OLED: A Modern Display Technology

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Abstract- As the time pass 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.

Index Terms- Light Emitting Diode, Cathode Ray Tube, Liquid Crystal Display, and Organic LED.

I. INTRODUCTION

rganic light emitting diodes (OLEDs) have been receiving a lot of attention over the world as a new type of display technology. OLEDs have many advantages over conventional display technologies. OLEDs are energy conversion devices (electricity-to-light) based on Electroluminescence. Electroluminescence is light emission from a solid through which an electric current is passed. First, the fabrication process is easy. and devices are thinner and lighter than those fabricated by cathode ray tube (CRT) display technology. Second, there are also some advantages over liquid crystal displays (LCD): OLEDS can be viewed from different angles and don't need a backlight. Finally, the drive voltage and power consumption are low. 1 The first commercial OLED display was introduced by Pioneer Electronics as the front panel of a car stereo in 1997. After that, some other applications are in the market, such as cell phones, digit cameras, GPS, radios etc. Another advantage of OLEDs is that they are current-driven devices, where brightness can be varied over a very wide dynamic range and they operate uniformly, without flicker. Both Active matrixes TFT's and Passive matrix Technologies are used for display and addressing purposes for high speed display of moving pictures and faster response. Already some of the companies released Cell Phones and PDA's with bright OLED technology for color full displays.

II. WHAT IS OLED?

An OLED is a solid state device or electronic device that typically consists of organic thin films sandwiched between two thin film conductive electrodes. When electrical current is applied, a bright light is emitted. OLED use a carbon-based designer molecule that emits light when an electric current passes through it. This is called electro phosphorescence. Even with the layered system, these systems are thin. Usually less than 500 nm or about 200 times smaller than a human hair. When used to produce displays. OLED technology produces self-luminous displays that do not require backlighting and hence more energy efficient. These properties result in thin, very compact displays. The displays require very little power, i.e., only 2-10 volts. OLED technology uses substances that emit red, green, blue or white light. Without any other source of illumination, OLED materials present bright, clear video and images that are easy to see at almost any angle. Enhancing organic material helps to control the brightness and color of light.

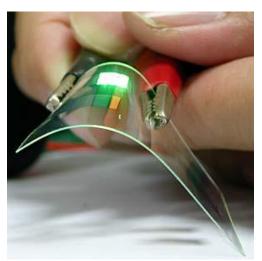


Figure 1: Demonstration of flexible OLED device

III. WORKING PRINCIPLE & STRUCTURAL ASPECTS

Organic Light Emitting Diodes (OLEDs) are thin-film multilayer devices consisting of a substrate foil, film or plate (rigid or flexible), an electrode layer, layers of active materials, a counter electrode layer, and a protective barrier layer At least one of the electrodes must be transparent to light.

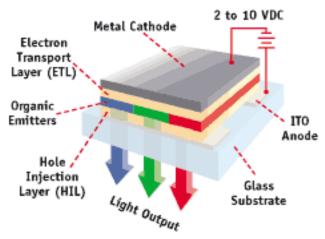


Figure 2 The typical structure of the OLED device.

The OLEDs operate in the following manner: Voltage bias is applied on the electrodes, the voltages are low, from 2.5 to ~ 20 V, but the active layers are so thin (~10Å to 100nm) that the electric fields in the active layers are very high, of the order of 105 - 107 V/cm. These high, near-breakdown electric fields support injection of charges across the electrode / active layers interfaces. Holes are injected from the anode, which is typically transparent, and electrons are injected from the cathode. The injected charges migrate against each other in the opposite directions, and eventually meet and recombine. Recombination energy is released and the molecule or a polymer segment in which the recombination occurs, reaches an exited state. Exactions may migrate from molecule to molecule. Eventually, some molecules or a polymer segments release the energy as photons or heat. It is desirable that all the excess excitation energy is released as photons (light).

The materials that are used to bring the charges to the recombination sites are usually (but not always) poor photon emitters (most of the excitation energy is released as heat). Therefore, suitable dopants are added, which first transfer the energy from the original exaction, and release the energy more efficiently as photons. In OLEDs, approximately 25% of the excisions are in the singlet states and 75% in the triplet states. Emission of photons from the singlet states (fluorescence), in most cases facilitated by fluorescent dopants, was believed to be the only applicable form of energy release, thus limiting the Internal Quantum Efficiency (IQE) of OLEDs to the maximum of 25%.

