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OLED – An Imminent Technology

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Abstract— Thinking about the statement 'Everything Is Just A Touch Away', becomes real when we talk about the shimmering OLED Technology. OLED is one of the most recent, upcoming and promising next-generation lighting technologies. It has taken over the world of LCDs and LEDs. OLED is an Organic Light Emitting Diode. OLED lighting panels are a thin device that emits uniformly distributed light over their surface. They can be made flexible and transparent. This paper focuses on a general discussion about the history of OLED and its evolution. The working is explained in a simplified manner without going into the deep details. This paper also focuses on the present as well as future aspects of OLEDs. Some advantages and disadvantages of OLEDs are also mentioned. In the end, the advancement ideas and development aspects are discussed in brief.

Keywords— OLED, LED, Display, Electrons, Panel, Diode, Applications

INTRODUCTION

OLED is a new promising technology that is gathering pace in the market because of its brilliant features. OLED's full form is Organic Light Emitting Diode. OLED displays have entered the market in the form of electronic equipments such as digital cameras, mobile phones, console games and radio displays. OLED displays have high switching speed that leads to high refresh rate and helps full motion videos to work properly. Due to the simple construction and polymer material, the cost of production reduces in OLED manufacture. Examples of thin displays start from Sony's first production XEL-1 with 3 mm thick screen that now has gone to 0.3 mm thick. In theory, these displays can be rolled up like real paper and can be hung on a wall using some adhesive [1]. The self luminescence property of OLED helps to bring bright real colours. OLED displays are being used in the mobile handsets as well. Day by day, the production cost of OLED screens is increasing. In June 2008, Samsung was one of the first companies to announce a $55 million investment for 2 inch OLED screen. OLED is a thin film solid state device [2]. It is basically an LED (Light Emitting Diode), in which the organic compound is used as emissive electroluminescent layer. When electric current passes through this compound, light is generated. There are two types of OLEDs:

a) OLED with small molecules
b) OLED with polymers

The OLED displays can be either active or passive.

AMOLED (Active Matrix Organic Light Emitting Diode) is a display technology which is being used in Television and display phones. The AMOLED display contains active matrix of OLED pixels. When electric current is passed, these pixels generate light. The TFT (Thin Film Transistor) works as switches that controls the flow of current to individual pixel. At each pixel level, at least two TFTs control the flow of current. One of the TFTs is used for the process of starting and stopping of the capacitor charger and other to give constant current. Super AMOLED is the term given by the Samsung that means that touch is integrated in the screen itself. Minimum sunlight is reflected by these screens. The future perspective of AMOLED is the transparent Super AMOLED Plus which will be flexible, 3D and unbreakable. In this, the substrate used is a polymer, so there is no need of glass cover or metal backing.

PMOLED (Passive-Matrix OLED), controls each row of display turn by turn. It does not contain storage capacitor, so they are not aligned most of the time. So, more voltage is required for brighter look. They are not efficient, have a short lifetime and suffer from less resolution and size [3]. OLED display does not require a backlight. So, it displays crisp images and deep black levels. OLEDs are thinner and lighter as compared to LCDs. Multi pixel colour display OLED have many remarkable applications. Single pixel form is being used by many lighting manufacturers in Europe like OSRAM and Philips.

HISTORY

The electroluminescence in organic compound was first observed by Andre Bernanose and his co-workers in France. In the experiment, they applied AC voltage to acridine orange. This lead to direct excitation of electrons those emitted light. Later in 1960, Martin Pope used DC voltage and vacuumed area on pure single crystal of anthracene for the production of electroluminescence. They described the need for holes and electron injecting electrode contacts. This was taken as a base for charge injection in all modern OLEDs. In 1965, pope proposed that electroluminescence in antracene crystal was due to reunion of electron and hole and the conductivity of antrascene was high in absence of external electric field. In 1965, W Helfrich and WG Schneider generated double injection recombination electroluminescence in anthracene using hole and electron injecting electrode. Polymer was first used for electroluminescence by Roger Partridge. Ching W Tang and Steven Van Slyke discovered the first diode device. The structure of this device consisted of two layers: one layer consisted of hole transporting and the other layer had electron transporting. In this paper, the emission of light and reunion took place in the middle of organic layer. As a consequence, it leads to improved efficiency and less use of voltage [4]. This is the current scenario of OLED working. OSRAM was the first company to introduce the first lighting device in 2008. It was a desk lamp that was created by Ingo Maurer who used 10 OLED panels.

