLEDs are sprayed on large films for large displays which reduces manufacturing cost.



How OLEDs Emit Light

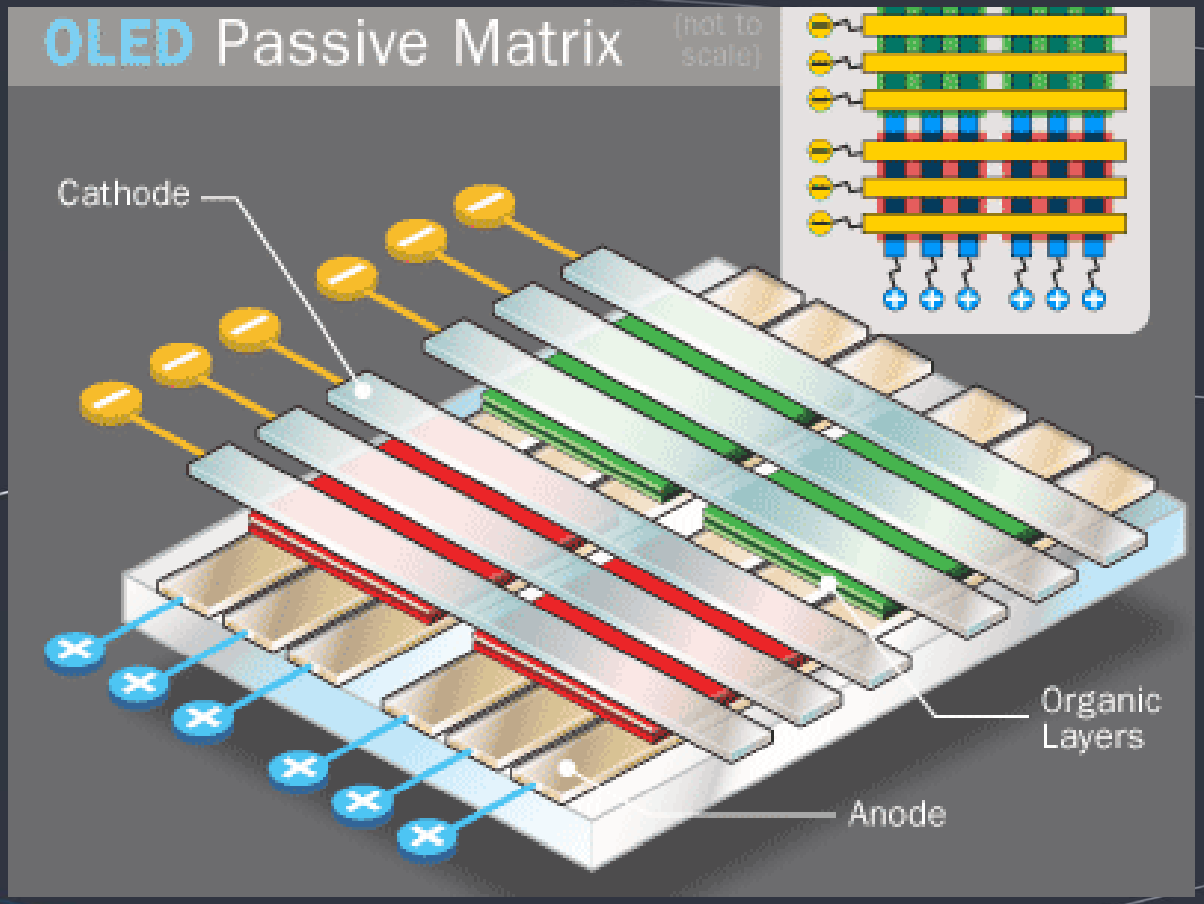

OLED Creating Light
©2005 HowStuffWorks
CATHODE
CATHODE
CATHODE
ANODE
Conductive Layer
Emissive Layer
1 Electrical current flows from the cathode to the anode through the organic layers, giving electrons to the emissive layer and removing electrons from the conductive layer.
Electron
2 Removing electrons from the conductive layer leaves holes that need to be filled with the electrons in the emissive layer.
3 The holes jump to the emissive layer and recombine with the electrons. As the electrons drop into the holes, they release their extra energy as light.
Light Photon

How OLEDs Emit Light

- Color of the light depends on the type of organic molecule in the emissive layer.
- The intensity or brightness of the light depends on the amount of electrical current applied.

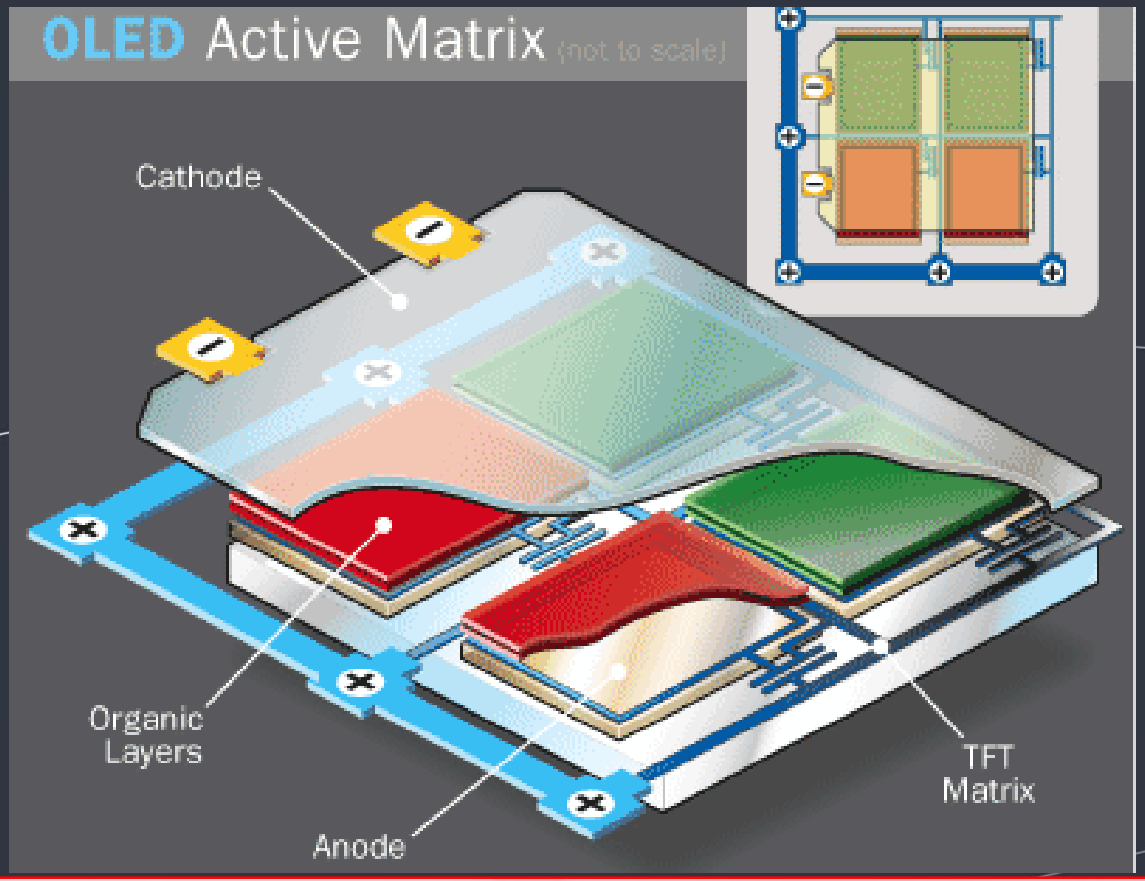
Types of OLEDs - Passive-matrix OLED (PMOLED)

