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A Review Paper on: Organic Light Emitting Diode over Conventional Led

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Abstract— Organic light emitting diode is a solid device containing thin films of organic molecules that create light with the application of electricity. Organic LED's can provide brighter ,crisper displays on electronic devices and it uses less power than conventional light emitting diodes use today. An organic LED is a solid state semiconductor device and it is 100 to 500 nanometers thick or 200 times smaller than a human hair. OLEDs can have two layers or three layers of organic material. Organic displays use a material with self-luminous property .This self-luminous property eliminates the need of back light in displays. OLEDs are lighter, thinner and more flexible than LEDs and LCD.

Keywords: OLED, LED, AMOLED

I. INTRODUCTION

An organic light emitting diode is simply a light emitting diode which has electro luminescent layer is composed of a film of organic compounds. The layers are made up of small organic molecules or macro polymers that conduct electricity. They have conductivity levels ranging from insulators to conductors, so OLEDs are considered as organic semiconductors. The layer of organic semiconductor material is formed between two electrodes, where at least one of the layers is transparent. Material with self- luminous property that eliminates the need o f a back light. These result in a thin and compact display.

II. LITERATURE SURVEY

An organic light- emitting diode (OLED) is a light- emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound which emits light in response to an electric current. This layer of organic semiconductor is situated between two electrodes; typically, at least one of these electrodes is transparent. OLEDs are used to create digital displays in devices such as television screens, computer monitors, 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. There are two main families of OLED: those based on small molecules and those employing polymers. Adding mobile ions to an OLED creates a light-emitting electrochemical cell (LEC) which has a slightly different mode of operation. OLED displays can use either passive-matrix (PMOLED) or active-matrix 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.

III. HISTORY

The first observations of electroluminescence in organic materials were in the early 1950 by André Bernanos and co-workers at the Nancy-University in France. They applied high alternating voltages in air to materials such as acridine orange. In 1960, Martin Pope and some of his co-workers at New York University developed ohmic dark-injecting electrode contacts to organic crystals .They further described the necessary energetic requirements for hole and electron injecting electrode contacts. These contacts are the basis of charge injection in all modern OLED devices. Pope's group also first observed direct current (DC) electroluminescence under vacuum on a single pure crystal of anthracene and on anthracene crystals doped with tetracene in 1963 using a small area silver electrode at 400 volts. The proposed mechanism was field-accelerated electron excitation of molecular fluorescence. Pope's group reported in 1965 that in the absence of an external electric field, the electroluminescence in anthracene crystals is caused by the recombination of a thermalized electron and hole, and that the conducting level of anthracene is higher in energy than the exciton energy level. Also in 1965, W. Helfrich and W. G. Schneider of the National Research Council in Canada produced double injection recombination electroluminescence for the first time in an anthracene single crystal using hole and electron injecting electrodes, the forerunner of modern double injection driven (100–3000 Hz) electrically insulated one millimetre thin layers of a melted phosphor consisting of ground anthracene powder, tetracene, and graphite

powder .Their proposed mechanism involved electronic excitation at the contacts between the graphite particles and the anthracene molecules. Electroluminescence from polymer films was first observed by Roger Partridge at the National Physical Laboratory in the United Kingdom. The device consisted of a film of poly(n-vinyl carbazole) up to 2.2 micrometres thick located between two charge injecting electrodes. The results of the project were patented in 1975 and published in 1983.The first diode device was reported at Eastman Kodak by Ching W. Tang and Steven Van Slyke in 1987. This device used a novel two-layer structure with separate hole transporting and electron transporting layers such that recombination and light emission occurred in the middle of the organic layer; this resulted in a reduction in operating voltage and improvements in efficiency that led to the current era of OLED research and device production. Research into polymer electroluminescence culminated in 1990 with J. H. Burroughes et al. at the Cavendish Laboratory in Cambridge reporting a high efficiency green light-emitting polymer based device using 100 nm thick films of poly(p-phenylene vinylene).Universal Display Corporation holds the majority of patents concerning the commercialization of OLEDs.

