ORGANIC LIGHT EMITTING DIODE (OLED)

Abstract:

Organic light-emitting diodes (OLEDs) operate on the principle of converting electrical energy into light, a phenomenon known as electroluminescence. They consist of emissive electroluminescent layer comprised of a film of organic compunds (carbon, hydrogen and oxygen). In its simplest form, an OLED consists of a layer of luminescent material sandwiched between two electrodes. When an electric current is passed between the electrodes, through the organic layer, light is emitted with a color that depends on the particular material used.

When OLEDs are used as pixels in flat panel displays they have some advantages over backlit active-matrix LCD displays - greater viewing angle, lighter weight, and quicker response. Since only the part of the display that is actually lit up consumes power, the most efficient OLEDs available today use less power.

Based on these advantages, OLEDs have been proposed for a wide range of display applications including magnified micro displays, wearable, head-mounted computers, digital cameras, personal digital assistants, smart pagers, virtual reality games, and mobile phones as well as medical, automotive, and other industrial applications.

Key Words:

- **OLED:**

  An organic light-emitting diode (OLED), also Light Emitting Polymer (LEP) and Organic Electro-Luminescence (OEL), is any light-emitting diode (LED) whose emissive electroluminescent layer is comprised of a film of organic compounds. The layer usually contains a polymer substance that allows suitable organic compounds to be deposited. They are deposited in rows and columns onto a flat carrier by a simple "printing" process. The resulting matrix of pixels can emit light of different colors.
- **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.

Conclusion: LED is gaining immense application in day to day . OLED is a miniaturized LED which will be used for extended visual applications.

INTRODUCTION

For the past forty years inorganic silicon and gallium arsenide semiconductors, silicon dioxide insulators, and metals such as aluminum and copper have been the backbone of the semiconductor industry. However, there has been a growing research effort in “organic electronics” to improve the semiconducting, conducting, and light-emitting properties of organics (polymers, oligomers) and hybrids (organic–inorganic composites) through novel synthesis and self-assembly techniques. Performance improvements, coupled with the ability to process these “active” materials at low temperatures over large areas on materials such as plastic or paper, may provide unique technologies and generate new applications and form factors to address the growing needs for pervasive computing and enhanced connectivity.

If we review the growth of the electronics industry, it is clear that innovative organic materials have been essential to the unparalleled performance increase in semiconductors, storage, and displays at the consistently lower costs that we see today. However, the majorities of these organic materials are either used as sacrificial stencils (photoresists) or passive insulators and take no active role in the electronic functioning of a device. They do not conduct current to act as switches or wires, and they do not emit light.

The ability of chemists to optimize the properties of the organic materials described above has provided key contributions to the growth of the electronics industry. However, it is possible in the near future we may reach the limits of performance improvements in silicon devices, magnetic storage, and displays that can be provided at a reasonable cost. As in the past, basic research on materials may provide a path to new product form factors.

So nontraditional materials such as conjugated organic molecules, short-chain oligomers, longer-chain polymers, and organic–inorganic composites are being developed that emit light, conduct current, and act as semiconductors. The ability of these materials to transport charge (holes and electrons) due to the π-orbital overlap of neighboring molecules provides their semiconducting and conducting properties. In addition to their electronic and optical properties, many of these thin-film materials possess good mechanical properties (flexibility and toughness) and can be processed at low temperatures using techniques familiar to the semiconducting and printing industries, such as vacuum evaporation, solution casting, ink-jet printing, and stamping. These properties could lead to new form factors in which roll-to-roll manufacturing could be used to create products such as low- cost information displays on flexible plastic, and logic for smart cards and radio-frequency identification (RFID) tags.

Similar enhancements in performance have been seen in the development of organic light-emitting diodes (OLEDs). Pioneering work was done at Eastman Kodak in 1987 on evaporated small molecules and at Cambridge University in 1990 on solution-processed semiconducting polymers. Currently, the highest observed luminous efficiencies of derivatives of these materials exceed that of incandescent lightbulbs, thus eliminating the need for the backlight that is used in AMLCDs.

The electronic and optical properties of these “active” organic materials are now suitable for some low-performance, low-cost electronic products that can address the needs for lightweight portable devices for the 21st century.