Each intersection is a pixel



Types of OLEDs - Active-matrix OLED (AMOLED)

TFT (thin film transistor) array forms a matrix that determines which pixel to turn on to form image



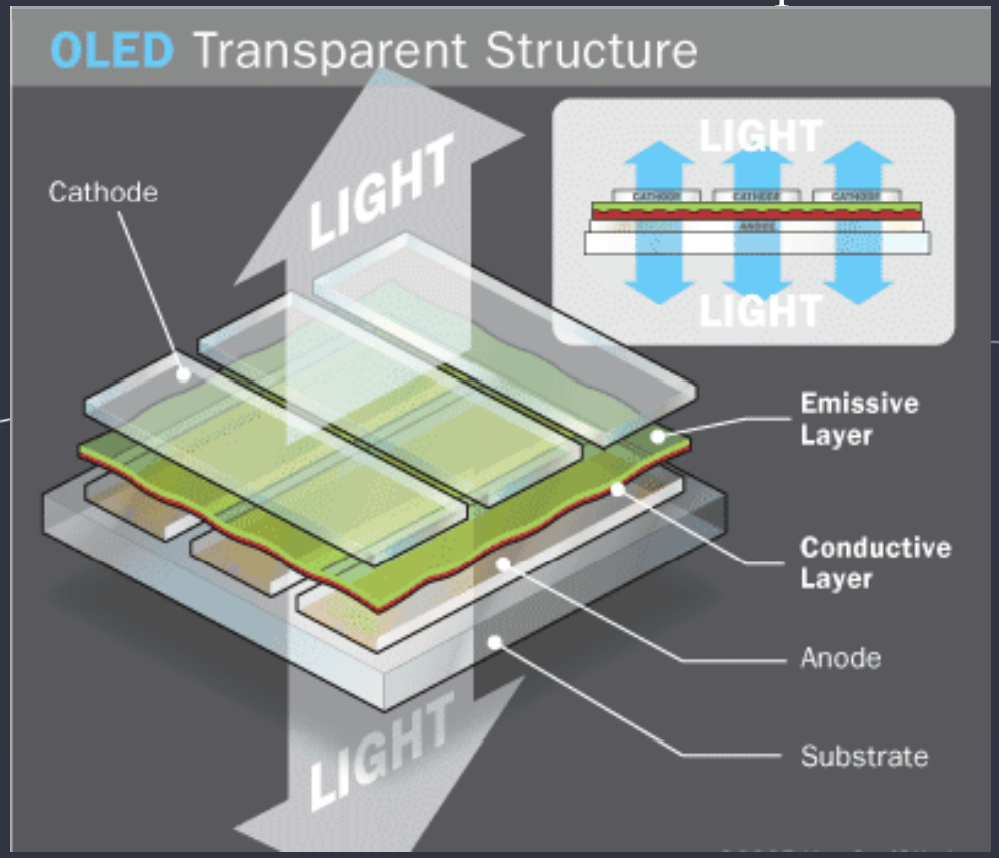
Types of OLEDs- Active-matrix vs Passive-matrix

- AMOLEDs consume less power, because TFT array requires less power than external circuitry that PMOLED needs.
- AMOLEDs are efficient for large displays.
- Have better refresh rate. Suitable for video images. Used in monitors, large screen TVs and billboards.

- PMOLEDs consume more power than other types of OLED, but even less than LCDs.
- Efficient for text and icons.
- Best for small screens (2-3 inch), cell phones, PDAs and MP3 players.