WORKING

OLED is a semiconductor device in a solid state. It is approximately 100-500 nm thick in structure. Two or three layers of organic materials are used to make an OLED. In this structure, third layer is used to carry the electrons from cathode to emissive layer. OLED contains anode and substrate. In an OLED, the organic matter is sandwiched between a cathode and an anode, which are the two electrodes and this arrangement is then put on a substrate. The organic molecules of the organic matter are electrically conductive in nature which is due to the delocalisation of Pi electrons. The conducting nature of organic materials can be as conductive as insulators and can also be as conductive as conductors [5]. This is the reason why they are considered as organic semiconductors. HOMO (Highest Occupied Molecular Orbital) and LUMO (Lowest Unoccupied Molecular Orbital) are the two parts of the semiconductor. In the beginning, the most simple polymer OLED that was made consisted of only one organic layer. But to improve efficiency, multilayer OLEDs were made with the help of two or more layers. The most prevalent OLEDs these days are made up of two layers, out of which one is conductive layer and the second one is an emissive layer. In the working of an OLED, the voltage is given to the OLED such that when compared to cathode, anode stays positive [6]. A good anode should have properties like good optical transparency, electrical conductivity and chemical stability. The current in the OLED flows from cathode to anode as the electrons are injected in the cathode of the LUMO layer and are withdrawn at anode from the HOMO layer. The anode gets rid of the electrons from the conductive layer. Electrons try to find the electron holes, which are present at the edges of conductive and emissive layer. Whenever an electron finds any electron hole, it fits by filling the hole and it leads to the release of energy by the electrons in the form of light (photon). In this way, the light is emitted by OLED. The colour intensity depends on the factors such as amount of electric current applied and the kind of organic matter present in the emissive layer. OLEDs produce full colour display using RGB matrix. It contains three basic colours i.e. green and blue, which have different aging rate. So to maintain the balance, a compensation algorithm is used [7].

ADVANTAGES AND DISADVANTAGES

1. Advantages

a) The display of organic light emitting diode is brighter than LEDs.
b) The backlight is not required in organic light emitting diode. LCD blocks the backlight to form images on the screen, while OLED produces their own light.
c) Power consumption is less in organic light emitting diodes.
d) It's easy to produce light emitting diodes.
e) Organic light emitting diodes have around 170 degree of field view.
f) The plastic displays of organic light emitting diodes are lighter, flexible and thinner.
g) As compared to LCD, OLED screen achieves greater contrast ratio in low light conditions.
h) Organic light emitting diode doesn't contain harmful material like mercury.
i) It is possible to make transparent panels with OLED that can be used in laptops, keyboards and phone.
j) OLED displays are resistant to physical damage.
k) OLED provides high colour quality and turns on immediately when the current is applied. OLED does not emit UV or IR radiations as it has got 3D capability.

2. Disadvantages

a) OLED can be damaged by water.
b) It is an expensive technology.
c) The working of organic light emitting diode is interrupted in sunlight.
d) Organic light emitting diode has relatively shorter life span, like the blue light. As OLED is made up of organic material, so the degradation of this material takes place which reduces its lifespan [8] [9].

USAGE

1. Present Use:

a) Curved TV- OLED technology is used in LG's Curved OLED TV as shown Figure 1. In this, electric current passes through an organic substance that glows in excited state. It shows crisp colours. It is 4.3mm in thickness and 17 kg in weight. OLED screen has minimum glare on the screen. It is a bit expensive and costs around $17000 [10].

Figure 1. OLED Curved TV

b) OLED displays are used in latest mobile phones like Samsung, Nokia, etc.
c) OLED displays are used in display screens of digital cameras like Kodak.
d) Military uses the unbreakable property of OLED displays. Due to ruggedness nature, military people need something really strong. The wide field of view property of OLED is also used. OLED consumes less power, so it is being used in thermal imaging, simulation and training in military. There are two types of applications of OLED in military: - The near eye micro display and flexible OLED which were developed by Universal Display Corporation (UDC). The devices that are used in military include display sleeves, windshield displays and visor mounted displays [11].
e) In 2008, the world's first flexible OLED was introduced for military operations which can be used for both daytime and night due to its property of emitting visible green emission during daytime and infrared (IR) emission during night.