ORGANIC ELECTRONICS

Organic electronics, or plastic electronics, is a branch of electronics that deals with conductive polymers, plastics, or small molecules. It is called 'organic' electronics because the polymers and small molecules are carbon-based, like the molecules of living things. This is as opposed to traditional electronics which relies on inorganic conductors such as copper or silicon.

The men principally credited for the discovery and development of highly-conductive organic polymers are Alan J. Heeger, Alan G. MacDiarmid, and Hideki Shirakawa, who were jointly awarded the Nobel Prize in Chemistry in 2000 for the 1977 discovery and development of oxidized, iodine-doped polyacetylene.

Since these organic materials and hybrids are polycrystalline, it will be difficult to achieve the mobility of the single-crystal silicon used in high-performance microprocessors. Measurements on single organic crystals of p-type pentacene and an n-type perylene which mark the upper boundary of performance show mobility's of 2.7 $cm^2V^{-1}s^{-1}$ and 5.5 $cm^2V^{-1}s^{-1}$—orders of magnitude lower mobility than single-crystal silicon. However, the organic–inorganic perovskites have demonstrated a Hall mobility of 50 $cm^2V^{-1}s^{-1}$, providing a possible path to increased performance.

The majority of these semiconducting organic materials are p-type, transporting holes (h^+) rather than electrons. While this journal issue focuses on p-type materials, n-type systems are also of interest because they enable the fabrication of p–n junctions, and complementary logic. Some examples have recently been reported in the literature.

Further research is needed to improve the mobility and environmental stability of n-type and p-type materials, as well as a fundamental understanding of electron injection, metal contact issues, electron transport, surface modification, and self-assembly. However, organic systems offer a great deal of flexibility in their synthesis, and as chemists develop new materials and learn how to better order and process them, it is hoped that mobility will continue to improve, perhaps reaching the performance of polysilicon and expanding the applications of such materials for low-cost logic chips.

Conductive polymers are lighter, more flexible, and less expensive than inorganic conductors. This makes them a desirable alternative in many applications. It also creates the possibility of new applications that would be impossible using copper or silicon.

New applications include smart windows and electronic paper. Conductive polymers are expected to play an important role in the emerging science of molecular computing.

In general organic conductive polymers have a higher resistance and therefore conduct electricity poorly and inefficiently, as compared to inorganic conductors. Researchers currently are exploring ways of "doping" organic semiconductors with relatively small amounts of conductive metals to boost conductivity.

ORGANIC SEMICONDUCTOR

An organic semiconductor is any organic material that has semiconductor properties. A semiconductor is any compound whose electrical conductivity is between that of typical metals and that of insulating compounds. Both short chain (oligomers) and long chain (polymers) organic semiconductors are known. Examples of semiconducting oligomers are: pentacene, anthracene and rubrene. Examples of polymers are: poly(3-hexylthiophene), poly(p-phenylene vinylene), F8BT, as well as polyaectylene and its derivatives.

There are two major classes of organic semiconductors, which overlap significantly: organic charge-transfer complexes, and various "linear backbone" polymers derived from polyacetylene, such as polyacetylene itself, polypyrrole, and polyaniline. Charge-transfer complexes often exhibit similar conduction mechanisms to inorganic semiconductors, at least locally. This includes the presence of a hole and electron conduction layer and a band gap. As with inorganic amorphous semiconductors, tunneling, localized states, mobility gaps, and phonon-assisted hopping also contribute to conduction, particularly in polyacetylenes. Like inorganic semiconductors, organic semiconductors can be doped. Highly doped organic semiconductors, for example Polyaniline (Ormecon) and PEDOT:PSS, are also known as organic metals.

Organic semiconductors are now-used as active elements in optoelectronic devices such as *organic light-emitting diodes* (OLED), *organic solar cells*, *organic field effect transistors* (OFET), electrochemical transistors and recently in biosensing applications.

OLED:

An organic light-emitting diode (OLED), also Light Emitting Polymer (LEP) and Organic Electro-Luminescence (OEL), is any light-emitting diode (LED) whose emissive electroluminescent layer is comprised of a film of organic compounds. The layer usually contains a polymer substance that allows suitable organic compounds to be deposited. They are deposited in rows and columns onto a flat carrier by a simple "printing" process. The resulting matrix of pixels can emit light of different colors.

Organic Solar Cells:

A solar cell or photovoltaic cell is a device that converts light energy into electrical energy. Compared to silicon-based devices, polymer solar cells are lightweight (which is important for small autonomous sensors), disposable, inexpensive to fabricate, flexible, designable on the molecular level, and have little potential for negative environmental impact.