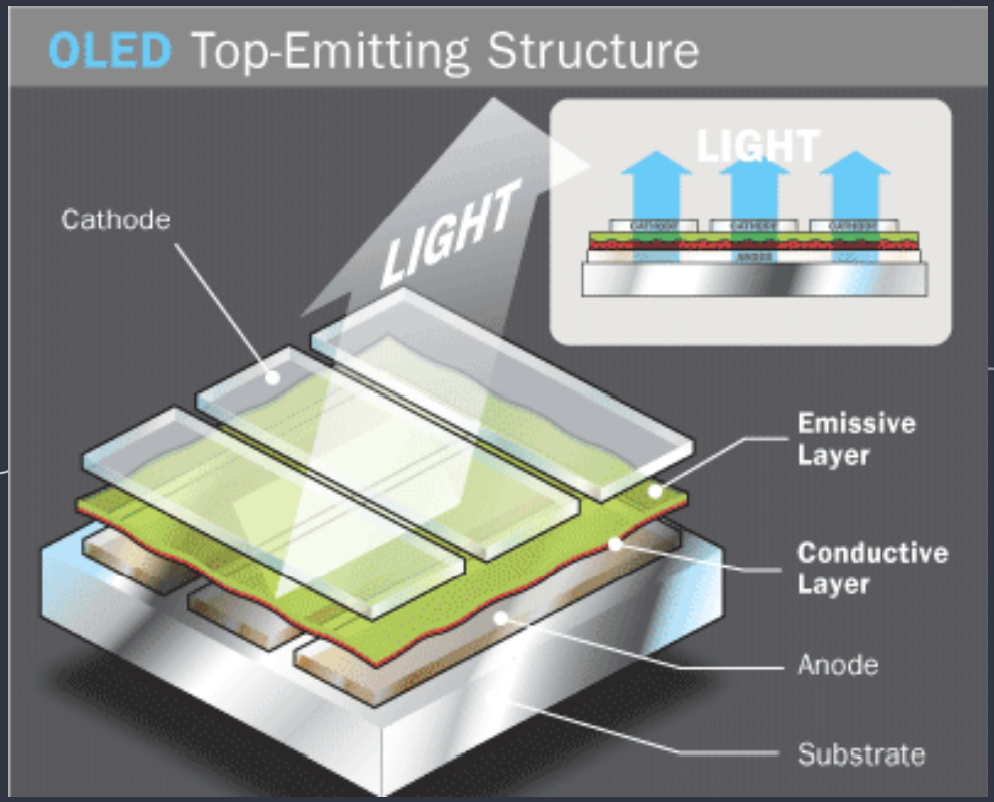
Types of OLEDs- Transparent OLED

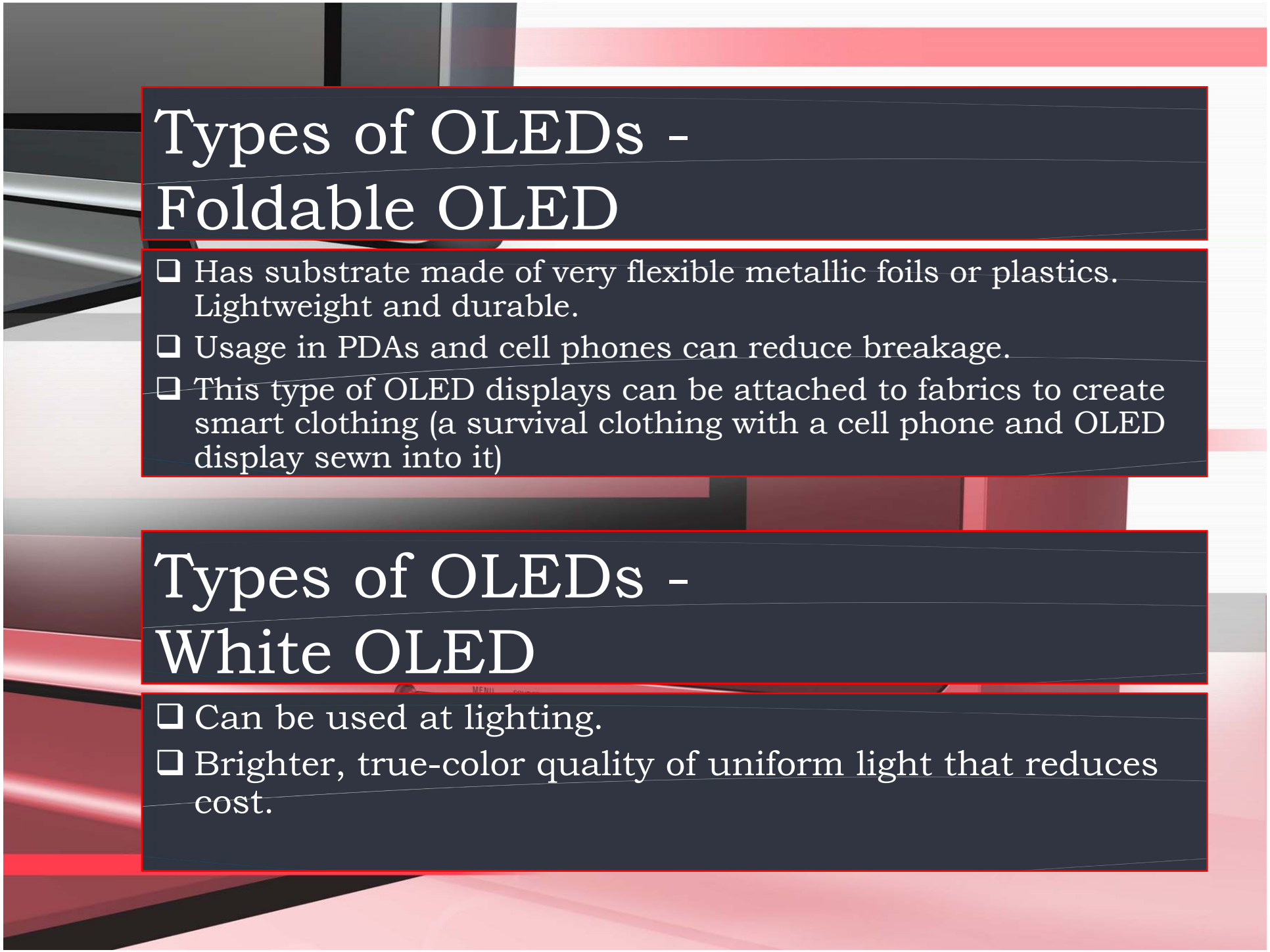
Up to 85% transparent when turned off, transparent components can be both active-matrix or passive-matrix



Types of OLEDs - Top-emitting OLED

Has a substrate that is either opaque or reflective.





Types of OLEDs - Foldable OLED

- Has substrate made of very flexible metallic foils or plastics. Lightweight and durable.
- Usage in PDAs and cell phones can reduce breakage.
- This type of OLED displays can be attached to fabrics to create smart clothing (a survival clothing with a cell phone and OLED display sewn into it)

Types of OLEDs - White OLED

- Can be used at lighting.
- Brighter, true-color quality of uniform light that reduces cost.

