Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

A New Generation of Organic Light-EmittingDisplays-OLED

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ABSTRACT:

Gradually as per advancements in this modern world, many changes came into the field of display devices. First came the small LED (Light Emitting Diode) display which shows numeric contain then after jumbo CRT (cathode ray tubes) which is used today also but due bulkiness we do not carry from one place to another and also required large area. Then after came LCD (Liquid crystal display) which is lighter and easy to carry, but the main problem with LCD is that it cannot seen clear picture from different angles. This all problem will be overcome by revolutionary discovery of OLED (Organic Light Emitting Diode). OLEDs can be fabricated using Polymers or by small molecules in the flat panel display zone unlike traditional Liquid- Crystal Displays. OLEDs are self-luminous& do not required any kind of backlighting. This eliminates the need for bulky & environmentally undesirable mercury lamps and yields a thinner, more compact display. Unlike other flat panel displays OLED has a wide viewing angle (up to 160 degrees), even in bright light. Their low power consumption (only 2 to 10 volts) provides for maximum efficiency and helps minimize heat and electric interference in electronic devices. These are Cheaper, Sharper, Thinner, and Flexible.

KEYWORDS:

- OLED – Organic Light Emitting Diode
- LCD – Liquid Crystal Display
- LED – Light Emitting Diode
- CRT – Cathode Ray Tube

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1. INTRODUCTION

An **Organic Light-Emitting Diode (OLED)** is a light-emitting diode (LED), in which the emissive electroluminescent layer(**Electroluminescent** Displays (ELDs) are a type of Flat panel display created by sandwiching a layer of electroluminescent material such as GA As between two layers of conductors. When current flows, The layer of material emits radiation in the form of visible light) is a film of organic compound that emits light in response to an electric current. OLED's are used to create digital displays in devices such as television screens, computer, portable systems such as mobile phones, handheld game consoles and PDAs. A major area of research is the development of white OLED devices for use in solid-state lighting applications.

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. OLED displays can use either passive-matrix (PMOLED) or active-matrix (AMOLED) addressing schemes. Active-matrix OLEDs (AMOLED) require a thin-film transistor backplane to switch each individual pixel on or off, but allow for higher resolution and larger display sizes.

An OLED display works without a backlight; thus, it can display deep black levels and can be thinner and lighter than a liquid crystal display (LCD). In low ambient light conditions (such as a dark room), an OLED screen can achieve a higher contrast ratio than an LCD, regardless of whether the LCD uses cold cathode fluorescent lamps or an LED backlight.

2. CONSTRUCTION

A typical OLED is composed of a layer of organic materials situated between two electrodes, the anode and cathode, all deposited on a substrate. The organic molecules are electrically conductive as a result of delocalization of pi electrons caused by conjugation over part or the entire molecule. These materials have conductivity levels ranging from insulators to conductors, and are therefore considered organic semiconductors. The highest occupied and lowest unoccupied molecular orbital's (HOMO and LUMO) of organic semiconductors are analogous to the valence and conduction bands of inorganic semiconductors.

Originally, the most basic polymer OLEDs consisted of a single organic layer. One example was the first light-emitting device synthesized by J. H. Burroughs et al., which involved a single layer of poly. However multilayer OLEDs can be fabricated with two or more layers in order to improve device efficiency.

As well as conductive properties, different materials may be chosen to aid charge injection at electrodes by providing a more gradual electronic profile, or block a charge from reaching the

opposite electrode and being wasted. Many modern OLEDs incorporate a simple bilayer structure, consisting of a conductive layer and an emissive layer.

OLED Structure

OLED structure has many **thin** layers of organic material. These OLEDs compose of aggregates of Amorphous and crystalline molecules arranged in irregular pattern. When current passes through these **thin** layers, light gets emitted from their surface by a process of electro phosphorescence.