Organic Field Effect Transistor:

An Organic Field-Effect Transistor (OFET) is a field effect transistor using an organic semiconductor in its channel. OFETs can be prepared either by vacuum evaporation of small molecules, or by solution-casting of polymers or small molecules. These devices have been developed to realize low-cost, large-area electronic products. OFETs have been fabricated with various device geometries. The most commonly used device geometry is bottom gate with top drain- and source electrodes, because this geometry is similar to the thin-film silicon transistor (TFT) using thermally grown Si/SiO_2 oxide as gate dielectric. Organic polymers, such as poly(methyl-methacrylate) (PMMA), can be used as dielectric, too.

In May 2007, Sony Corp. reported the first full-color, video-rate, flexible, all plastic display , in which both, the thin film transistors as well as the light emitting pixels were made of organic materials.

Organic semiconductors are poised to give us flat and even flexible electronics. Light-emission from these materials is particularly promising - when a voltage is applied to a thin film of a semiconducting polymer it gives out light, providing the basis for new display technologies. This could give curved or flexible displays, television screens that can be rolled up or folded like newspapers, light-emitting clothing for fashion or safety applications, even light-emitting wallpaper; the range of applications seems to be limited only by our imagination. Just as remarkable is the way that such devices can be made: it is possible to deposit semiconducting polymers and dendrimers by printing. This will greatly simplify the manufacturing process, increasing flexibility, reducing cost, and opening up new markets.

Organic semiconductors have many advantages, such as easy fabrication, mechanical flexibility, and low cost. Melanin is a semiconducting polymer currently of high interest to researchers in the field of organic electronics in both its natural and synthesized forms.

ORGANIC LED

4.1 Introduction:

An organic light-emitting diode (OLED), also Light Emitting Polymer (LEP) and Organic Electro-Luminescence (OEL), is any light-emitting diode (LED) whose emissive electroluminescent layer is comprised of a film of organic compounds. The layer usually contains a polymer substance that allows suitable organic compounds to be deposited. They are deposited in rows and columns onto a flat carrier by a simple "printing" process. The resulting matrix of pixels can emit light of different colors.

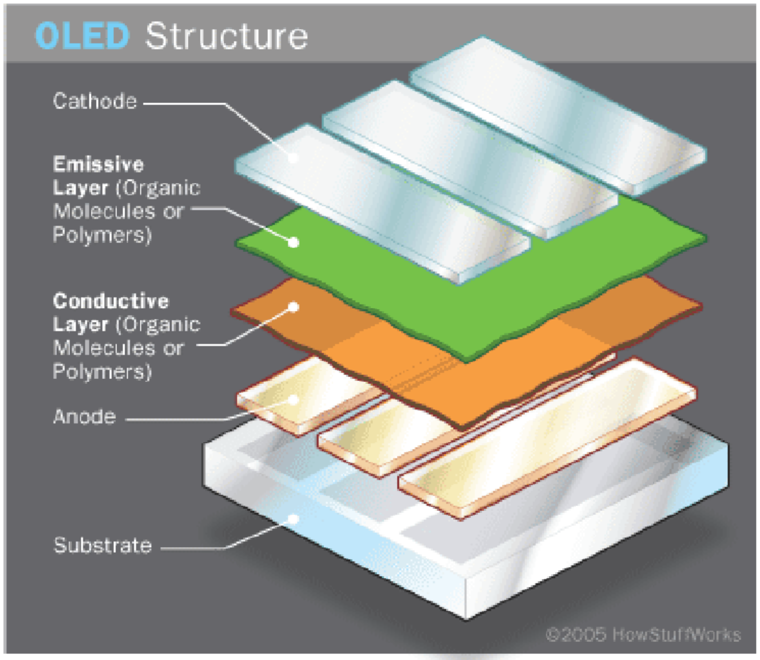
Such systems can be used in television screens, computer displays, portable system screens, advertising, information and indication. OLEDs can also be used in light sources for general space illumination, and large-area light-emitting elements.