OLED Advantages and Disadvantages

OLEDs compared to LEDs and LCDs;

Advantages:

- OLEDs can be used as display choice in small devices and large screen TVs (like LCDs). Also they can form the digits on digital clocks and other electronic devices (like LEDs).
- They are thinner, lighter and more flexible than LEDs and LCDs
- OLED subtrates can be plastic rather than the glass used for LEDs and LCDs, this causes flexibility rather than rigidness.
- OLEDs are brighter than LEDs and LCDs, don't require glass or other light emitting inorganic crystal layers.

OLED Advantages and Disadvantages

Advantages continue …

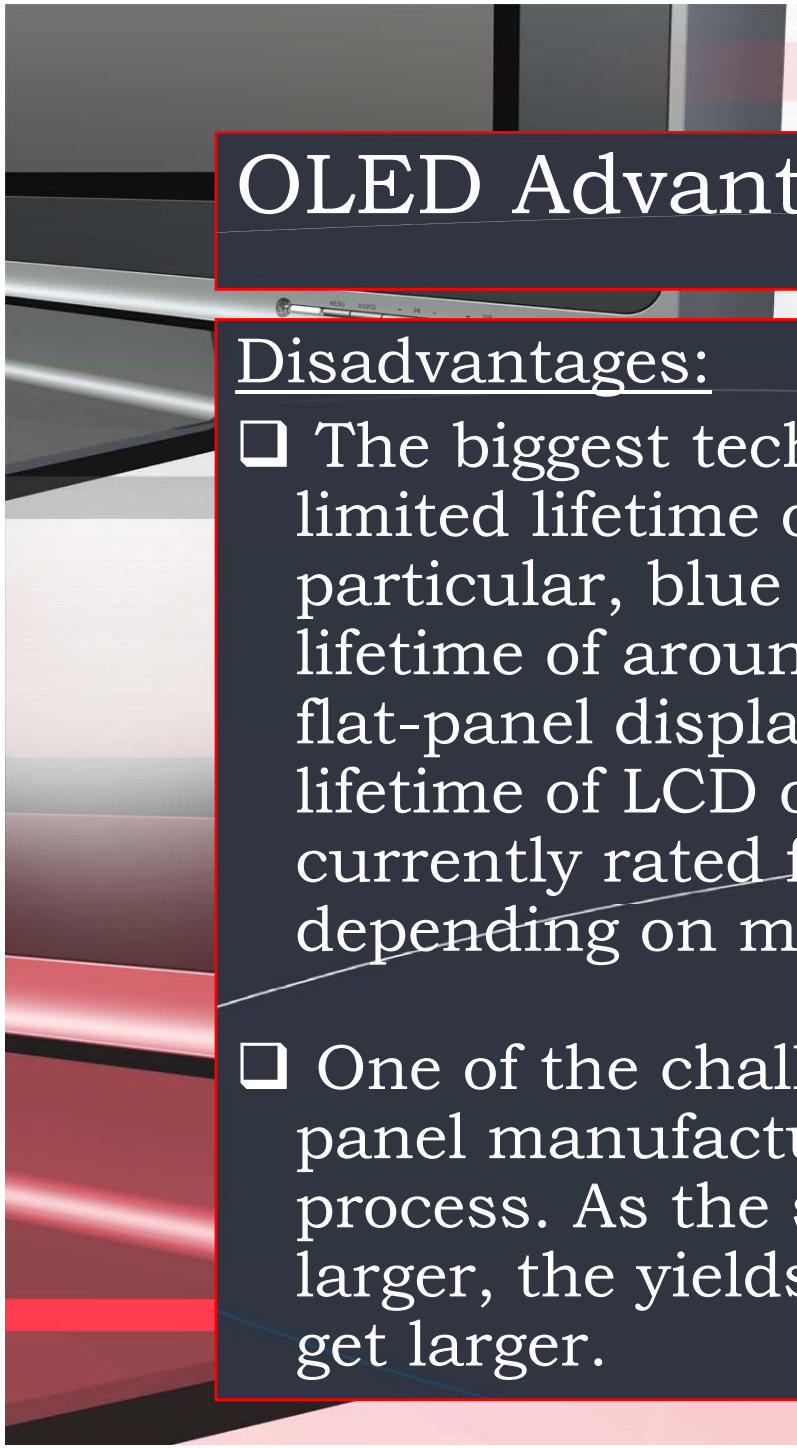
- OLEDs don't require backlighting like LCDs, consume much less power than LCDs. (most of the LCD power goes to backlighting) LCDs work selectively blocking areas of the backlight to make the images while OLEDs generate light themselves. This issue is important for battery operated devices such as cell phones.
- OLEDs are easier to produce and can be made to larger sizes. It is easier to lay down large scale plastics than liquid crystals.

OLED Advantages and Disadvantages

Advantages continue …

- OLEDs enable a greater range of colors, brightness, and viewing angle than LCDs, because OLED pixels directly emit light. OLED pixel colors appear correct and unshifted, even as the viewing angle approaches 90 degrees from normal. Whereas, LCDs work by blocking light which causes viewing obstacle from certain angles.
- OLEDs are durable. They can operate in a broader temperature range.
- The response time for OLED TVs is very fast, so there is no motion blur while watching television. (AMOLED pixels turn on and off more than 3 times faster than the speed of comvolutional motion picture film)

OLED Advantages and Disadvantages



Disadvantages:

- The biggest technical problem for OLEDs is the limited lifetime of the organic materials. In particular, blue OLEDs historically have had a lifetime of around 5,000 hours when used for flat-panel displays, which is lower than typical lifetime of LCD or PDP technology – each currently rated for about 60,000 hours, depending on manufacturer and model.

- One of the challenges is the fact that AMOLED panel manufacturing is still an inefficient process. As the size of OLED displays becomes larger, the yields and manufacturing losses also get larger.