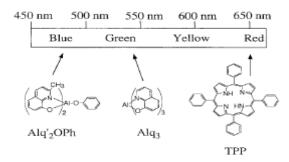


Figure.3: Different Light Emitting Polymers for different colors.

IV. BASICS OF LIGHT EMISSION

Light is one type of energy. So in order to emit light, the molecules must absorb energy from other sources. Once a molecule has absorbed enough energy, it can go to the excited electronic state. When the molecule relaxes to the ground singlet state, it can use different processes, one of which is to emit light. Fluorescence occurs when it returns from an excited singlet state to the ground singlet states. Because the two states have same multiplicity, it is spin-allowed and is very fast (10⁻⁵ to 10⁻⁸ seconds). Phosphorescence occurs when it returns from an excited triplet state: this is spin-forbidden and is often slow (10⁻⁴ seconds to minutes).

Colors	Red	Green	Blue
Efficiency (cd/A)	5.5	19	5.9
Lifetime (h)	80,000	40,000	7,000

Table.1: Present OLEDs efficiency and lifetime

V. FABRICATION METHODS FOR OLEDS

There are two methods to fabricate OLEDs: thermal evaporation of the organic small molecules and spin-coating polymer layers. Thermal evaporation is often performed in a vacuum. The vacuum pressure is usually about 10⁻⁶ torr or better. In addition to depositing molecules, it can also be used to deposit cathode materials. There are some advantages to using thermal evaporation. During the fabrication the thickness of each layer can be monitored easily, compared to spin-coating. The vacuum equipment is already in the semiconductor industry, and it is easy to achieve the multi-color displays by using shadow masks for depositing organic materials. Spin-coating is widely used in the polymer-based LEDs. The polymer layers can be deposited from solution directly, but the thickness can't be monitored during the deposition.

VI. OLEDS AS WHITE LIGHT SOURCE

In contrary to display applications where all colors are equally important, "good quality" white is of prime importance for general illumination. Individual colors are not as important. OLEDs have typically very broad band emissions, which makes them uniquely suitable for applications where white with high CRI and the desired position on the chromaticity diagram is desirable. Both small-molecular and polymeric systems with singlet (fluorescence) emitters have achieved full color with good positions on the CIE diagrams in Fig.4.

VII. FIVE BASIC METHODS OF PRODUCING WHITE LIGHT ARE KNOWN AND RESEARCHED AT THIS TIME.

1. Mixing two, or more different dyes (emitters), or polymers which emit different colors, in one layer: Copolymers whose segments emit different colors are also used as single

layers. Good quality white light was generated in OLEDs with three fluorescence emitters in a single layer with R, G, and B.

- 2. Deposition of three emission layers, each with different (R, G, B) emitters: One of the approaches to generate white light was to segregate three dopants into three separate emissive layers. The concept is enabled by the long diffusion lengths of triplet excitons, which may cross several layers before transferring the energy to an emitter. Triplets may migrate up to 1000Å. The thickness and the composition of each layer must be precisely controlled to achieve the color balance.
- 3. Using "horizontally stacked" narrow bands or pixels emitting in basic colors: (an analog of LCD displays): An extension of the tri-junction concept leads to another approach, basically similar to that used in LC flat panel displays, where the colors are separated and addressed independently as an array of individual pixels, dots, etc. The individual color-emitting segments / devices may be deposited as dots, miniature squares, circles, thin lines, very thin stripes etc. If that approach turns out to be feasible, and good white can be obtained, the system would have a number of advantages.
- 4. Using monomer-excimer complexes: The basic idea is to employ a lumophore, which forms a broadly emitting state, and a lumophore (or lumophores) which form excimers or exciplexes (excited states whose wave function extend over two molecules, either identical - excimers or dissimilar - exciplexes). Some phosphorescent dopant molecules indeed form excimers. These molecules are bound together only in the excited state but not in the ground state. The energy of the excimer is always lower than the energy of an excited single molecule and its emission is typically very broad. Thus, if an OLED is made with two blue dopants, one of which does not form excimers and the other does, the device will emit blue light from the former dopant, and lower-energy light (typically yellow) from the excimer of the latter dopant. The light from the blue dopant will mix with the light from the yellow excimer to make white light. None of the blue light will be lost because the excimer has no ground state to absorb it, and the blue emitter does not absorb yellow. The ratio of blue to yellow emission can be readily tuned by varying the ratio of the two dopants without the complication of energy transfer from blue to yellow.