Electronically, OLED is similar to old-fashioned LEDs -- put a low voltage across them and they glow. Light-emitting diodes, based upon materials like Gallium Arsenide, Gallium Phosphide, and, most recently, Gallium Nitride, have been around since the late '50s. They are mostly used as indicator lamps, although they were used in calculators before liquid crystals, and are used in large advertising signs, where they are valued for very long life and high brightness. Such crystalline LEDs are not inexpensive, and it is very difficult to integrate them into small high-resolution displays.

OLEDs can provide brighter, crisper displays on electronic devices and use less power than conventional light-emitting diode (LEDs) or liquid crystal displays (LCDs) used today.

4.2 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.



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.

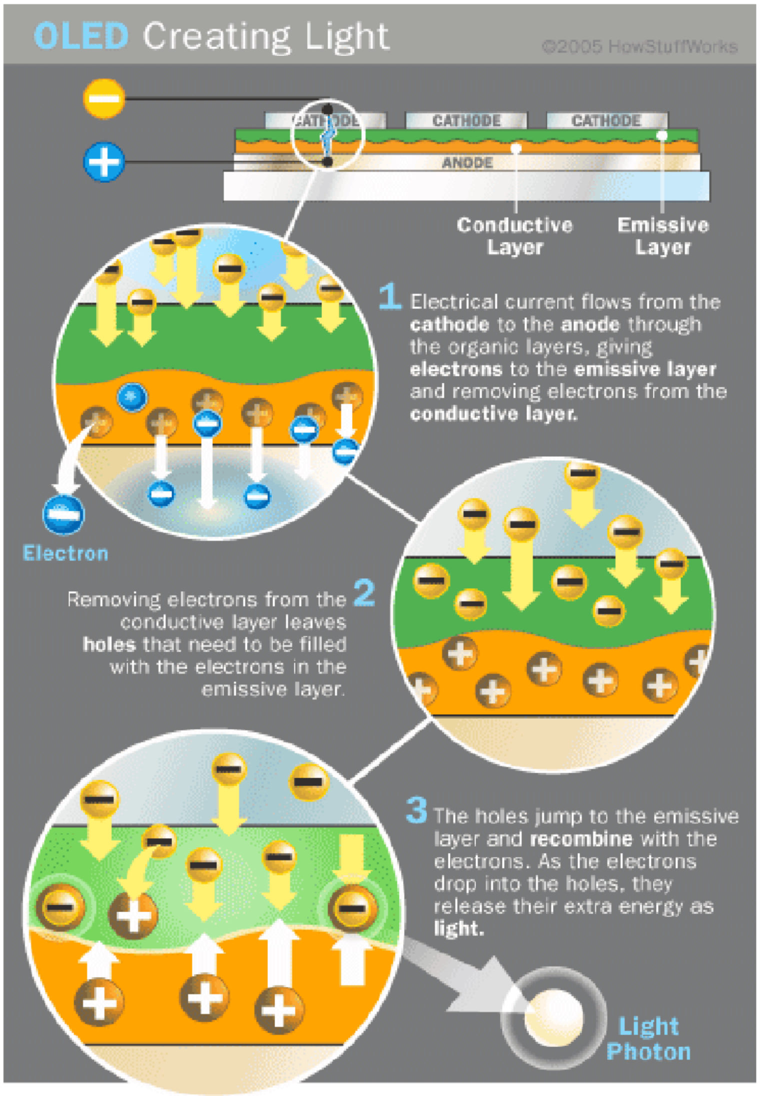
Conducting layer - This layer is made of organic plastic molecules that transport "holes" from the anode. One conducting polymer used in OLEDs is polyaniline.

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.

4.3 How do OLEDs Emit Light?

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



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.**

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.**

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.
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.

4.4 Making OLEDs:

Laboratory set up of a high-precision inkjet printer for making polymer OLED displays

The biggest part of manufacturing OLEDs is applying the organic layers to the substrate. This can be done in three ways:

- Vacuum deposition or vacuum thermal evaporation (VTE) - In a vacuum chamber, the organic molecules are gently heated (evaporated) and allowed to condense as thin films onto cooled substrates. This process is expensive and inefficient.
- Organic vapor phase deposition (OVPD) - In a low-pressure, hot-walled reactor chamber, a carrier gas transports evaporated organic molecules onto cooled substrates, where they condense into thin films. Using a carrier gas increases the efficiency and reduces the cost of making OLEDs.
- Inkjet printing - With inkjet technology, OLEDs are sprayed onto substrates just like inks are sprayed onto paper during printing. Inkjet technology greatly reduces the cost of OLED manufacturing and allows OLEDs to be printed onto very large films for large displays like 80-inch TV screens or electronic billboards.

