ORGANIC LIGHT

EMITTING DIODE

”OLED”

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ABSTRACT

A new ultralow-cost, lightweight and flexible display technology, based on organic light emitting diodes (OLEDs) is emerging. OLEDs are thin film devices which use electroluminescent organic materials. The advantages of organic materials derive from the easiness of chemical manipulation to tune the colours and to obtain low-cost processability such as inkjet printing on plastic substrates.

Organic light emitting diodes (OLEDs) are electronic devices made by placing a thin film of an electroluminescent organic material between two conductors of different work functions. When an electrical voltage is applied, electrons and holes are injected into the electroluminescent material. When these recombine, light is emitted. Additional thin film layers are usually added for different purposes such as electron and hole transport.

INTRODUCTION

An **organic light emitting diode** (**OLED**) is a light -emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compounds which emit light in response to an electric current .This layer of organic semiconductor material is situated between two electrodes. Generally, at least one of these electrodes is transparent.

OLEDs are used in television screens, computer monitors, small, portable system screens such as mobile phones and PDAs, watches, advertising, information, and indication. . Such portable applications favor the high light output of OLEDs for readability in sunlight, and their low power drain. Portable displays are also used intermittently, so the lower lifespan of OLEDs is less important here. Prototypes have been made of flexible and rollable displays which use OLEDs’ unique characteristics. OLEDs have been used in most Motorola and Samsung colour cell phones, as well as some LG and Sony Ericsson phones OLEDs are also used in light sources for space illumination and in large-area light-emitting elements. Due to their early stage of development, they typically emit less light per unit area than inorganic solid-state based LED point-light sources. An OLED display functions without a backlight. Thus, it can display deep black levels and can be thinner and lighter than liquid crystal displays. In low ambient light conditions such as dark rooms, an OLED screen can achieve a higher contrast ratio than an LCD using either cold cathode fluorescent lamps or the more recently developed LED backlight.

# OLED Components

Like an LED, an OLED is a solid-state semiconductor device that is 100 to 500 nanometers thick or about 200 times smaller than a human hair. OLEDs can have either two layers or three layers of organic material; in the latter design, the third layer helps transport electrons from the cathode to the emissive layer. In this article, we'll be focusing on the two-layer design.

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An OLED consists of the following parts:

* **Substrate** (clear plastic, glass, foil) - The substrate supports the OLED.
* **Anode** (transparent) - The anode removes electrons (adds electron "holes") 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 transport "holes" from the anode. One conducting polymer used in OLEDs is polyaniline.
  + **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. One polymer used in the emissive layer is polyfluorene.
* **Cathode** (may or may not be transparent depending on the type of OLED) - The cathode injects electrons when a current flows through the device.

**WORKING**

OLEDs emit light in a similar manner to LEDs, through a process called **electrophosphorescence**.

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The process is as follows:

1. The battery or power supply of the device containing the OLED applies a voltage across the OLED.
2. An electrical current flows from the cathode to the anode through the organic layers (an electrical current is a flow of electrons).
   * The cathode gives electrons to the emissive layer of organic molecules.
   * The anode removes electrons from the conductive layer of organic molecules. (This is the equivalent to giving electron holes to the conductive layer.)
3. At the boundary between the emissive and the conductive layers, electrons find electron holes.
   * When an electron finds an electron hole, the electron fills the hole (it falls into an energy level of the atom that's missing an electron).
   * When this happens, the electron gives up energy in the form of a photon of light (see How Light Works).
4. The OLED emits light.
5. The color of the light depends on the type of organic molecule in the emissive layer. Manufacturers place several types of organic films on the same OLED to make color displays.
6. The intensity or brightness of the light depends on the amount of electrical current applied: the more current, the brighter the light.

**TYPES OF OLED**

# Types of OLEDs: Passive and Active Matrix

There are several types of OLEDs:

* Passive-matrix OLED
* Active-matrix OLED
* Transparent OLED
* Top-emitting OLED
* Foldable OLED
* White OLED

Each type has different uses. In the following sections, we'll discuss each type of OLED. Let's start with passive-matrix and active-matrix OLEDs.

**Passive-matrix OLED (PMOLED)** 

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, passive-matrix OLEDs consume less battery power than the LCDs that currently power these devices.

**Active-matrix OLED (AMOLED)** 

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.

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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.

**Transparent OLED** 

Transparent OLEDs have only transparent components (substrate, cathode and anode) and, when turned off, are up to 85 percent 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.

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**Top-emitting OLED** 

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.

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**Foldable OLED**

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 attached to fabrics to create "smart" clothing, such as outdoor survival clothing with an integrated computer chip, cell phone, GPS receiver and OLED display sewn into it.

**White OLED**

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.

**MAIN APPLICATIONS OF OLED**

OLED will cause a major revolution in two segments. They are:-

* DISPLAY
* LIGHTING

The advantage of using OLED in the above two segments will be clearly detailed ..it is already being used in display systems and its newer applications include signs and lighting. The first OLED lights were commercialized in May 2009. Philips Lighting opened up a webshop, where OLED lighting samples under the brand name ‘Lumiblade’ can be ordered online.