IV. WORKING PRINCIPLE

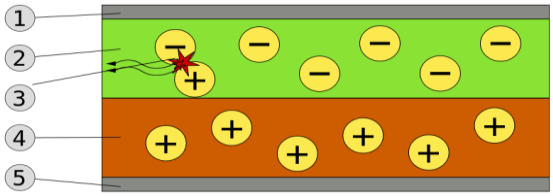

Fig 4.1: Schematic of a bilayer OLED: 1. Cathode (−), 2. Emissive Layer, 3. Emission of radiation, 4. Conductive Layer, 5. Anode (+)

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 all of the molecule. These materials have conductivity levels ranging from insulators to conductors, and are therefore considered organic semiconductors. The highest occupied and lowest unoccupied molecular orbitals (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. Burroughes et al., which involved a single layer of poly (p-phenylene vinylene). However multilayer OLEDs can be fabricated with two or more layers in order to improve device efficiency. As well as conductive properties, different materials devices. In the same year, Dow Chemical researchers patented a method of preparing electroluminescent cells using high voltage (500–1500 V) AC- 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. More recent developments in OLED architecture improves quantum efficiency (up to 19%) by using a graded heterojunction. In the graded heterojunction architecture, the composition of hole and electron-transport materials varies continuously within the emissive layer with a dopant emitter. The graded heterojunction architecture combines the benefits of both conventional architectures by improving charge injection while simultaneously balancing charge transport within the emissive region. 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 exciton, 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. As electrons and holes are fermions with half integer spin, an exciton may either be in a singlet state or a triplet state depending on how the spins of the electron and hole have been combined. Statistically three triplet excitons will be formed for each singlet exciton. Decay from triplet states (phosphorescence) is spin forbidden, increasing the timescale of the transition and limiting the internal efficiency of fluorescent devices. Phosphorescent organic light-emitting diodes make use of spin–orbit interactions to facilitate intersystem crossing between singlet and triplet states, thus obtaining emission from both singlet and triplet states and improving the internal efficiency. Indium tin oxide (ITO) is commonly used as the anode material. It is transparent to visible light and has a high work function which promotes injection of holes into the HOMO level of the organic layer. A typical conductive layer may consist of PEDOT:PSS as the HOMO level of this material generally lies between the work function of ITO and the HOMO of other commonly used polymers, reducing the energy barriers for hole injection. Metals such as barium and calcium are often used for the cathode as they have low work functions which promote injection of electrons into the LUMO of the organic layer. Such metals are reactive, so they require a capping layer of aluminum to avoid degradation. Experimental research has proven that the properties of the anode, specifically the anode/hole transport layer (HTL) interface topography plays a major role in the

efficiency, performance, and lifetime of organic light emitting diodes. Imperfections in the surface of the anode decrease anode-organic film interface adhesion, increase electrical resistance, and allow for more frequent formation of non-emissive dark spots in the OLED material adversely affecting lifetime. Mechanisms to decrease anode roughness for ITO glass substrates include the use of thin films and self-assembled monolayer. Also, alternative substrates and anode materials are being considered to increase OLED performance and lifetime. Possible examples include single crystal sapphire substrates treated with gold (Au) film anodes yielding lower work functions, operating voltages, electrical resistance values, and increasing lifetime of OLEDs. Single carrier devices are typically used to study the kinetics and charge transport mechanisms of an organic material and can be useful when trying to study energy transfer processes. As current through the device is composed of only one type of charge carrier, either electrons or holes, recombination does not occur and no light is emitted. For example, electron only devices can be obtained by replacing ITO with a lower work function metal which increases the energy barrier of hole injection. Similarly, hole only devices can be made by using a cathode made solely of aluminum, resulting in an energy barrier too large for efficient electron injection.

V. ADVANTAGES

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 displays. However, fabrication of the OLED substrate is more costly than that of a TFT LCD, until mass production methods lower cost through scalability. Roll-to-roll vapour-deposition methods for organic devices do allow mass production of thousands of devices per minute for minimal cost, although this technique also induces problems in that devices with multiple layers can be challenging to make because of registration, lining up the different printed layers to the required degree of accuracy.