OLED TYPES

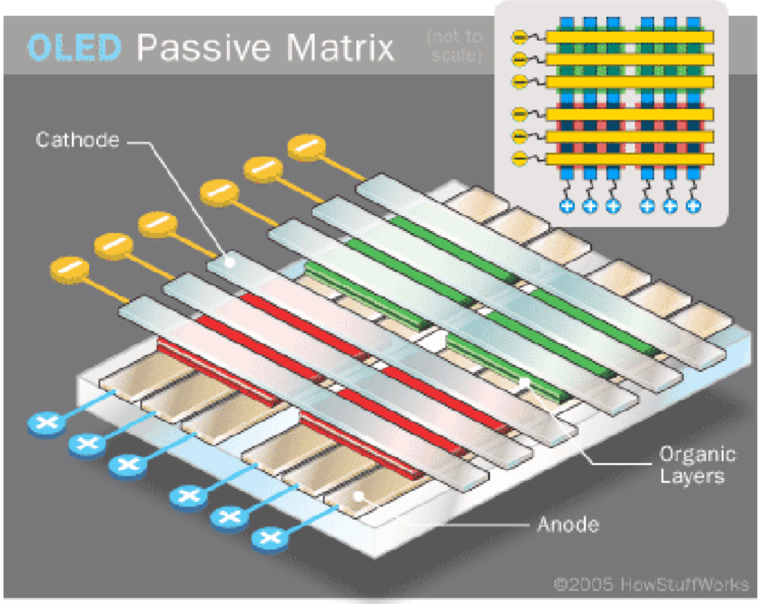
There are several types of OLEDs:

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

5.1 Passive and Active Matrix OLEDs:

Passive-matrix OLED (PMOLED):

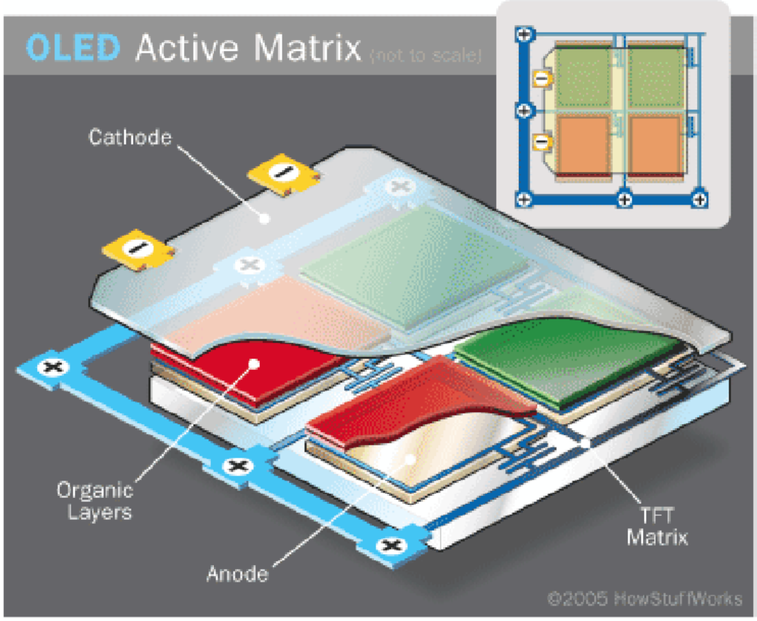
PMOLEDs have strips of cathode, organic layers and strips of anode. The anode strips are arranged perpendicular to the cathode strips. The intersections of the cathode and anode make up the pixels where light is emitted. External circuitry applies current to selected strips of anode and cathode, determining 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.