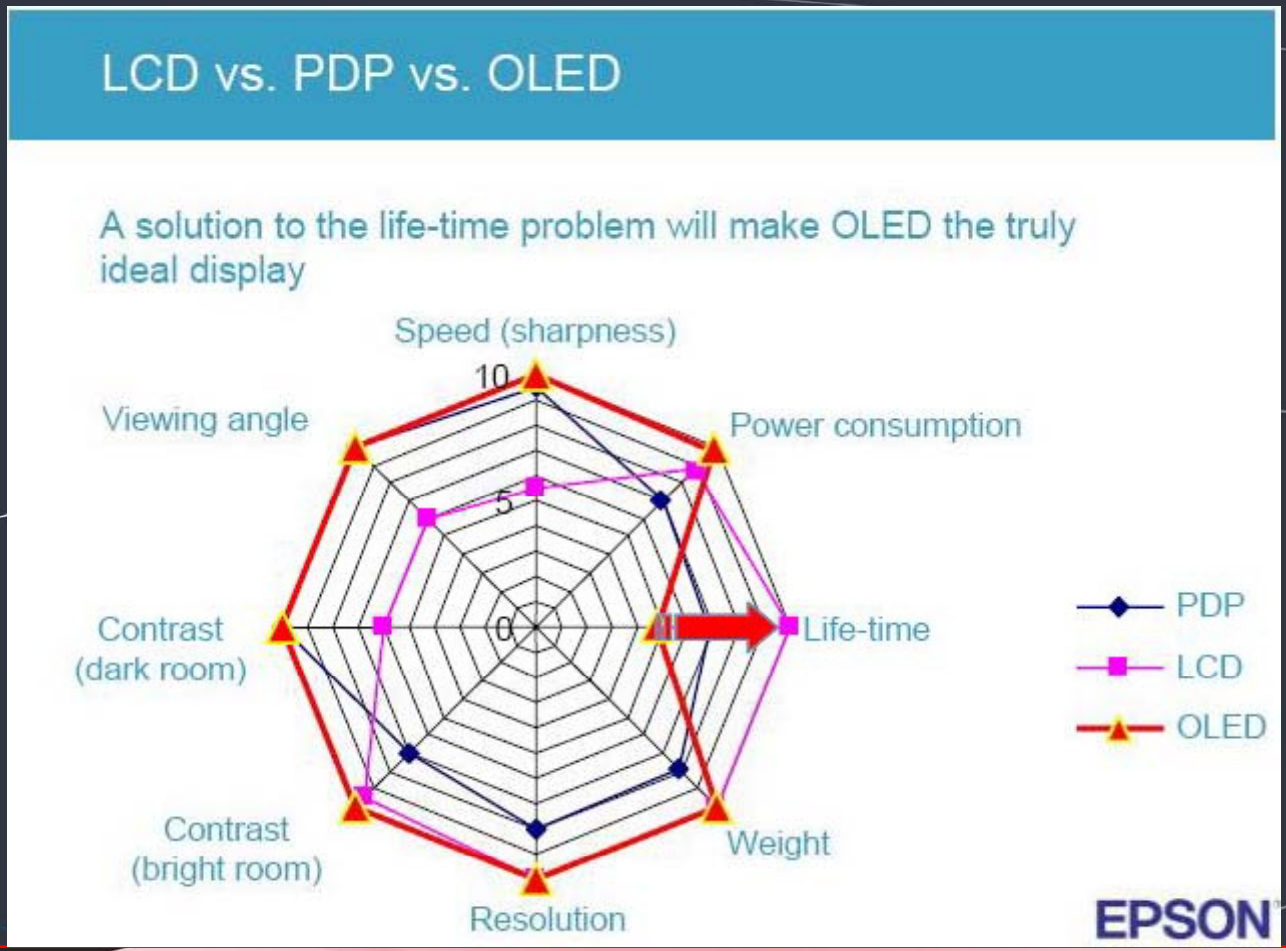
OLED Advantages and Disadvantages

Disadvantages continue…

- AMOLED suppliers cannot guarantee high volumes because the technology is coming from a single source.
- The intrusion of water into displays can damage or destroy the organic materials. Therefore, improved sealing processes are important for practical manufacturing and may limit the longevity of more flexible displays.
- Commercial development of the technology is also restrained by patents held by Eastman Kodak and other firms, requiring other companies to acquire a licence.
- The main problem about big size panels are based on the manufacturing difficulty.

Comparison of OLED and LCD

- General comparison of LCD vs PDP vs OLED:



Comparison of OLED and LCD

- A comparison of OLED vs LCD on product base:

Display	Emagin OLED	CRL Opto /MicroPix
Type	Active matrix, small molecules OLED.	Active matrix, Ferroelectric Crystal, Reflective LCD.
Resolution	852x600 SVGA+	1280x1024 SXGA
Pixel Pitch and Fill Factor	15 µm, 66%	13,62 µm , 90%
Colour representation	Three subpixels in a vertical strip with RGB colour filters.	Field sequential R G B
Active Area	12,8 x 9,0 mm	17,4 x 14,0 mm
Operating/ Storage Temperature	-40 to 85 °C / -51 to 90°C	10 to 60 °C / -10 to 75°C
Frame Rate	Up to 85 Hz	Up to 120 Hz
Driving voltage (including interfaces)	5 V	5 V
Colour Depth	256 per RGB colour (24 bit)	256 per RGB colour (24 bit)

Table 3.1. Specifications of the two displays [35][36].

Comparison of OLED and LCD

- A power consumption comparison of OLED vs LCD:

LCOS	Power dissipation (mW)	Comment
Display	600	1280*1024 pixels
LED backlight	1000	Luminance of 500 cd/m^2
LED backlight	200	Luminance of 100 cd/m^2
Display+LED	800	1280*1024 pixels, luminance of 100 cd/m^2
OLED		
Display	150	852*600 pixels, luminance of 100 cd/m^2

Table 3.7 The power supply for the OLED and LCOS according to eMagin and CRL opto [34][39].

