

# OLED: An emerging display technology

## Introduction

An exciting technology has been available in many small devices such as cell phones and digital camera displays for the last 13 years. Soon it may be available for use in larger standard office and home entertainment displays. The technology is organic light emitting diode (OLED). It is possible that in the next 2-3 years you may see an 80" OLED in your living room or board room that only requires 10 or less volts of power to operate.

OLED display devices use organic carbon-based films, sandwiched together between two charged electrodes. One is a metallic cathode and the other a transparent anode, which is usually glass. Online encyclopedia, Wikipedia, defines an organic compound as "any member of a large class of chemical compounds whose molecules contain carbon, with the exception of carbides, carbonates, carbon oxides and gases containing carbon."

The basic components of an OLED are:

- **Substrate.** This is support for the OLED.
- **Anode.** The anode removes electrons when a current flows through the device.
- **Organic layers.** These layers are made of organic molecules or polymers.
  - Conducting layer. This layer is made of organic plastic

molecules that send electrons out from the anode.

- Emissive layer. This layer is made of organic plastic molecules (different ones from the conducting layer) that transport electrons from the cathode; this is where light is made.

- **Cathode (may or may not be transparent depending on the type of OLED).** The cathode injects electrons when a current flows through the device.

Applying the organic layers to the substrate can be accomplished in three ways:

### 1. Vacuum Deposition or Vacuum Thermal Evaporation (VTE).

In a vacuum chamber, the organic molecules are evaporated through a slow heat process and then allowed to condense as thin films onto a cooled substrate. This is a very inefficient and expensive process.

### 2. Organic Vapor Phase Deposition (OVPD).

This process employs an inert carrier gas (such as nitrogen) to precisely transfer films of organic material onto a cooled substrate in a hot-walled, low-pressure chamber. The precise transfer and ability to better control film thickness translates to lower material cost and higher production throughput.

### 3. Inkjet Printing.

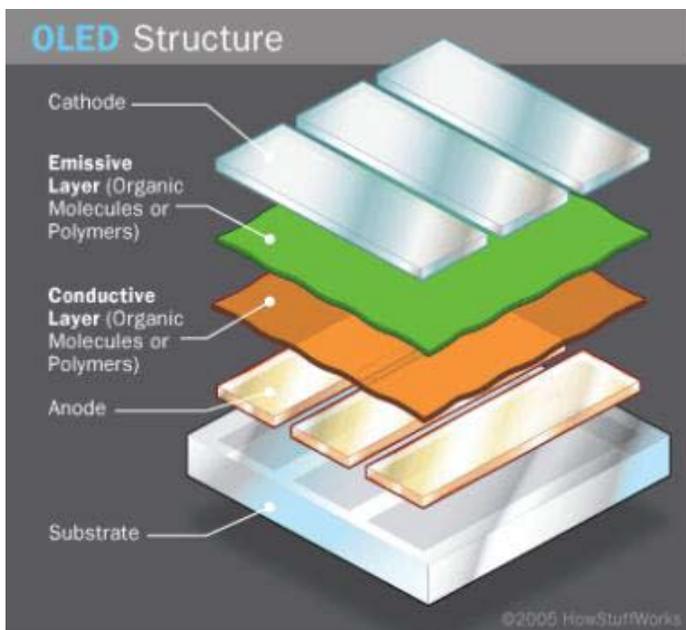
OLEDs are sprayed onto the substrate the same way our desktop inkjet printer sprays ink onto paper. This greatly reduces the cost of manufacturing OLEDs and allows for printing on very large films. This allows for a much lower cost and larger home displays and PIPD products.

One of the major benefits of OLEDs is their low power consumption when compared to traditional LEDs or LCDs. OLEDs also do not require backlighting to function, which in addition to using less power, also lowers manufacturing costs.

Even with all the layers that make up an OLED, this is an emissive technology – meaning it generates its own light. An OLED display is very thin and compact, typically has a viewing angle of 160 degrees and will operate on as little as 2 volts.

Imagine today's typical 60" flat-screen display, but instead of an 8-in. thick, 250-lb. plasma display or a 65-lb. LCD, your 60" OLED display is only 1/2" thick and weighs roughly 30 lbs.!

