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Organic Light Emitting Diode and Energy Efficient Material for Sustainable Green Environment

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Abstract- **An organic light-emitting diode (OLED) is a light emitting diode (LED) constructed by using organic molecules that emits light in response to an electric current. The OLED are highly energy efficient material compared to conventional artificial light sources. The Organic light emitting diode emits light by emissive electroluminescent layer, a film of organic compound. The layer of organic semiconductor is situated between two electrodes in which at least one of the electrodes is transparent. Major usage of OLED is in digital displays devices such as television screens, computer monitors, portable systems such as mobile phones, handheld game consoles and other displays. OLED have two main families: those based on small molecules and second class employ polymers as construction unit. The fundamental of OLED construction materials, energy efficiency of new OLED materials and application design has been discussed here.**

Keywords: OLED, Display, Energy Efficient, Luminescence,

I. INTRODUCTION

Urbanization and advances in technologies has led to increase in per capita consumption of energy and the demand of energy is increasing day by day globally. As more people are moving towards utilization of newer technologies, the global demand for energy is predicted to rise in the coming decades. The International Energy Agency's 2007 World Energy Outlook states that between 2017 and 2030, global energy needs are expected to increase many fold [1].Fossil fuels will remain the dominant source of energy to meet out the increasing demand through utilization of other alternate sources of energy is expected to increase. There are various reasons behind this major demand of energy for its consumption. First is the increase in population. The growing world's population underpins an expanding appetite for energy in all its forms. This is because growing population means more use of resources and thus more demand for energy. Increase in urbanization is the second big reason of growth in energy demand. The world's population is increasingly concentrating in cities and towns due to which the urbanization rate is increasing. Urbanization tends to increase the consumption of modern forms of energy which results in increase in demand of energy. With the increase of such major energy demand, energy conservation becomes the area of consideration.

Technological advances are moving towards the development of less energy consumptive consumer goods (Energy efficient goods (mainly electronics) giving same or similar output service with less consumption of energy). For example, the traditional tungsten bulb were replaced with fluorescent bulbs (CFL) (which provided same domestic lightening with very less electricity consumption). Recently comparatively more energy efficient Light Emitting Diode (LED) bulbs are taking place of CFL bulbs. Constrain and limitations of production of LED are being mitigated by development of Organic Light Emitting Diodes (OLED).Organic LED is well known today and has attracted considerable interest of scientists for development of energy efficient materials. A first break through was achieved in 1987 by Tang and Van Slyke from Kodak, when they reported efficient and low voltage OLEDs from p-n hetero-structure devices using the film of vapour deposited organic material [2,3]. After their report, a quick progress was achieved in the optimization of device parameters such as brightness, efficiency and durability[4]. In today's context, there is a great interest in optimization of device structure and material screening to achieve OLEDs with improved reliability and performance. Herein this review discusses the fundamental of designing, science behind the OLED structure, application and design advances in development of different type of OLED.

II. OLED DESIGN

The basic structure of an organic LED consists of a thin film of organic material (emitting layer) between the two electrodes (figure 1)[5]. When a voltage is applied between the electrodes, as a result a photon is emitted due to charge mobility. The components in an OLED differ according to the number of layers of the organic material [6].There are a basic single layer OLED, two layers OLED and also three layers OLEDs. As the number of layers increases the efficiency of the device also increases. The increase in layers also helps in injecting charges at the electrodes and thus helps in blocking a charge from being dumped after reaching the opposite electrode. Any type of OLED consists of the following components [7].

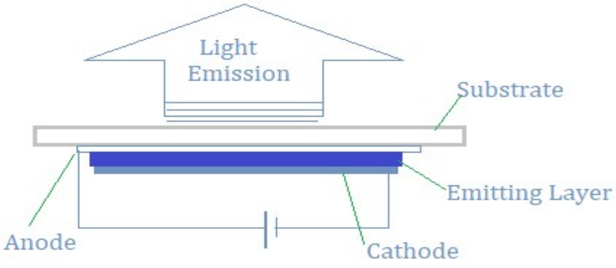

Figure 1: Fundamental design of an OLED

III. SUBSTRATE

It is the basic support layer that is used to provide support for other layers of the OLED. The most commonly used substrates include plastic foils and glass. The transparent support based OLED devices are classified as bottom emission devices through the transparent substrate on which the panel was manufactured.