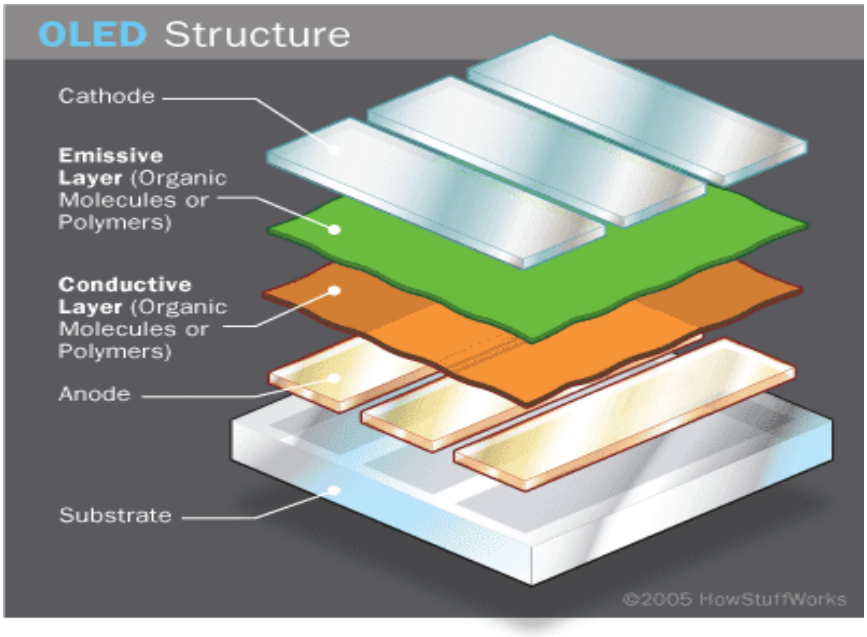

Fig. No. 1:"Structure of OLED"

3. OLED WORKING:

During operation, a voltage is applied across the OLED such that the anode is positive with respect to the cathode. Anodes are picked based upon the quality of their optical transparency, electrical conductivity, and chemical stability. A current of electrons flows through the device from cathode to anode, as electrons are injected into the LUMO of the organic layer at the cathode and withdrawn from the HOMO at the anode. This latter process may also be described as the injection of electron holes into the HOMO. Electrostatic forces bring the electrons and the holes towards each other and they recombine forming an exaction, a bound state of the electron and hole. This happens closer to the emissive layer, because in organic semiconductors holes are generally more mobile than electrons. The decay of this excited state results in a relaxation of the energy levels of the electron, accompanied by emission of radiation whose frequency is in the visible region. The frequency of this radiation depends on the band gap of the material, in this case the difference in energy between the HOMO and LUMO.

When a DC bias is applied to the electrodes, the injected electrons and holes can recombine in the organic layers and emit light of a certain colour depending on the properties of the organic material. Since charge carrier transport in organic semiconductors relies on individual hopping processes between more or less isolated molecules or along polymer chains, the conductivity of organic semiconductors is several orders of magnitude lower than that of their inorganic counterparts. Before actually decaying radioactively, an electron-hole pair will form an exaction in an intermediate step, which will eventually emit light when it decays.

Depending on its chemical structure, a dye molecule can be either a fluorescent or a phosphorescent emitter. Only in the latter, all exactions – singlet's and triplets – are allowed to decay radioactively. In the former, however, three quarters of all excites – the triplet excites – do not emit any light. Fluorescent emitters therefore have a maximum intrinsic efficiency of only 25 % and their application is avoided if possible. However, up to now, the lifetimes of phosphorescent emitters, especially at a short wavelength (blue), are inferior to those of fluorescent ones.

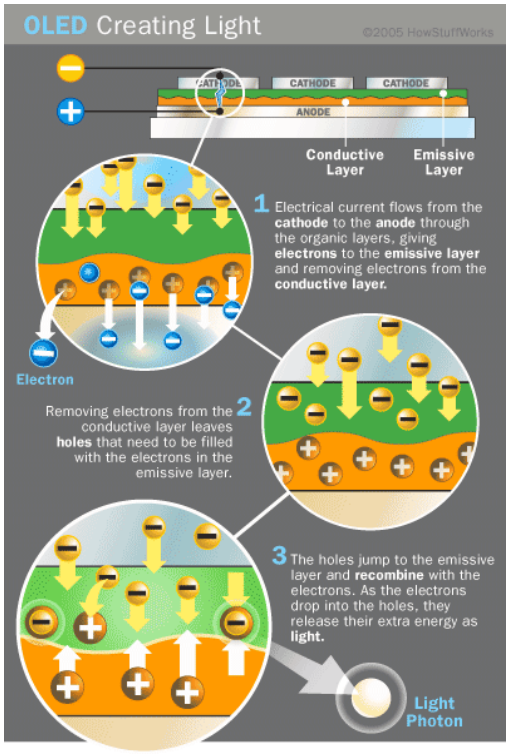

Fig. No. 2: "WORKING OF OLED"