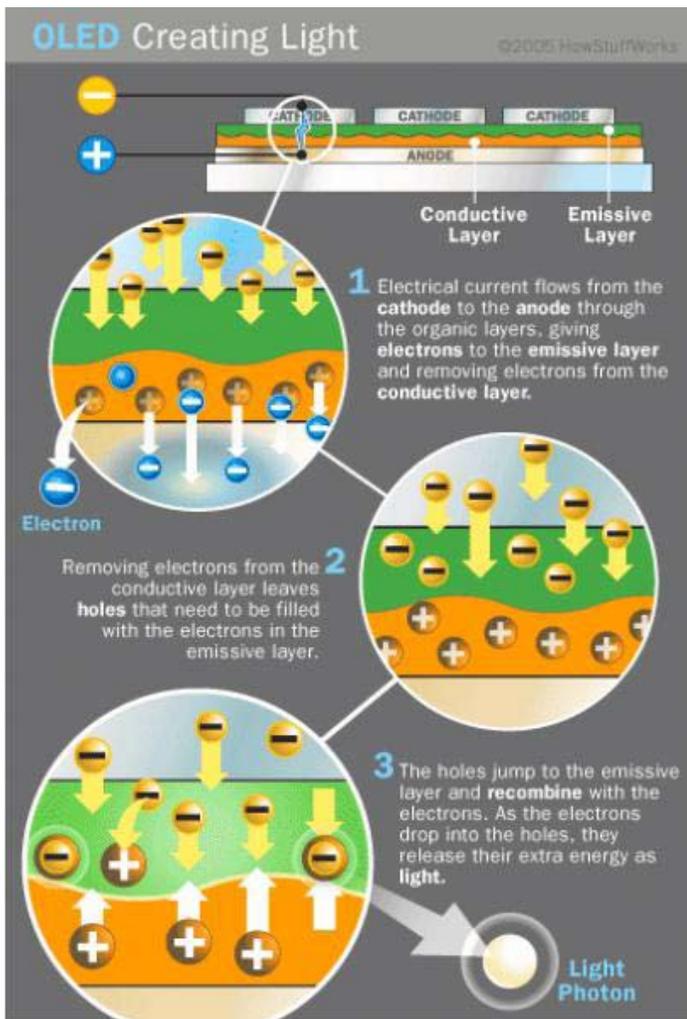
Other OLED advantages over traditional LCDs include:



- Increased brightness
- Faster response time (fast action, live events)
- Greater durability
- Thinner and lighter weight product
- Higher contrast

### How do OLEDs work?

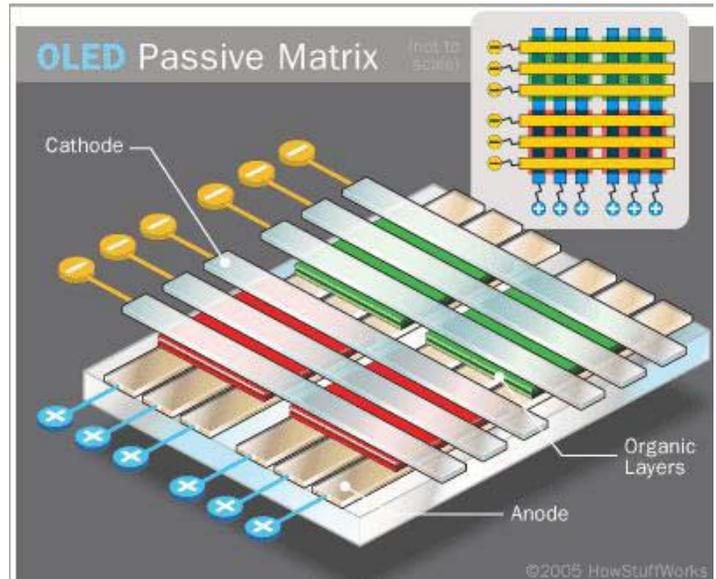
As previously mentioned, OLEDs are an emissive technology, which means they emit light instead of diffusing or reflecting a secondary source, as LCDs and LEDs currently do. Below is a graphic explanation of how the technology works.



### Types of OLEDs

There currently are six types of OLED screens, each designed for a different type of use. The types are:

1. **Passive Matrix OLEDs (PMOLEDs)** have strips of cathode, organic layers and strips of anode. The anode strips are arranged perpendicular to the cathode strips. The intersections of the cathode and anode make up the pixels where light is emitted. External circuitry applies current to selected strips of anode and cathode, determining which pixels get turned on and which pixels

