A Review on Emerging Technology of Organic Light Emitting Diode (OLED) In Display Devices

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Abstract- *Organic light emitting diode (OLED) is a self luminous optoelectronic device that is having more efficient power than liquid crystal display (LCD). LCDs have improved greatly since their first appearance in the large screen display area, but there is only so much that can be done. Plasmas are also great, but they are highly complex and expensive. They suffer from poor brightness and picture quality. There is a technology being developed in research labs around the world that could change all this. It's called an OLED display, and it could truly change the way we look at technology . Nowadays , we see that display devices are thin, high resolution and low power consuming. Organic materials are having more advantages over inorganic materials. They may often be solution-processed, allowing the fabrication of devices such as circuits, displays, and radio-frequency identification devices on plastic substrates, and deposition by unconventional means, such as screen and inkjet printing. These improvements are complemented to the research and development taking place in organic light emitting diode (OLED) technology. This paper describes the structure of OLED , its operation , types of OLEDs, Advantages, Disadvantages and its applications in display devices.*

Keywords- organic light-emitting diode (OLED), display devices, thin-film-transistors (TFT).

I. INTRODUCTION

OLED stands for Organic Light Emitting Diode, sometime they are referred to as Organic Light Emitting Devices. OLEDs are made from an organic material that has luminescent properties that glows when voltage passes through it. They operate on the principle of converting electrical energy into light, a phenomenon known as electro luminescence.

Display systems are primary sources of power consumption in battery-powered electronics despite the advances in low- power display technologies. As of today, liquid crystal display (LCD) panels are widely used in portable as well as desktop systems. The LCD panels do not illuminate themselves and require a high intensity backlight, which generally consumes a significant amount of power due to low transmittance of the LCD panels [1], and [2]. OLED technology uses materials from two different groups. The first includes materials with low molecular weight called small-molecule (SM) OLEDs, originally developed by the Ching Tang group at the Kodak Laboratories in 1987. The deposition of SM-OLEDs is based on vacuum thermal evaporation. The other group of materials includes polymer-based OLEDs consisting of long polymer organic chains deposited by spin-cast or ink-jet methods. SM-OLEDs achieve higher efficiencies and currently dominate OLED applications.[3]

II. DEVICE STRUCTURE

A small-molecular OLED consists of one organic layer or multiple organic layers between two electrodes. The one organic layer device is called a single layer device. Thus, the organic material must serve all the three main functions: electron transport, hole transport and emission. In this case, the injection rates of both carriers should be almost equal for high efficiency.[4] Otherwise, the surplus electrons or holes will not recombine, which results in low operation efficiency [5]. We can overcome this disadvantage by employing multiple organic layers in the OLED structure. The basic device structure with three layers is shown in Figure 1. This structure employs an electron transport layer (ETL), a hole transport layer (HTL) and an emissive layer. The emitter material can be either a layer between ETL and HTL or a dopant in one of these layers, close to the recombination zone. The dopant with a lower excitation energy than its matrix will yield a high luminescent efficiency.

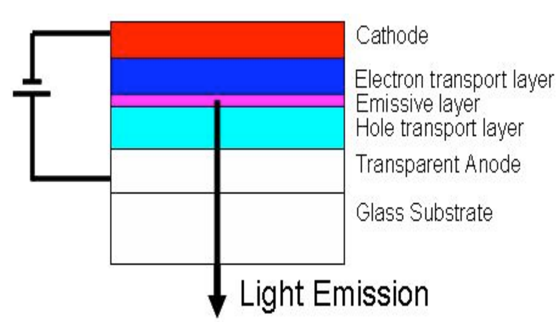

Fig 1. Configuration of OLED.