IV. ANODE

The first layer of the substrate constitutes Anode. The electrode anode component usually used is Indium Tin Oxide (ITO). The Indium Tin Oxide material is transparent to visible light and is sufficiently good conductor of current. The ITO anode material has a high work function as it has to promote injection of holes into the HOMO level of the organic layer. The ITO is an inorganic material and its organic materials substitutes have been developed. A typical conductive organic layer behaving as a *transparent electrode* that replace the traditionally used ITO consists of poly (3,4-ethylenedioxythiophen) poly (styrenesulfonate) i.e. the PEDOT : PSS a composite polymer (figure 2) 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. Recent advances in nano-materials have provided high conducting materials suitable for different applications. The nano-material based anode made up of Graphene (single layered graphite material)(figure3) yields more performance comparable to ITO transparent anodes. Graphene is single layered structure made up of hexagonal carbon network and can be considered as an indefinitely large aromatic molecule, akin to the ultimate case of the family of flat polycyclic aromatic hydrocarbons. This provides a cloud of mobile electron on the surface of graphenelayer. Graphene behave as semi-metal with small overlap between the valence and conduction band i.e. is a zero band gap material, making it suitable for use as electrode.

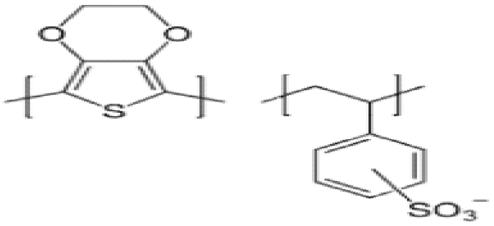

Figure 2: Chemical structure of PEDOT: PSS

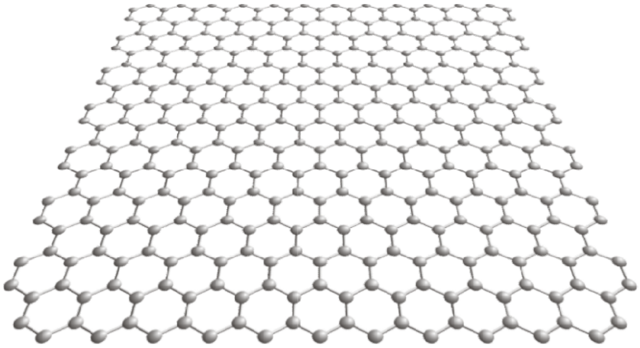

Figure 3: Graphene structure

V. CATHODE

The other electrode cathode serves the purpose of injecting electron in LUMO of different layers of OLED. The material of cathode component depends on the type of OLED required. Usually metals like Barium, Calcium and Aluminium are used as a cathode because they have lesser work functions than anode which help in injecting electrons into the LUMO level of the different layers [8]. Depending on the design of OLED, the cathode is mostly placed on the other side of light emitting layer. The electrons transfer from cathode to the emissive layer may be mediated through a layer of organic molecules called electron transport layer.

VI. ELECTRONS TRANSPORT LAYER

There is generally layer of organic molecules that sits between cathode and light emitting layer. This layer is referred as Electron transport layer. This layer helps in the transportation of electrons from the cathode and into the emitting layer of the OLED via a hopping mechanism involving transitory production of anion radicals of the molecules involved [9]. The commonly used organic components in electron transport layer include

PBD =2-(4-biphenyl)-5-(4-alpha-butylphenyl)-1, 3, 4-oxadiazole;

AlQ3 = tris(8-hydroxyquinoline)Aluminium;

TPBI =1, 3, 5-tris (N-phenylbenzimidizol-2- yl) benzene;

BCP = Bathocuprene.

These molecules are capable of receiving electrons from cathode, get converted into radical anion and then transfers electrons to LUMO of the emissive layer with themselves conversion in original form, thus making an easy transfer of electrons through hopping mechanism. The commonly used compounds are shown in figure4:

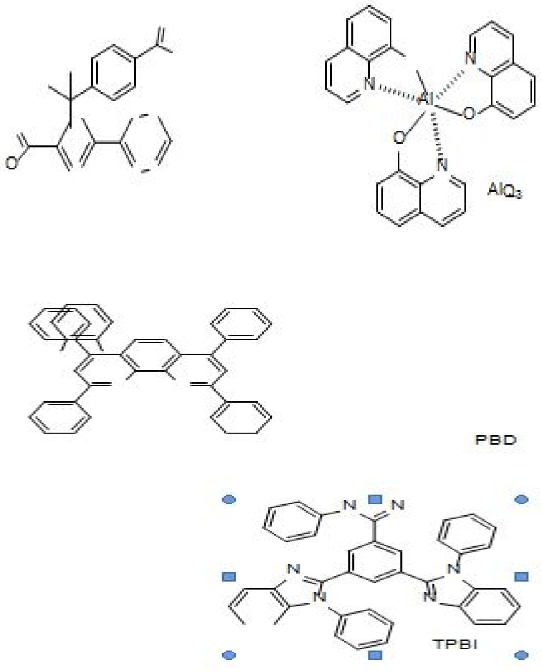

Figure 4: Representative organic molecules used as Electron transport layer

VII. HOLES TRANSPORT LAYER

HTL is another component of OLED which provides a charge hopping pathway for positive charge carriers so that it can migrate from the anode into the emission layer. It gets easily oxidised and fairly stable in the one-electron oxidized form due to which it is required. It acts as an electron blocking layer to prevent the flow of electron. Some molecules like TPD and NPB are used in hole transport layer. The characteristics of these molecules are as follows:

TPD: N,N′-Bis(3-methylphenyl)-N,N′-dipheny lbenzidine (figure 5) is abbreviated as TPD. It is widely used as a hole transport material in organic electronic devices. It has received considerable attention for its outstanding characteristics. Its chemical formula is $C_{38}H_{32}N_2$ with molecular weight of 516.67g/mol. TPD is also used as a blue-violet light emitting material or host material on the phosphorescence organic light emitting diodes. This is because its wide energy band is about 3.2 ev with highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) 5.5 ev and 2.3 ev respectively.

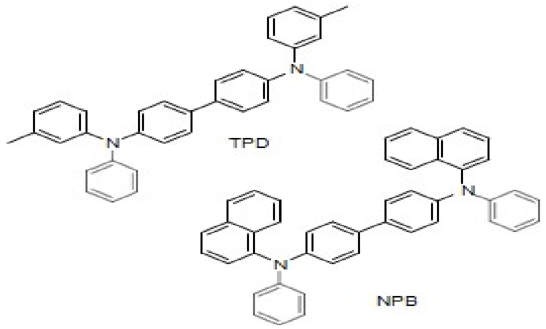

Figure 5: Chemical structure of organic molecules used in Hole layer

NPB: N, N′-Di (1-naphthyl)-N,N′-diphenyl-(1,1′-biphenyl)-4,4′-diamine (figure 5) is also known as NPB. It is used intensively in OLEDs and other organic electronic devices such as polymer photovoltaics (OPV) and perovskite solar cells for its outstanding hole transport capability. Its chemical formula is $C_{44}H_{32}N_2$ with molecular weight 588.74g/mol. The glass transition temperature (Tg) of NPB is 95°C and because of that it has become most commonly used material in OLED application. The higher glass transition temperature enhances device morphology and is beneficial for device longevity [9].

VIII. EMISSIVE LAYER

The emissive layer is main layer of OLED responsible for emission of light. Its component is made up of organic plastic polymer molecules; out of which the most commonly used is polyfluorene (figure 6) [10].Polyfluorenes are polymer materials similar to other conjugate polymers. These polyfluorenes have potential to act as an electro active and photoactive materials both. The low band gaps make polyfluorene highly thermal stable and facile for their color tenability. Along with this,the another quality of polyfluorenes is the thermo tropic liquid crystallinity, allowing the polymers to rub polyimide layers. In organic semiconductors, holes are generally more mobile than electrons. The decay of the excited state results in a relaxation of the energy level 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 energy between the HOMO and the LUMO (figure 7). The colour of the light produced can be varied according to the type of organic molecule used for its process. To obtain colour displays, a number of organic layers are used. Another factor of the light produced is its intensity. If more

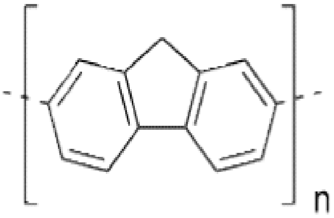

Figure 6: Chemical structure of polyfluorene current is applied to the OLED, the brighter the light appears.