Table No. 1. : "Technical Characteristics"

Energy Efficiency	: 180 lm/Wt
Current Efficiency	: 40 cd/A
Internal Quantum Efficiency	: 100%
External Quantum Efficiency (Illuminated photon/Formed photon)	: 40%
Operating Voltage	: 5 - 8 V
Inclusion Voltage	: 3 - 9 V
Angle of View	
Brightness	: 1000 cd/m²
Contrast	: 100:1
Life Time	: 6 - 11 years
Temperature Range	: -40…+50 oC

4. TYPES OF OLED:

There different types of OLED available at the moment and all of them are designed for a different aim. Types are the below:

a. ***Passive Matrix OLEDs (PMOLEDs):*** They have strips of cathode, organic layers and stripes of anode. Anode and cathode stripes are placed perpendicular each other. Pixels are generated at the region where cathode and anode are intersected with the emitted light. A current is applied to some strips of cathode and anode to determine pixels whether on or off. Also this amount of this current affects the brightness. Although this type of OLED is easy to produce; compared to others, they consume more power which is because of the supplied current. However power consumption is still less than LCDs and they are suitable for text or icon based small screens around 2-3 inches. For instance, some cell phones and MP3 players have this type of OLEDs.

b. ***Active Matrix OLEDs (AMOLEDs):*** They have full layers of cathode, organic molecules and anode. However there is a thin film transistor (TFT) which forms a matrix on the anode layer. This array sets pixels on or off to generate an image. This type consumes power less than PMOLEDs just because TFT array therefore AMOLEDs are preferred in large displays. Large screen TV's, monitors and billboards are some products that this type is used.

c. ***Top-emitting OLEDs:*** They have opaque or reflective substrates. They have mostly active matrix design since it fits best. This type is used in smart cards.

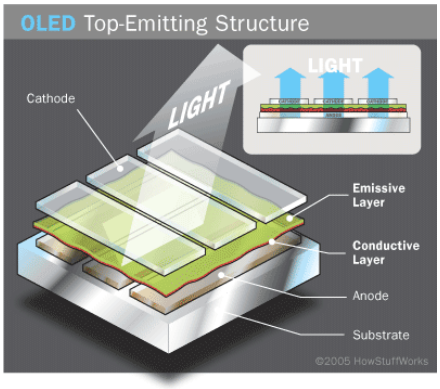

Fig. No. 3:Structure of Top Emitting OLED

d. Foldable OLEDs: Very flexible metallic foils or plastics are used on the substrate of foldable OLEDs. They are very light and strong. They are used in cell phones thus products will be stronger for breakage issues. Other areas that this type used can be integrated computer chips and GPS devices.

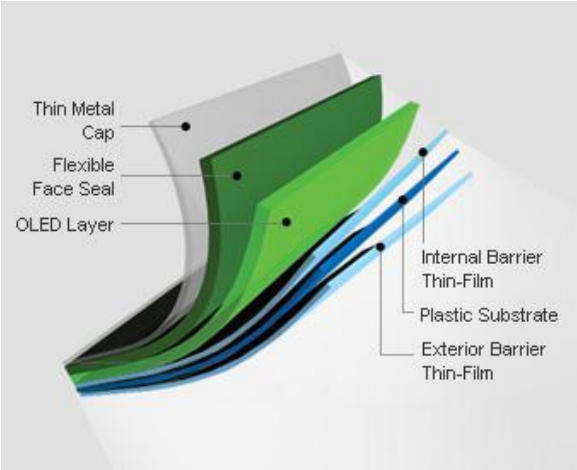

Fig.No. 4:"Structure of Foldable OLED"

e. White OLEDs: White light is emitted in this type and it generates a brighter light. Also it is more uniform and more energy efficient than regular fluorescent lights. This type has the true-color characteristics of incandescent lighting. Therefore it is possible to be replaced with fluorescent lights that we currently use because of the economy OLEDs provide.