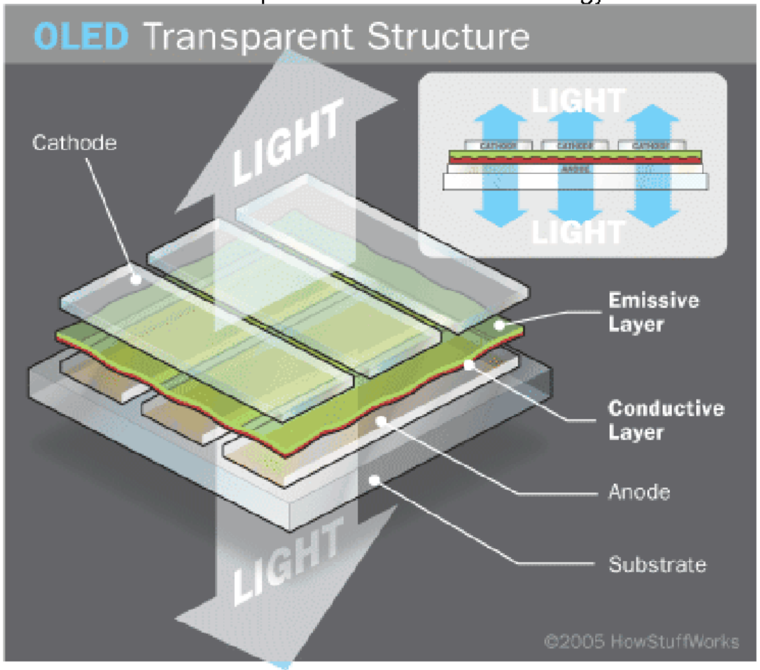


AMOLEDs consume less power than PMOLEDs because the TFT array requires less power than external circuitry, so they are efficient for large displays. AMOLEDs also have faster refresh rates suitable for video. The best uses for AMOLEDs are computer monitors, large-screen TVs and electronic signs or billboards.

5.2 Transparent, Top-emitting, Foldable and White OLEDs:

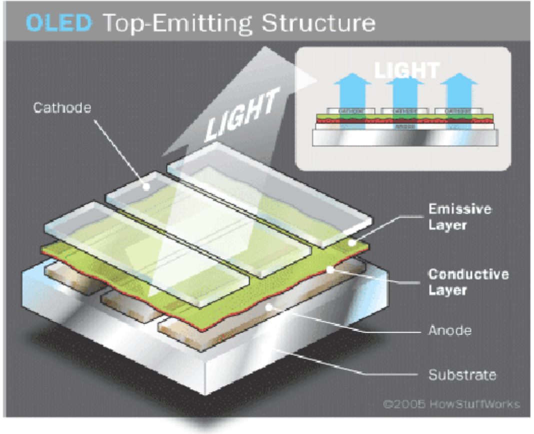
Transparent OLED:

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.



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.



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.

OLED ADVANTAGES AND DRAWBACKS

6.1 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:

- 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.

LCD technology engages a backlight, whereas OLED has no backlighting function. Hence an LCD is not possible to display true black, OLED has a so called off element which produces no light and consumes no power. In general, organic LED technology consumes less power. This is especially useful for devices that are supplied by battery power. As there is no backlighting they can have a thinner form and a more light weighted character.

The manufacturing process of OLEDs is different to those of LCD technology. OLEDs can be printed onto almost any substrate with inkjet printer technology. That is why new applications like displays embedded in clothes or roll-up displays are possible.

Because of the different manufacturing process it is possible to produce OLED displays at a lower cost in comparison to liquid crystal displays (LCDs) or plasma displays.

OLED technology allows an increased brightness and a higher contrast. A wide range of pixel sizes as well as a wide viewing angle are one of the benefits. The viewing angle can be up to 160 degrees. The response time for full motion-video is faster and greyscale is more excellent. Other benefits are low power consumption and low operating voltages between 2 and 10 volts usually. Displays powered by OLED are allowing a broader operating temperature range than traditional displays.

LCD technology is wasting power because the liquid crystal acts as a polarizer which filters out half of the light emitted by the backlight. As mentioned above, OLED hat no backlighting and therefore not this drawback. But there are some other drawbacks we will discuss right now.

6.2 Comparison of different display technologies

We will compare OLED, LCD and CRT and will give pros and cons for each technology.

LCD means liquid crystal display and its technology is widely used in modern television screens or computer displays. LCDs are non-organic and non-emissive devices, that means they do not produce any form of light. They just pass or block light reflected from an external light source. This is called a backlighting system. Because of this backlighting system LCDs are consuming more power than OLED displays.

OLED displays consume much less power, simply because no backlighting is needed. In addition, they have a higher contrast and are brighter than LCDs. OLED allows thinner, lighter and more flexible designs, the viewing angle is wider (up to 160 degrees and above). This is because they produce there own light, whereas LCDs need a backlight.