III. OLED OPERATION

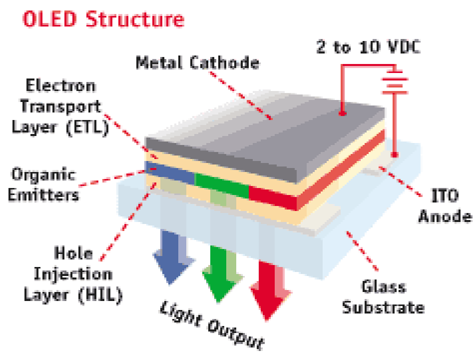

Fig 2. OLED Working Principle [6]

The basic OLED cell structure consists of a stack of thin organic layers sandwiched between a transparent anode and a metallic cathode. The organic layers comprise a hole-injection layer, a hole-transport layer, an emissive layer, and an electron-transport layer. When an appropriate voltage (typically between 2 and 10 volts) is applied to the cell, the injected positive and negative charges recombine in the emissive layer to produce light (electro luminescence). The structure of the organic layers and the choice of anode and cathode are designed to maximize the recombination process in the emissive layer, thus maximizing the light output from the OLED device.

IV. TYPES OF OLEDS

There are two forms of OLED displays: Passive-matrix and Active-matrix.

Passive Displays:

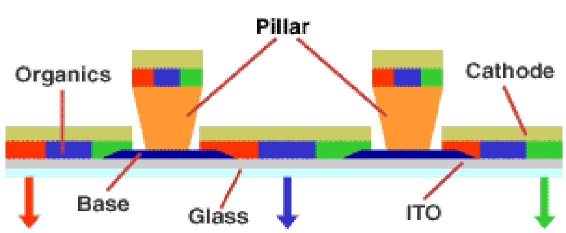

Fig 3.The Passive-matrix OLED display

The passive-matrix OLED display has a simple structure and is well suited for low-cost and low-information content applications such as alphanumeric displays. It is formed by providing an array of OLED pixels connected by intersecting anode and cathode conductors.

Organic materials and cathode metal are deposited into a "rib" structure (base and pillar), in which the rib structure automatically produces an OLED display panel with the desired electrical isolation for the cathode lines. A major advantage of this method is that all patterning steps are conventional, so the entire panel fabrication process can easily be adapted to large-area manufacturing. [7]

To get a passive-matrix OLED to work, electrical current is passed through selected pixels by applying a voltage to the corresponding rows and columns from drivers attached to each row and column. An external controller circuit provides the necessary input power, video data signal and multiplex switches. Data signal is generally supplied to the column lines and synchronized to the scanning of the row lines. When a particular row is selected, the column and row data lines determine which pixels are lit. A video output is thus displayed on the panel by scanning through all the rows successively in a frame time, which is typically 1/60 of a second.

Active Displays:

In contrast to the passive-matrix OLED display, active-matrix OLED has an integrated electronic back plane as its substrate and lends itself to high-resolution, high-information content applications including videos and graphics. This form of display is made possible by the development of poly silicon technology, which, because of its high carrier mobility, provides thin-film-transistors (TFT) with high current carrying capability and high switching speed.

In an active-matrix OLED display, each individual pixel can be addressed independently via the associated TFT's and capacitors in the electronic back plane. That is, each pixel element can be selected to stay "on" during the entire frame time, or duration of the video. Since OLED is an emissive device, the display aperture factor is not critical, unlike LCD displays where light must pass through aperture. Therefore, there are no intrinsic limitations to the pixel count, resolution, or size of an active-matrix OLED display, leaving the possibilities for commercial use open to our imaginations. Also, because of the TFT's in the active-matrix design, a defective pixel produces only a dark effect, which is considered to be much less objectionable than a bright point defect, like found in LCD's.

V. 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.[8]
- 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
- 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.

VI. 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.
- Water can easily damage OLEDs.

VII. OLED APPLICATIONS

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.[9]

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.

VIII. CONCLUSION

OLED displays are an innovative new display technology that offers improved performance as well as wide applications. Full color displays using OLEDs are in a position to replace LCDs in the small scale display market.[10] OLEDs offers a low manufacturing cost, a brighter, more vibrant display, as well as a larger viewing angle. A lower power consumption makes OLED perfect for portable devices which work on battery power. The ink-jet printing method used with OLEDs is sure to spark display applications never before possible with either LCD or Plasma.

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