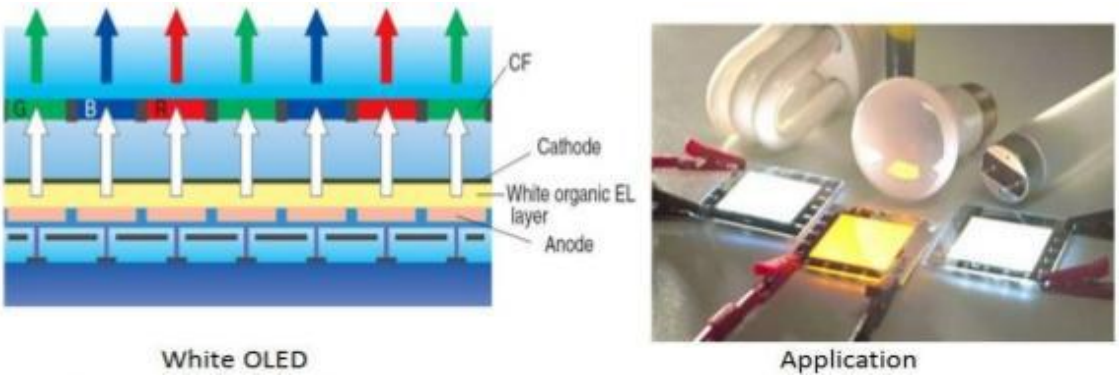

Fig. No. 5:"Structure of White OLED"

5. COMPARISON

5.1Comparison of LCD & OLED

The exception is **OLED**. Televisions based on Organic Light Emitting Diode display technology are fundamentally different from **LCD** TVs. The most basic **difference** is that each pixel provides its own illumination, while all of the pixels in an **LCD** TV are illuminated by an LED backlight.

Table No. 2: "Comparison of LCD & OLED"

Display technique	LCD	OLED
Technological type	Back light/LED	Self-illumination
Contrast ratio	5000:1	Infinite
Lifetime	Medium	Medium
Operating temperature (In degree Celsius)	-40 to 100	-30 to 85
Cost	Low	Medium
PPI	Max 250ppi	Max 300ppi
Viewing angle	Low	Higher than LCD

5.2 Comparison Between LED & OLED:

With **OLED**, the colors do not get washed out when viewers watch from extreme angles. **OLED** offers the ability to develop lighter and thinner displays than **LED** screens do. **OLED** screens are more energy efficient when **compared** to their **LED** counterparts. **LED**, LCDs and **OLED** ties in terms of resolution, lifespan, and burn-in.

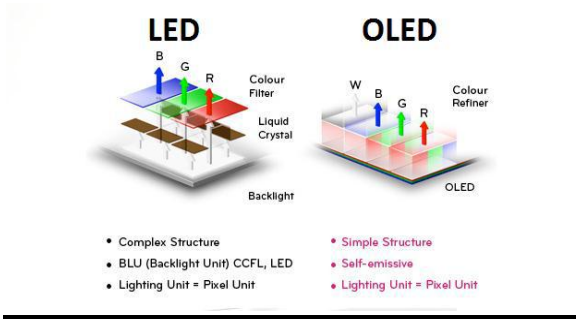

Fig.No. 6: "Comparison of LED & OLED"

6. SUMMARY ON OLED

6.1 Advantages of OLED:

1. OLED's are biodegradable.
2. OLED's are thinner, lighter and more flexible compared to the crystalline layers in LCD's or LED's.
3. OLED's are flexible, they can be folded and rolled up as in the case of roll-up displays embedded in textiles. This is because the substrate used in OLED is plastic rather than the glass used for an LCD or an LED.
4. OLED's are brighter than LEDs. They have greater artificial contrast ratio. Because the organic layers of an OLED is much thinner than the corresponding inorganic crystal layers of an LED, the conductive and emissive layers of an OLED can be multi-layered and does not require glass which absorbs some part of light.
5. An OLED does not require backlight as in the case of an LCD. This in turn reduces the power consumption by an OLED. LCD's requires illumination to produce visible image which requires more power, whereas OLED's generate its own light.
6. Process of producing an OLED is easier and it can be made into large thin sheets. It is much more difficult to grow so many liquid crystal layers.
7. OLED's have wider viewing angles compared to LCD's as an OLED pixel emits light directly. OLED pixel colors are not shifted as we change the angle of observation to 90° from normal.
8. An OLED has much faster response time compared to an LCD.

6.2 Disadvantages:

1. Lifespan: Lifetime of an OLED is lesser than LCD. Red and green OLED films have longer lifetimes (46,000 to 230,000 hours), blue OLED's currently have much shorter lifetimes (up to around 14,000 hours)[3].
2. Material used in OLED to produce blue light degrades faster than materials producing other colors this causes reduction of overall luminescence.
3. Interaction of OLED with water causes instant damage.
4. OLED uses three times more power to display an image with white background, usage of white background leads to reduced battery life in mobile devices.