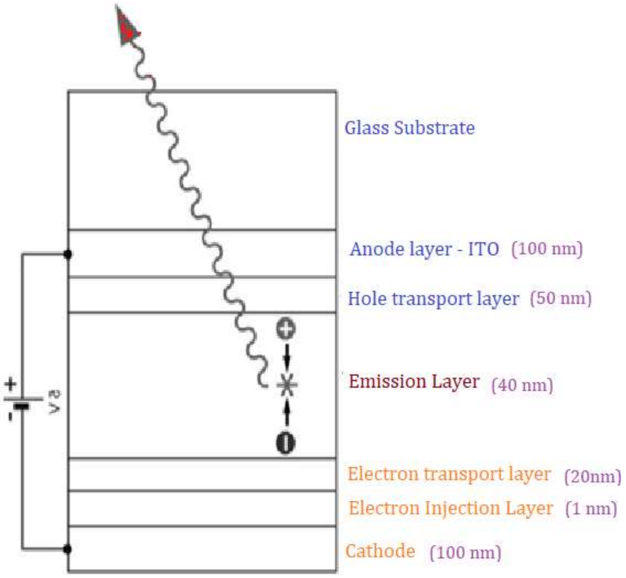

Figure 7: Basic process of light emitting in OLED.

Figure 7 shows a typical and well established set up of an OLED (more detailed of figure 1 including Hole transport layer and electron transport layer). It consists of a number of thin layers. These are either solution processed or vacuum-deposited, for example, on a glass substrate. In operation, holes are injected from a transparent anode, mostly consisting of a non- stoichiometric composite of SnO_2 (10-20%) and In_2O_3 (90-80%) called “indium tin oxide” (ITO)[11].Adjacent to this anode layer, a hole injection/transported layer (HTL) is normally applied to allow for a well balanced hole transport into the light emission layer (EML). At the opposite side is a metal-cathode with a suitably chosen work function injects electrons into an electron transport layer (ETL)[12]. It has been shown that an additional very thin layer of Lithium Fluoride (LiF) or Cesium Fluoride (CsF) (0.5 to 1nm) strongly reduces the injection barrier and also protects the ETL from chemical reactions with the cathode material. Clearly, although electron transport from cathode to the EML must be efficient, it is also important that the electron current is well balanced with the hole current in order to avoid ohmic loses. Such loses can be minimized by introducing a hole blocking layer between the EML and the ETL and an electron blocking layer HTL and the EML. These additional layers (which are not shown in the figure 7) prevent holes/electrons from crossing and leaving the EML without electron hole recombination. As a result, the device efficiency can be increased. However, such blockings may lead to the build-up of high charge densities at the interfaces, with un-favorable consequences for the device lifetime. The emissive layer emits light photon by induced excitation by electron energy current. The release of photon light can be explained diagrammatically by Jablonski diagram.

IX. JABLONSKI DIAGRAM

The Jablonski diagram is used to depict the sub-molecular or subatomic energy levels i.e. it is basically an energy diagram, arranged with energy on a vertical axis. When energy, in an energy diagram is arranged on a vertical axis then such a diagram is known as Jablonski diagram. In most of the diagrams it has been observed that the energy levels are usedschematically instead of being quantitatively denoted. Mostly energy diagrams are represented in columns in which every column denotes the specific spin multiplicity for a particular species. However in some energy diagrams the energy levels within the same spin multiplicity is divided into different columns. The horizontal lines in each energy diagram represents eigenstates for that particular molecule within each column where as the limit of electronic energy states in energy diagram is represented by the bold horizontal lines. The composition is such that, there are multiple vibronic energy states in each electronic energy state. There is a possibility that these multiple vibronic energy states may get paired with the electronic state. Further these vibrational energy states are subdivided into rotational energy levels. But talking about Jablonski diagrams typically such intense level of details can be omitted. The electronic energy state inversely depends on the difference in energy that means as there is increase in the electronic energy states then the difference in energy reduces, there by becoming a continuum that can be approach with classical mechanics. Besides this another relation is seen between the electronic energy levels and the vibronic energy level. As the electronic energy levels get closer together, the vibronic energy levels overlap at higher rate.

When the molecule is exposed to a particular wavelength of light then transition of state takes place between eigenstates which is represented by the straight and curved lines, in the figure 8. Here the straight lines and the curved lines represent the conversion between a photon of light and the energy of an electron, and transitions of electrons without anyinteraction with light respectively. In Jablonski diagram different pathways denotes how the energy is accepted by an electron and then how the energy is dissipated from a photon of a particular wavelength. That is why in most of the energy diagrams the arrow start with going from the ground electronic state and finish with going to the ground electronic state [13].