**DISPLAY**

#### Plasma, and LCD televisions will soon be a thing of the past, imagine a television screen as thin as a piece of paper that weighs no more than a few ounces. Or, so flexible it could be worn around your wrist and is virtually indestructible.

**ITS ADVANTAGES**

* **Lower cost in the future:** OLEDs can be printed onto any suitable substrate by an inkjet printer or even by screen printing, theoretically making them cheaper to produce than LCD or plasma displays. However, fabrication of the OLED substrate is more costly than that of a TFT LCD, until mass production methods lower cost through scalability. Roll-roll vapour-deposition methods for organic devices do allow mass production of thousands of devices per minute for minimal cost, although this technique also induces problems in that multi-layer devices can be challenging to make.
* **Light weight & flexible plastic substrates:** OLED displays can be fabricated on flexible plastic substrates leading to the possibility of flexible organic light emitting diodes being fabricated or other new applications such as roll up displays embedded in fabrics or clothing. As the substrate used can be flexible such as PET the displays may be produced inexpensively.
* **Wider viewing angles & improved brightness:** OLEDs can enable a greater artificial contrast ratio (both dynamic range and static, measured in purely dark conditions) and viewing angle compared to LCDs because OLED pixels directly emit light. OLED pixel colours appear correct and unshifted, even as the viewing angle approaches 90° from normal.
* **Better power efficiency:** LCDs filter the light emitted from backlight, allowing a small fraction of light through so they cannot show true black, while an inactive OLED element does not produce light or consume power.
* **Response time:** OLEDs can also have a faster response time than standard LCD screens. Whereas LCD displays are capable of between 2 and 8 ms response time offering a frame rate of +/-200 Hz, an OLED can theoretically have less than 0.01 ms response time enabling 100,000 Hz refresh rates.

**LIGHTING**

The existing sources of light are inefficient. At present, only about 30% of the energy consumed for general illumination is used to generate light; the rest is wasted as heat. Incandescent lamps, light bulbs, consume 45% of all the lighting energy and yet produce only 14% of light, measured in lumens. About 90% of the energy goes to the production of heat. Fluorescent lamps are about four times more energy efficient, but still, a significant fraction of the used energy is wasted. Other sources of light, halogen lamps, high intensity discharge lamps, have only a limited use and are not much more efficient than the fluorescent lamps. Not much progress has been made in the energy efficiency of all the conventional sources of light within the past 30 - 50 years. These sources have reached the technological maturity, and little can be done to make them more efficient. Therefore, new lighting technologies are desirable and necessary. One of the new lighting technologies which emerged within the past two decades and has the potential of becoming more energy-efficient then the existing light sources, is the Solid State Lighting technology of Organic Light Emitting.

OLEDs will eventually displace area (distributed)sources such as fluorescent lamps, but in many applications also incandescent lamps.OLEDs will also create new lighting possibilities by enabling large area illumination sources, panels, ceilings, walls, partitions, fabrics etc.OLEDs have all the attributes to effectively compete with incandescent and fluorescent lighting, because they will

\* be much more energy efficient,

\* generate pleasing white light with high CRI (Color Rendition Index),

\* enable "designer color" on demand,

\* provide new design opportunities for architects.

There are still many technical obstacles that have to be overcome before OLEDs become a viable alternative to fluorescent and incandescent lighting.

**Problems with OLED** 

OLED seems to be the perfect technology for all types of displays, but it also has some problems:

* **Lifetime** - While red and green OLED films have longer lifetimes (46,000 to 230,000 hours), blue organics currently have much shorter lifetimes (up to around 14,000 hours).
* **Manufacturing** - Manufacturing processes are expensive right now.Its price will come down only after 2012.
* **Water** - Water can easily damage OLEDs hence it must be made waterproof.

**CONCLUSION**

The future for OLEDs looks bright! For conventional displays, OLED will offer a better, clearer picture and lower power consumption. OLED technology will spread far; it will make new displays into previously undeveloped markets. We will see the emergence of transparent and flexible displays.

Transparent displays may finally bring out a useful wearable PC. They should look a lot like the ones that appear in movies. They should be as transparent as glass or plastic. Flexible displays will also come out in the future. These will be mostly used in mobile devices because they offer a smaller size and are more durable. There will be a few other applications for this flexible display that will use the flexibility of the display.

OLEDs are not without their problems. There aren’t a lot, but the lifetime is something to consider. The red and green organic materials are fine; they last roughly 20,000 hours and newer material will last 25,000 hours or more. The problem is the blue organic material. It doesn’t last nearly as long. Buying an OLED now will result in your buying another one real soon. Research is being done on the blue OLED, and progress is coming slowly but surely. The question is how long we will have to wait for the blue material to catch up. PHOLED research leads to the same result; the blue organic material still has a smaller lifespan than the rest. While OLEDs aren’t perfect yet, they still offer a bright future for displays.

**REFERENCE**

* Antoniadis, Homer, Ph.D. "Overview of OLED Display Technology." Osram Optical Semiconductors.
* Howard, Webster E. "Better Displays with Organic Films." Scientific American.
* Wikipedia Encyclopedia
* Universal Display Corporation: Technology
* S M Kelly , “ Flat Panel Displays”.