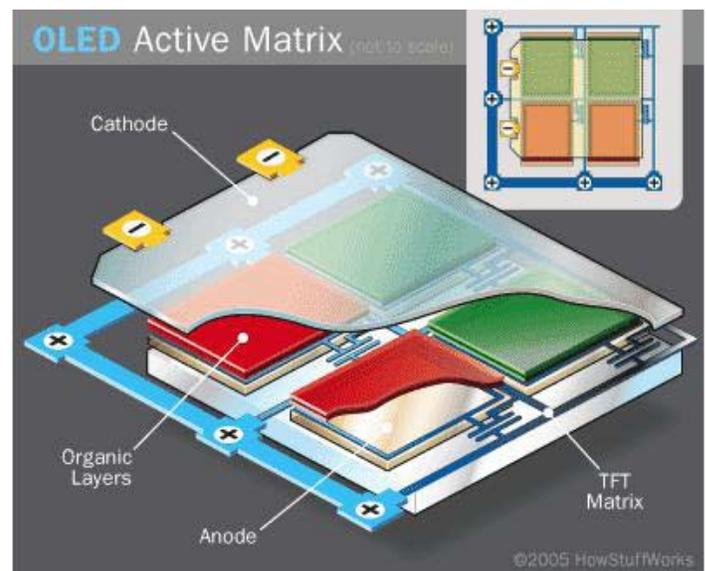


remain off. Again, the brightness of each pixel is proportional to the amount of applied current.

PMOLEDs are easy to make, but they consume more power than other types of OLED, mainly due to the power needed for the external circuitry. PMOLEDs are most efficient for text and icons and are best suited for small screens (2- to 3-inch diagonal) such as those you find in cell phones, PDAs and MP3 players. Even with the external circuitry, PMOLEDs consume less battery power than the LCDs that are currently used in these devices.

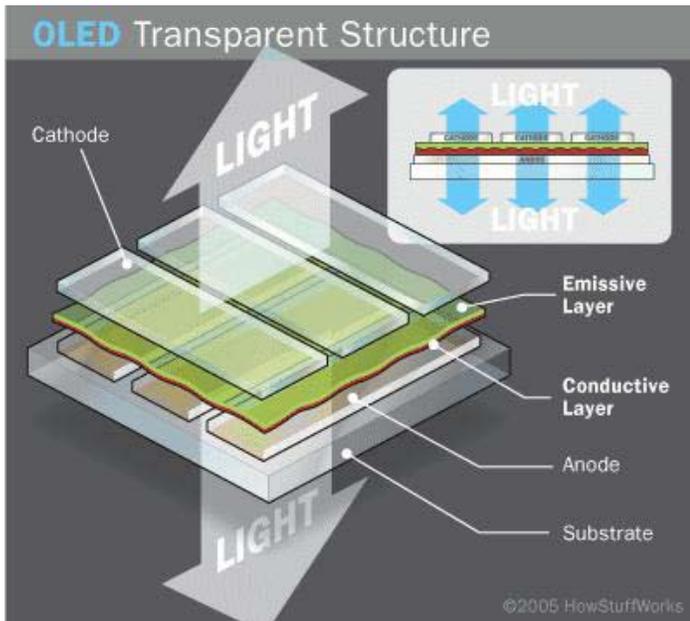
2. **Active-matrix OLEDs (AMOLEDs)** have full layers of cathode, organic molecules and anode, but the anode layer overlays a thin film transistor (TFT) array that forms a matrix. The TFT array itself is the circuitry that determines which pixels get turned on to form an image.

AMOLEDs consume less power than PMOLEDs because the TFT

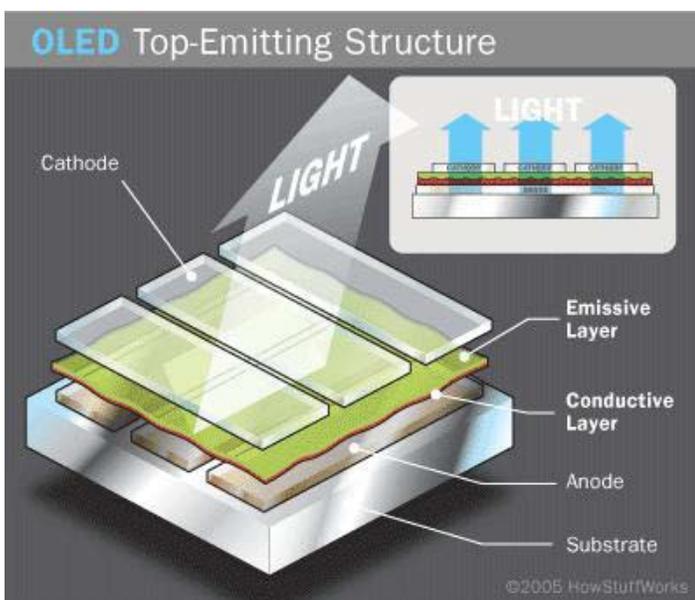


array requires less power than external circuitry, so they are efficient for large displays. AMOLEDs also have faster refresh rates suitable for video. The best uses for AMOLEDs are computer monitors, large-screen TVs and electronic signs or billboards.