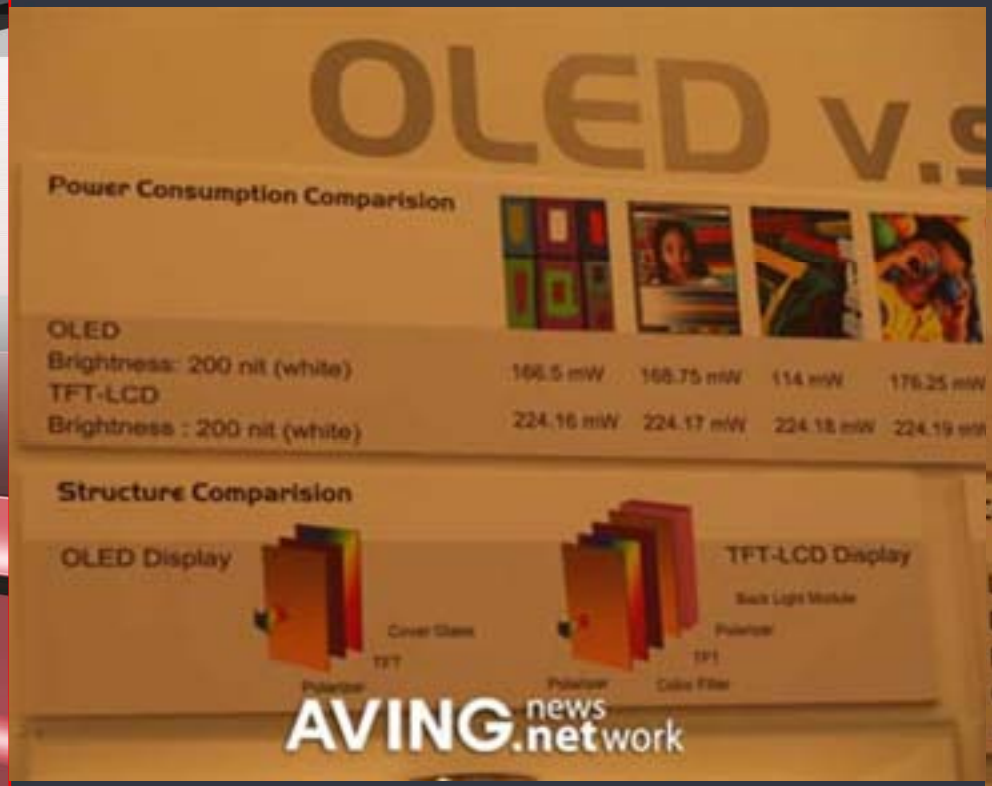
Comparison of OLED and LCD

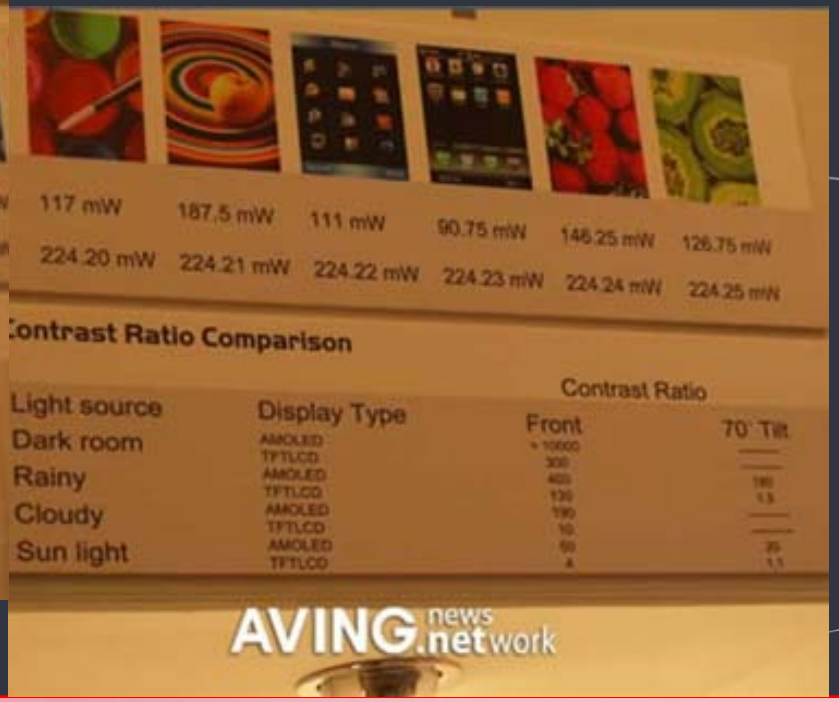
- CMEL demonstrated at the Display Taiwan 2007 exhibition a comparison of TFT-LCD vs OLED with diagonal size 2.4 inch and resolution of 240x320 pixel. Power consumption comparison chart is at the next slide.

Comparison Item	OLED	LCD
Thickness	1.5mm	2mm
Color	262k	262k
Viewing Angle (L/R/H/V)	180/180/180/180	50/50/40/40
Contrast Ratio	>10000	200
White Uniformity	>95	>70
Response Time	0.02msec	30msec

Comparison of OLED and LCD

- A power consumption comparison of OLED vs LCD on video image base:





Comparison of OLED and LCD

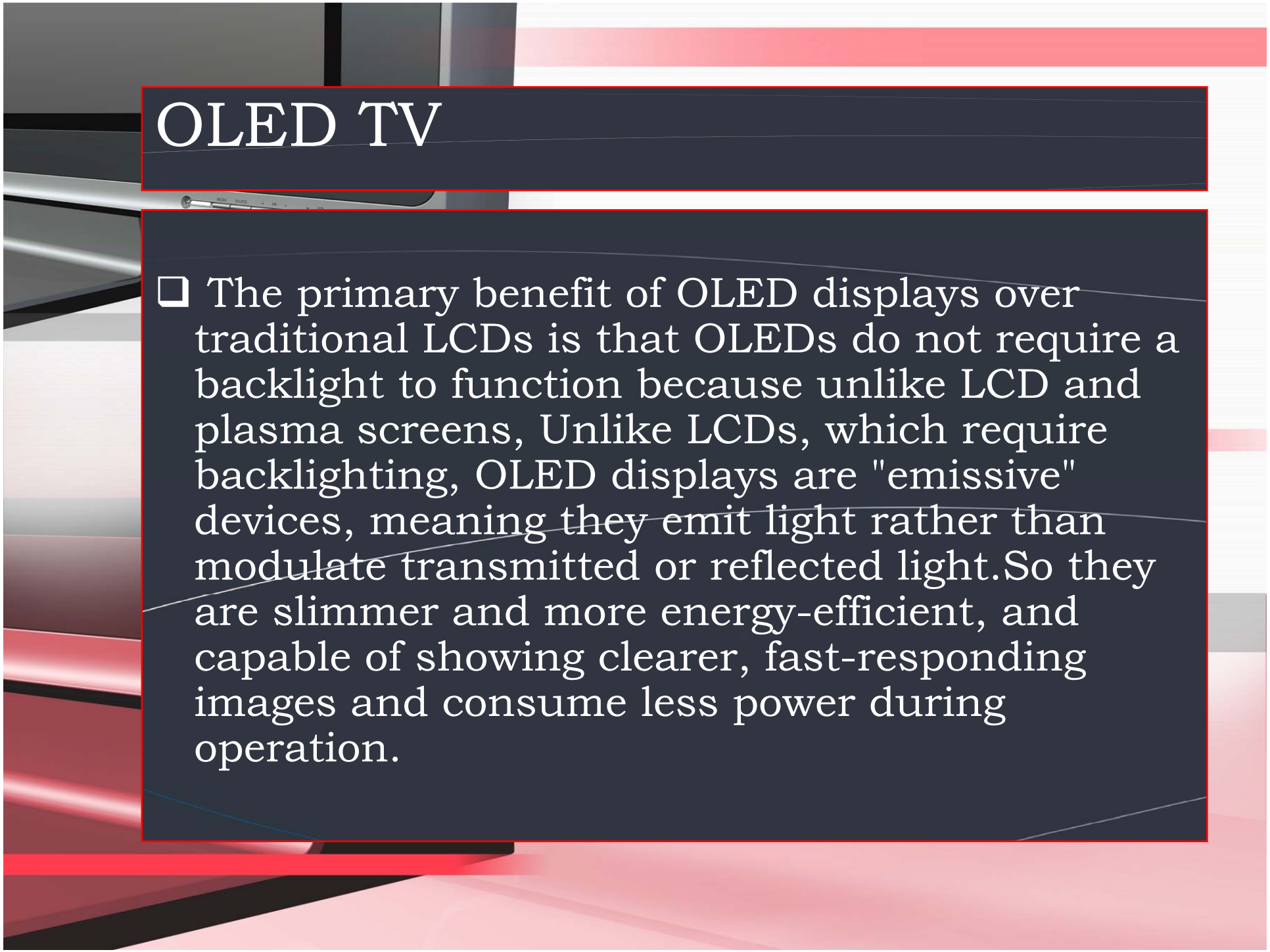
- A contrast ratio comparison of OLED vs LCD:

Contrast Ratio Comparison

Light source	Display Type	Contrast Ratio	
		Front	70° Tilt
Dark room	AMOLED	> 10000	----------
	TFTLCD	300	----------
Rainy	AMOLED	400	180
	TFTLCD	130	1.3
Cloudy	AMOLED	190	----------
	TFTLCD	10	----------
Sun light	AMOLED	50	20
	TFTLCD	4	1.1

Why OLED is a next generation display technology?

- Vibrant colors
- High contrast
- Excellent grayscale
- Full-motion video
- Wide viewing angles from all directions
- A wide range of pixel sizes
- Low power consumption
- Low operating voltages
- Wide operating temperature range
- A thin and lightweight form factor
- Cost-effective manufacturability



OLED TV

- The primary benefit of OLED displays over traditional LCDs is that OLEDs do not require a backlight to function because unlike LCD and plasma screens, Unlike LCDs, which require backlighting, OLED displays are "emissive" devices, meaning they emit light rather than modulate transmitted or reflected light.So they are slimmer and more energy-efficient, and capable of showing clearer, fast-responding images and consume less power during operation.

OLED TV

- In OLED technology, there is no operation needed to create black color because not energized diodes give the black color as default. Other colors are generated by energizing the related diodes. This means higher contrast ratios.

- In november 2007 Sony has started to sell their 11” OLED TV(the XEL-1). But this cannot be considered a real commercial OLED TV. They are only producing 2,000 of those units monthly, the price is extremly high - around 1,800$ for a 11" TV. Even the power consumption of those TVs is rather high - higher than compatiable LCDs.

OLED TV

Sony has demonstrated 27”, 1,000,000:1 contrast ratio, 1080p OLED TV demonstrated in CES 2007.

OLED TV

Samsung Electronics has developed the first 31-inch AM OLED TV in the world with the new unit set to be displayed for the first time at the 2008 CES Expo in Las Vegas.

OLED TV

Samsung updates- 40” TVs in 2010.