6.3 Applications of OLED:

OLED's are currently being used in developing small screen devices such as cell phones, PDA's, DVD players and digital cameras. Its ability to be foldable and flexible makes it weight and

space saving technology.High transmission speed of OLED's can be used in visible optical communications. The communication field is limited near the emitting area of an OLED, resulting in a safe data transmission.

OLED's are also used in multiple-input/multiple-output (MIMO) wireless optical channels. OLED's are emissive transmitters printed on flexible sheets of plastic. High transmission speed of OLED's can be used in visible optical communications. The communication field is limited near the emitting area of an OLED, resulting in a safe data transmission.

7. CONCLUSION AND FUTURE POSSIBILITIES

A great progress has been made in the field of organic electronics and devices in terms of synthesis, development and applications of electron transport materials to improve the performance of OLED's. The effectiveness of the OLED device is governed by three important processes: charge injection, charge transport and emission. Light emission through phosphorescent dyes has been utilized in OLEDs and gives good results. OLEDs have achieved long operational stability. The performance of OLEDs meets many of the targets necessary for applications in displays.

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. OLEDs refresh faster than LCDs (almost 1,000 times faster). A device with an OLED display changes information almost in real time. Video images could be much more realistic and constantly updated. 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.

Achieving higher data rate, such as 10-15 Mbit/s, so that OLED can be adopted in standard 10BASE-T Ethernet communications. Working with the manufacturers to improve the device response time (newer display has faster response and wider dynamic contrast range). The newspaper of the future might be an OLED display automotive dashboards, billboard-type displays, home and office lighting.

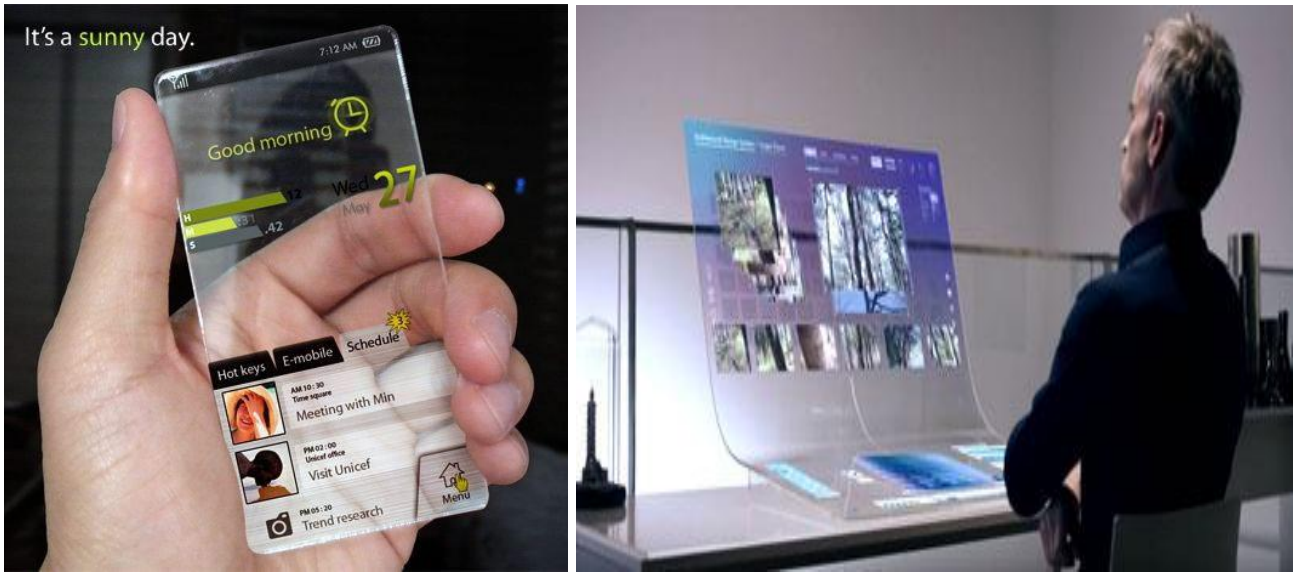

Fig.No. 7:"Example of Future OLEDS"

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