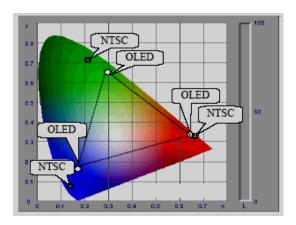


Figure. 4: A CIE chromaticity diagram showing the positions of "fluorescent" OLEDs in comparison with the NTSC standards.

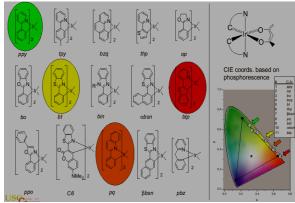


Figure. 5: A few examples of Iridium – based emitters designed to cover the chromaticity spectrum

5. Using an efficient blue emitter and down conversion phosphors: In principle, this method utilizes coupling of a blueemitting OLED with one or more down-conversion layers, one of which contains inorganic light-scattering particles. In an example, a blue OLED was prepared on a glass substrate with polyfluorene based light emitting polymer, a PEDOT/PSS hole injection layer on an ITO anode, and a NaF/Al cathode. Then, two separate layers of Lumogen TM F orange and red, molecularly dispersed in poly methylmethacrylate, were deposited on the other side of the glass substrate, followed by a layer of Y(Gd)AG:Ce phosphor particles dispersed in poly (dimethylsiloxane). The quantum efficiency photoluminescence of the dyes in the PMMA host was found to be >98%, and the quantum yield of the Y(Gd)AG:Ce phosphor was 86%. The device produced excellent quality white light with CRI 93 and the blackbody T 4130K. At 5.5V, the device exhibits 1080 cd/m2 and 3.76 lumens per electrical watt. This concept could be obviously extended to other efficient blue-emitting OLEDs. As with other methods of generating white light, the lifetime of the blue emitting OLED is of a prime concern. All methods have been shown to produce good quality white.

VIII. COMPARISON

OLED and LCD

From calculator screens, LCDs are used in mobile phones, computers, and a lot more applications. OLEDs produce their own light unlike LCDs which require a backlight. Another advantage of OLED is the lower power consumption compared to the LCD which has a great amount of the power consumption. The lack of a backlight also means that an OLED display can be significantly slimmer than an LCD display. Manufacturing OLEDs could also be a lot cheaper than manufacturing LCDs [15].



Fig 6 OLED v/s LCD

OLED and LED

OLED display can be thinner and lighter than LED display. They provide very wide and consistent color no matter where you are seated in the room. LED display tends to get significantly dimmer as one move away from center and many exhibit color shift. OLEDs are quite energy efficient. The greatest attribute of OLED is the ability to have the deepest blacks of any flat panel technology. OLEDs can make more colors than LED display.

IX. MERITS

The different manufacturing process of OLEDs lends itself to several advantages over flat-panel displays made with LCD technology.

- 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 display. However, fabrication of the OLED substrate is more costly than that of a TFT LCD, until mass production methods lower cost through scalability.
- Light weight & flexible plastic substrates: OLED displays can be fabricated on flexible plastic substrates leading to the possibility of flexible organic lightemitting diodes being fabricated or other new applications such as roll-up displays embedded in fabrics or clothing.
- Better power efficiency: LCDs filter the light emitted from a back light
- Response time: OLEDs can also have a faster response time than standard LCD screens.

X. Demerits

- Outdoor performance: As an emissive display technology, OLEDs rely completely upon converting electricity to light, unlike most LCDs which are to some extent reflective.
- Power consumption: While an OLED will consume around 40% of the power of an LCD displaying an image.

- Screen burn-in: Unlike displays with a common light source, the brightness of each OLED pixel fades depending on the content displayed. The varied lifespan of the organic dyes can cause a discrepancy between red, green, and blue intensity. This leads to image persistence, also known as burn in.
- UV sensitivity: OLED displays can be damaged by prolonged exposure to UV light. The most pronounced example of this can be seen with a near UV laser (such as a Bluray pointer) and can damage the display almost instantly with more than 20mW leading to dim or dead spots where the beam is focused.
- 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
- Water Water can easily damage OLEDs.

XI. CONCLUSION

In the future, OLEDs will probably conquer a large portion of the micro display market. Their higher efficiency and lower weight will make them quite competitive with LCD displays. There are no *fundamental* obstacles for OLEDs to become a technology of choice for general lighting. However, there still exist a number of "*incremental*" roadblocks that have to be overcome, many of which may require inventions or major breakthroughs, and most of these roadblocks are materials related. The rate of progress will depend on the success in designing and synthesis of novel high performance, stable materials components of OLED devices to replace those that are still deficient.

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