Light weight and flexible plastic substrates

OLED displays can be fabricated on flexible plastic substrates leading to the possible fabrication of flexible organic light-emitting diodes for other new applications, such as roll-up displays embedded in fabrics or clothing. As the substrate used can be flexible such as polyethylene terephthalate (PET),the displays may be produced inexpensively. Further, plastic substrates are shatter resistant, unlike glass displays used in LCD devices.

Wider viewing angles and improved brightness

OLEDs can enable a greater artificial contrast ratio (both dynamic range and static, measured in purely dark conditions) and a wider viewing angle compared to LCDs because OLED pixels emit light directly. OLED pixel colors appear correct and unshifted, even as the viewing angle approaches 90° from normal.

Better power efficiency and thickness

LCDs filter the light emitted from a backlight, allowing a small fraction of light through. So, they cannot show true black. However, an inactive OLED element does not produce light or consume power, thus allowing true blacks. Dismissing the backlight also makes OLEDs lighter because some substrates are not needed. This allows electronics potentially to be manufactured more cheaply, but, first, a larger production scale is needed, because OLEDs still somewhat are niche products. When looking at top-emitting OLEDs, thickness also plays a role when talking about index match layers (IMLs). Emission intensity is enhanced when the IML thickness is 1.3–2.5 nm. The refractive value and the matching of the optical IMLs property, including the device structure parameters, also enhance the emission intensity at these thicknesses.

Response time

OLEDs also have a much faster response time than an LCD. Using response time compensation technologies, the fastest modern LCDs can reach as low as 1ms response times for their fastest color transition and are capable of refresh frequencies as high as 144 Hz (frame interpolation on modern "240Hz" and "480Hz" LCD TVs is not a true increase in refresh frequency). OLED response times are up to 1,000 times faster than LCD according to LG, putting conservative estimates at under 10μs (0.01ms), which in theory could accommodate refresh frequencies approaching 100 kHz (100,000 Hz). Due to their extremely fast response time, OLED displays can also be easily designed to interpolate black frames, creating an effect similar to CRT flicker in order to avoid the sample-and-hold behaviour used on both LCDs and some OLED displays that creates the perception of motion blur.

VI. MANUFACTURERS AND COMMERCIAL USES

OLED technology is used in commercial applications such as displays for mobile phones and portable digital media players, car radios and digital cameras among others. Such portable applications favour the high light output of OLEDs for readability in sunlight and their low power drain. Portable displays are also used intermittently, so the lower lifespan of organic displays is less of an issue. Prototypes have been made of flexible and rollable displays which use OLEDs' unique characteristics. Applications in flexible signs and lighting are also being developed. Philips Lighting have made OLED lighting samples under the brand name "Lumiblade" available online and Novaled AG based in Dresden, Germany, introduced a line of OLED desk lamps called "Victory" in September, 2011.OLED displays were used in watches made by Fossil (JR-9465) and Diesel (DZ-7086).In 2014, Mitsubishi Chemical Corporation (MCC), a subsidiary of the Mitsubishi Chemical Holdings developed an organic light-emitting diode (OLED) panel with a life of 30,000 hours, twice that of conventional OLED panels.

VII. CONCLUSION

Organic light emitting diode makes electronic viewing more convenient as they are more energy efficient. OLED is so revolutionary that in the field of illumination it is being hailed as "the first discovery since Edison". Today, OLED technology is widely seen as a next generation component for flat panel displays and is expected to become a key technology in the development of flexible displays. OLEDs offer many advantages over both LEDs and LCDs. They are thinner, lighter and more flexible than the crystalline layers in an LED or LCD. They have large fields of view as they produce their own light.

VIII. FUTURE SCOPE

Research and development in the field of OLEDs is proceeding rapidly and lead to future applications in the heads up display, automotive dash boards ,billboard type displays. Because OLEDs refresh faster than LCDs, a device with OLED display could change information in real time. Video images could be much more realistic and constantly updated. OLEDs have large fields of view as they produce their own light. OLEDs have wide viewing angle than LCDs and can replace LCDs in future. It is a key technology in the development of flexible displays.

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