CRT means cathode ray tube. It is the old traditional technology used in computer or television screens. A cathode ray tube is like an electronic vacuum tube employing a focused beam of electrons. Displays with CRT technology are cheap to produce and have a wide viewing angle. Manufacturing of LCDs is more cost-intensive than producing CRTs, but the power consumption is lower and the smaller design allows thinner products. LCDs are emitting fewer electromagnetic emissions than CRTs.

OLED seems to be the perfect technology, but there are also some disadvantages we want to mention. The lifetime is limited, especially those of blue organics. Manufacturing is at this time more cost-intensive than producing LCDs. Water can easily damage OLEDs, so complex sealing is necessary.

Despite these small disadvantages OLED is emerging the new technology for thin panel displays.

6.3 Drawbacks:

The biggest technical problem for OLEDs is the limited lifetime of the organic materials. In particular, blue OLEDs typically have lifetimes of around 5,000 hours when used for flat-panel displays, which is lower than typical lifetimes of LCD, LED technology – each currently rated for about 60,000 hours, depending on manufacturer and model. But in 2006 experiments found that it is possible to swap the chemical component for a phosphoresent one, if the subtle differences in energy transitions are accounted for, resulting in lifetimes of up to 20,000 hours for blue PHOLEDs.

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.

OLED APPLICATIONS

7.1 Current OLED Applications:

OLED technology is already used in some devices. Most of them are cellular phones or portable music players, but also other products use this new technology.

Cellular/mobile phones

There are many mobile phones that use OLED displays. Samsung has several models like the SGH-E700, E715 or E730. All these models use an external OLED screen with different resulutions (64 x 96, 96 x 96 pixels) and different color depths (either 256 colors or 65k colors). The Samsung SGH-X120 uses a main OLED screen with 128 x 128 pixels.

The S88 phone from BenQ-Siemens uses a two inch active-matrix OLED display with about 262k colors and 176 x 220 pixels. LG Electronic offers several mobile phones with an OLED technology. LG LP4100 has an external display powered with the new technology. LG's model VX8300 has an organic light-emitting diode display with 262,000 colors and a resolution of 176 x 220 pixels.

Other mobile phone manufacturers like Motorola, Nokia, Panasonic or SonyEricsson are also using organic light emitting diodes for their external displays.

MP3 players

MobiBLU ships an mp3 player that features an OLED display, the DAH-1500i model. The popular Creative Zen Micro has also an organic LED display with 262k colors. The Sony NW-A3000 and NW-A1000 both have an OLED display. The Zen Sleek music player from Creative has a new 1.7 inch organic LED display. The Gigabeat audio player from Toshiba features also an OLED screen.

Digital cameras

The Kodak EasyShare LS633 is the world's first digital camera with an organic LED display. The Sanyo Xacti HD1 is a high definition camera that features an OLED display. Other digital cameras with an OLED screen are from Hasselblad (H2D-39 and 503CWD for example).

Photo Courtesy HowStuffWorks Shopper

Kodak LS633 EasyShare with 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.

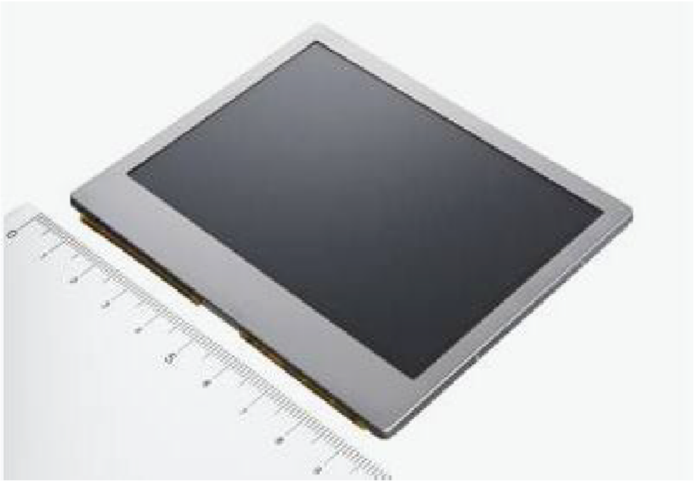


Photo courtesy Sony Corporation

OLED display for Sony Clie

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

Sony 11-inch XEL-1 OLED TV:

In October 2007, Sony announced that it would be the first to market with an OLED television. The XEL-1 will be available in December 2007 for customers in Japan. It lists for 200,000 Yen -- or about $1,700 U.S.