OLED TV

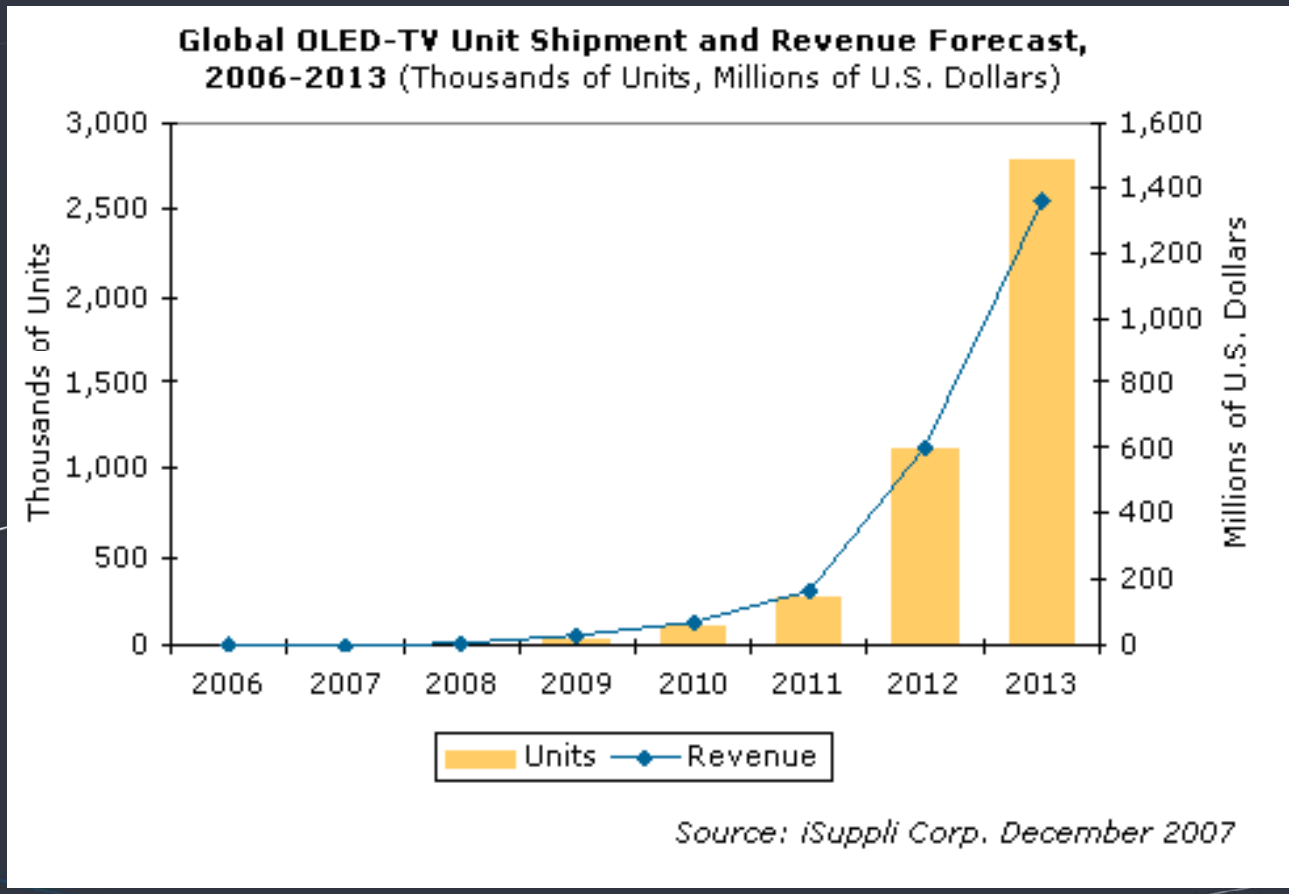
- A few more brands are likely to enter the OLED-TV market in 2009, including Toshiba Corp. and Panasonic Corp. The major motivation for these companies' entrance into the market is to make a statement to the industry that they are capable of producing OLED TVs.
- Toshiba Corp. and Matsushita Electric Industrial Co. Ltd, meanwhile, have formed their own joint venture—the Toshiba Matsushita Display Technology Co. Ltd—which will manufacture OLED panels for flat-screen TVs, with production of 20.8-inch screens beginning 2009.
- Companies such as Samsung SDI Co. Ltd, LG Electronics Inc. and Chi Mei EL Corp. (CMEL) have embarked on full-scale production of AMOLEDs in 2007.

OLED Market Potential

- iSuppli forecasts the global OLED TV market will reach 2.8 million units by 2013. In terms of global revenue, OLED TV will hit $1.4 billion by 2013.

- The following figure presents iSuppli's forecast for the global OLED-TV unit shipments and revenue for the period of 2006 through 2013.

OLED Market Potential



Application areas of OLED technology

Some OLED products and their features

5.5" OLED display

Drive	Active-matrix
Size	5.5"
Aspect Ratio	3:4
Number of Colors	262,144 colors

EPSON

2.1" QCIF OLED display

Drive	Active-matrix
Size	5.3 cm (2.1")
Number of pixels	144 x RGB x 176
Thickness	2.36 mm
Resolution	130 ppi
Number of Colors	262,144 colors
Power consumption	150 mW

EPSON

Some OLED products and their features

40" WXGA OLED display

Size	40"
Pixel	1280 x RGB x 768 dots (WXGA)
Addressing	Active matrix
Density	38 ppi
Color	260k colors

EPSON

12.5" VGA OLED display

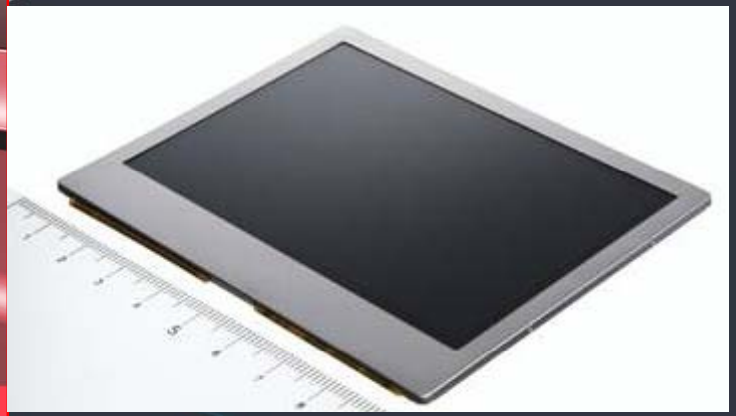
Size	31.68 cm (12.5")
Thickness	1.6 mm
Number of pixels	640 (H) x RGB x 480 (V)
Resolution	64 ppi
Brightness	White 150 cd/m² (w/o pol)
Number of colors	262,144 colors (6-bit)
Refresh rate	60 fps

EPSON


wise
40 inch AMOLED
SAMSUNG


Kodak
Kodak
EasyShare


Jade Master Project
There They Comes
Think About Happiness
00:03:51 / 00:06:48




SONY


fujitsu
SONY
03-Jan-2007
07:06 PM
Menu
Name
M300

Conclusion

- It is clear that OLED is the next generation displaying technology. Reducing power consumption, extending lifetimes, achieving larger sizes and attaining reasonable pricing eventually will help OLED TV to be competitive not so far.

For more information...

- Please visit below sites for more information about OLED TV.
  - http://www.oledbuyingguide.com/oled-tv-articles/oled-tv-vs-plasma-tv.html
  - http://computeraccessories.suite101.com/article.cfm/oled_monitors
  - http://reviews.cnet.com/4520-6449_7-6741419-1.html
  - http://www.fpslabs.com/news/latest/oled-production-to-rise-in-2008-and-beyond


..:: THANK YOU ::..
BEKO