**3. Transparent OLEDs** have only transparent components (substrate, cathode and anode) and, when turned off, are up to 85% as transparent as their substrate. When a transparent OLED display is turned on, it allows light to pass in both directions. A transparent OLED display can be either active- or passive-matrix. This technology can be used for heads-up displays.



**4. Top-emitting OLEDs** have a substrate that is either opaque or reflective. They are best suited to active-matrix design. Manufacturers may use top-emitting OLED displays in smart cards.



**5. Foldable OLEDs** have substrates made of very flexible metallic foils or plastics. Foldable OLEDs are very lightweight and durable. Their use in devices such as cell phones and PDAs can reduce breakage, a major cause for return or repair. Potentially, foldable OLED displays can be sewn into fabrics for "smart" clothing, such as outdoor survival clothing with an integrated computer chip, cell phone, GPS receiver and OLED display sewn into it.

**6. White OLEDs** emit white light that is brighter, more uniform and more energy efficient than that emitted by fluorescent lights. White OLEDs also have the true-color qualities of incandescent lighting. Because OLEDs can be made in large sheets, they can replace fluorescent lights that are currently used in homes and buildings. Their use could potentially reduce energy costs for lighting.

### OLED Advantages

The LCD is currently the display of choice in small devices and is also popular in large-screen TVs. Regular LEDs often form the digits on digital clocks and other electronic devices. OLEDs offer many advantages over both LCDs and LEDs, including:

- The plastic, organic layers of an OLED are thinner, lighter and more flexible than the crystalline layers in an LED or LCD.
- Because the light-emitting layers of an OLED are lighter, the substrate of an OLED can be flexible instead of rigid. OLED substrates can be plastic rather than the glass used for LEDs and LCDs.
- OLEDs are brighter than LEDs. Because the organic layers of an OLED are much thinner than the corresponding inorganic crystal layers of an LED, the conductive and emissive layers of an OLED can be multi-layered. Also, LEDs and LCDs require glass for support, and glass absorbs some light. OLEDs do not require glass.
- OLEDs do not require backlighting like LCDs. LCDs work by selectively blocking areas of the backlight to make the images that you see, while OLEDs generate light themselves. Because OLEDs do not require backlighting, they consume much less power than LCDs (most of the LCD power goes to the backlighting). This is especially important for battery-operated devices such as cell phones.
- OLEDs are easier to produce and can be made to larger sizes. Because OLEDs are essentially plastics, they can be made into large, thin sheets. It is much more difficult to grow and lay down so many liquid crystals.
- OLEDs have large fields of view, about 170 degrees. Because LCDs work by blocking light, they have an inherent viewing obstacle from certain angles. OLEDs produce their own light, so they have a much wider viewing range.

### OLED Disadvantages

OLED seem to be the perfect technology for all types of displays, however, they do have some problems, including:

- **Lifetime.** While red and green OLED films have long lifetimes (10,000 to 40,000 hours), blue organics currently have much shorter lifetimes (only about 1000 hours).
- **Manufacturing.** Processes are expensive right now.
- **Water.** Water can easily damage OLEDs.

## OLED Applications

OLED technology was invented by Eastman Kodak in the early 1980s and, currently, OLEDs are used in small-screen devices such as cell phones, PDAs and digital cameras. In March 2003, the company introduced the world's first digital camera with an OLED display. In September 2004, Sony Corporation announced that it was beginning mass production of OLED screens for its CLIE PEG-VZ90 model of personal-entertainment handhelds.

Several companies have already built prototype computer monitors and large-screen TVs. In May 2005, Samsung Electronics announced that it had developed the first 40" OLED-based, ultra-slim TV.

OLED Research and development is moving forward at a rapid pace and may soon lead to applications in heads-up displays (HUD), automotive dashboards, billboard-type displays, home and office lighting, and flexible displays. OLEDs refresh approximately 1000 times faster than LCDs. Although a device with an OLED display could change information in real time, the eye cannot perceive changes to video faster than about 13ms. Refresh rate is also not the end-all in display products. Many of the high-end monitors take advantage of advanced engineering in scalars and other components to make the view more pleasing to the eye.

## References

[www.wikipedia.com](http://www.wikipedia.com)

*This white paper was published in and based on information as of January 2007. Technical information is subject to change.*