Front Back Left Side Remote Controller

Photo Courtesy Sony

the Sony 11-inch XEL-1 OLED TV.

Main Features of "XEL-1":

Thinness: Proposes new TV form factor measuring approximately 3mm thinness (at its thinnest point)

As OLEDs are light-emitting, there is no need for a separate light source such as a backlight system. Sony's "Organic Panel" consists of an organic material layer of just several hundred nanometers thickness, with two extremely thin glass panels aligned on either side of the organic material layer. This realizes a new TV form factor measuring approximately 3mm at its thinnest point.

High contrast: Reproduces realistic images using exquisite shades of black and flexible control of color tone and gradation

With its light-emitting structure, the OLED display can prevent light emission when reproducing shades of black, enabling "XEL-1" to reproduce very deep blacks (contrast ratio 1,000,000:1).

Furthermore, XEL-1 can control all the phases of light emission from zero to peak brightness, generating color expression and subtleties conventional displays cannot match.

High peak brightness: Faithfully reproduces picture glow

"Super Top Emission," a technology unique to Sony and incorporated in its "Organic Panel" has a high aperture ratio which allows for efficient light emission from the organic materials, realizing high peak brightness. This enables "XEL-1" to faithfully reproduce light flow such as reflections of sun light or camera flashlights through the image reproduced on the display.

Excellent color reproduction: Delivers pure and vivid colors in both dark and bright images

In order to use OLED to generate the full spectrum of Sony's TV color requirements, Sony developed its own proprietary organic materials, with bright coloration. In addition, the micro-cavity structure of "Super Top Emission" and the color extracting technology within its embedded color filter enable "XEL-1" to reproduce natural colors beautifully. As a result, the fresh colors of ripe fruit and shades of deep cobalt blue can be stunningly reproduced. The "Organic Panel" can also sustain its color reproduction capability in scenes of diminished brightness, enabling "XEL-1" to faithfully recreate even dark movie scenes using the colors that were originally intended.

Rapid response time: Smoothly reproduces fast moving images such as sports scenes

Since OLED can spontaneously turn the light emitted from the organic material layer on and off; OLED is capable of very rapid response times. Newly developed OLED drive circuits enable "XEL-1" to reproduce fast moving images such as sports scenes smoothly and naturally.

Low power consumption

OLED does not require a separate light source due to its light-emitting structure, therefore it can be powered using very low voltages. This means that OLED TVs consume extremely low levels of power compared with other display devices. The power consumption of "XEL-1" is as low as 45W.

7.2 Future Applications:

Research and development in the field of OLEDs is proceeding rapidly and may lead to future applications in heads-up displays, automotive dashboards, billboard-type displays, home and office lighting and flexible displays. Because OLEDs refresh faster than LCDs -- almost 1,000 times faster -- a device with an OLED display could change information almost in real time. Video images could be much more realistic and constantly updated.

OLED keyboard

A Russian company has showed a prototype of an OLED keyboard. The keys are displayed with OLED technology. Thus the whole keyboard is highly configurable. The position, appearance and function of the keys are switchable. In addition, the keyboard looks awesome because of its LEDs.

The keys can display icons as well as regular symbols. Its possible to associate keys with mathematical functions, HTML codes or other special characters. It is also possible to configure a gaming keyboard layout for first-person shooters, strategy games or other purposes. There are preconfigured layouts for Quake, Photoshop and other mainstream games and applications.

Windows that light-up at dark:

It is true, this could be possible with OLED. This is because organic light emitting diodes can be transparent. A window could act as a normal window at day, but at night it can be used as a light resource. This vision can replace the boring old bulb in the middle of every room. It is getting even better: nearly every surface can become a lighting source. It does not matter if its curved or flat - OLED sheets are flexible and ultra-flat.

OLEDs can mimic a natural feeling of light in the dark. If turned off, they are transparent - an ideal precondition for windows. It is also imaginable that tables, cupboards or other furniture are used as a light source.

The problem is (as in general for OLED) the fast burnout of the blue component. Blue is one of the major colors needed to make white light. Physicist are working to resolve this problem.

The newspaper of the future might be an OLED display that refreshes with breaking news and like a regular newspaper, you could fold it up when you're done reading it and stick it in your backpack or briefcase.