2. Future Use:

a) Future OLED TV- The future TV would be 80 inch wide and 0.25 inch thick. They could be rolled up when not in use. They will be very light in weight [12].
b) Philips and BASF are making a car with transparent roof. The roof will be solar powered, when these will be switched off the roof will become transparent [16].
c) OLED panels will be used in windows. When they will be switched on, it will make the window opaque and emit lights of desired colours. When they will be switched off it will make the window see through.
d) OLED panels will be used in the washrooms in the place of mirrors. A person can use it as a mirror or a warm reflecting planer. The tiles can be replaced by OLED to make warm surroundings.
e) Large OLED ceilings as shown in Figure 2, will be used as an artificial sky in a building [13].

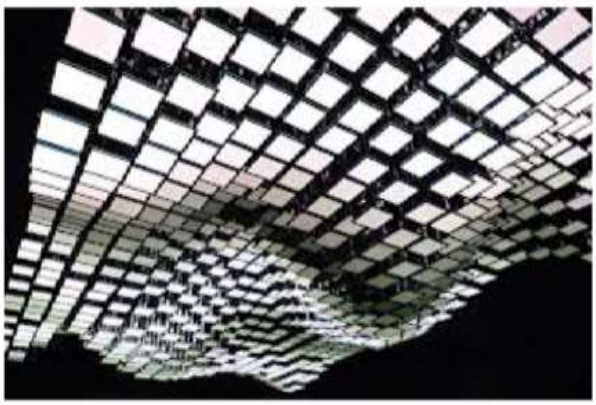

Figure 2. OLED Ceilings

f) OLED will work in an interactive mode. The roof of bus top will be made of OLED. It will light up only when there will be people underneath it.

g) Audi, Phillips, Merck are working on Audi TT that will be worlds first OLED car with real lighting panel as shown in Figure 3 [19].

Figure 3. OLED Lighting Panel

h) Use in Laptops as shown in Figure 4, OLED panel will be used to make laptop screen. The screen will be 40 % translucent. All the data will appear in luminescence form [14].

Figure 4. OLED Laptop Screen

i) Used in Keyboards- OLED will be used in keyboards as shown in Figure 5. It will be a large panel that would be touch sensitive. It is called Optimus Tactus [18]. OLED will also be used in individual keys. According to the application, the context will change on the keys like in the case of different languages.

Figure 5. OLED Keyboard

j) Use in mobile phones-OLED will be used in future mobile phones that will be flexible, roll able, and bendable as shown in Figure 6 [17].

Figure 6. OLED Mobile Phones

k) Use in Light Car open source- OLED will be used in these future cars as shown in Figure 7. The outline of the rare lights will be of OLED. The complete back panel of the car will be motion display panel that will display the warnings related to the features of the car like speed over limit, brakes failure and many more [15].

Figure 7. OLED Back Panels

l) OLED will be used in military operations in the form of shades, camouflage systems and smart light emitting windows.

CONCLUSION

OLED Technology is evolving very fast. It has become the new glitter of all the gadgets. It is taking the electronic aspect to a new dimension. All the electronic companies are trying to implement and use this technology in one way or the other. Till now it is not widespread because of its cost, lack of knowledge among masses and developments. With the help of OLED technology:

a) The battery life of gadgets will be longer.
b) The display of devices will consume relatively less energy.
c) The viewing angles of the displays will be larger.
d) The displays will have sharper colours and deeper blacks.
e) The display panels will be thin as paper.
f) The cars will be able to communicate with each other through displays.

The human race is using OLED technology in advancements and improvements. The resources are being carefully used as OLED is much more efficient as compared to existing ongoing gadgets. OLED technology is not harmful, it is efficient in terms of power consumption and it has thinner displays and is more flexible. Unbreakable devices can be made using this technology as the refreshing rate of OLED is very fast, so in near future we could expect a newspaper made of OLED panel that would refresh with the latest breaking news every second. In terms

of advancements, care should be taken that this technology will be used for the human mankind and not against it. Still OLED framework has a long way to go, this is just the beginning. In near future, we can think about everything being controlled with the OLED panels, starting with laptops to the kitchen slabs. This is how technology evolves and advances.

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