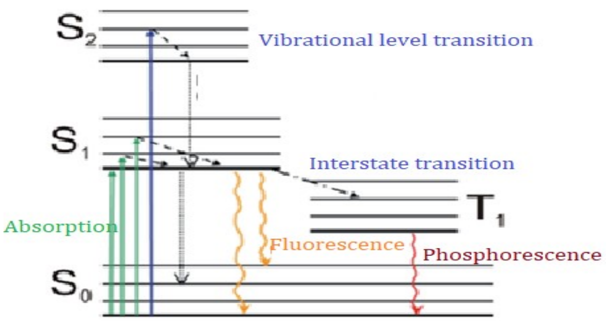

Figure 8: Jablonski diagram

X. JABLONSKI DIAGRAM AND OLED

The Jablonski diagram shows a dopant molecule that can be excited from its singlet state to its first excited singlet state by overlap of its absorption with the emission from the host dye such as aluminum quinolate [14]. By overlapping of absorption with the emission from the host dye the Jablonski diagram displays a do-pant molecule that can be excited from its singlet state to its first excited singlet state. The first dopants which shifted the energy of the emission of the device more towards red and the improves the efficiency and stability of the device were primarily the fluorescent do pants. The Holy Grail in the Jablonski diagram is to identify do pants that can capture the energy in the triplet state, which is 75% of the energy in the system. The transfer of electron from singlet to ground state results in Fluorescence and when the electron transfer is from singlet to triplet state and then to ground state, it leads to luminescence.

XI. SPECIFIC FABRICATION PROCEDURES

The OLED are synthesized by layer by layer accumulation of different components. There are different fabrication methods available that used to achieve different degree of efficiency and easiness of synthesis. These fabrication technologies include:

Spin-Coating

Spin Coating is one of the most common techniques for applying thin films to substrates. The use of spin coating in OLEDs has relatively thin films and high uniformity required for effective device preparation, as well as the need for self-assembly and organization to occur during the casting process [15].

Ink-Jet Printing

Ink-jet printing has the desirable ability to allow precision deposits without the use of a mask. It also produces less stray particles, thus boosting yields. Inkjet method forms films by discharging the required amount of organic material onto large glass substrates in regular atmospheric conditions. These significant advantages make this technology interesting to be applied [16].

Vacuum Deposition

OLEDs today are widely manufactured using this Fabrication procedure called vacuum deposition, where the organic materials are evaporated or sublimed in high vacuum to form molecular beams towards the substrate. Vacuum accumulation help to achieve thin layer deposition for uniform fabrication of OLED.

Device Efficiency

The efficiency of an OLED is characterized by its quantum efficiency by two different parameters; the external quantum efficiency (next) and the internal quantum efficiency (nint). Next is defined as the number of emitted photons divided by the number of injected charges. However the efficiency of OLEDs is determined to a significant extent by the efficiency of electron and hole injection into the organic layers. The current efficiency (nl) is expressed in CdA-1 (quality of device). The efficiency is improved by doping the emitting layer with various organic dyes.

External efficiency is a measuring scale of extent of light production in the given power supplied. External power efficiency is a result of product of the internal efficiency and the light out-coupling efficiency. Only 20% light used to be emit by typical OLEDs in the forward direction. The remaining energy is dissipated in substrate or waveguide modes which go to the side, which can open intriguing possibilities for sensors in the OLED. Internal efficiency is the measure of total efficiency of the device i.e. efficiency of all the components in the OLED.

There is a series of requirements that must be fulfilled by materials used for an OLED device, such as suitability for some specific fabrication procedure (eg. Spin-coating, inkjet printing, vacuum deposition), good film-forming properties, sufficiently high glass transition temperature to avoid crystallization of the layer material within the desired lifetime of the device and chemical and photochemical stability of the device. Moreover holes barriers and electron injection barriers must be low and the motilities as well as so that the energies, HOMO and LUMO, must match for adjacent layers. Another requirement that should be satisfied is that the lower triplet state of the host material used for EML lies significantly higher (i.e. about 3000cm^{-1} or approximately 0.4 ev) than the triplet of the emitting complex. Otherwise, the triplet of the host material can be populated easily, and subsequently the excitation energy can easily diffuse towards the quenching sites, or can be quenched at the host itself.

XII. DISPLAY TECHNOLOGY

OLED displays are not just thin and efficient - they provide the best image quality ever and they can also be made transparent, flexible, foldable and even roll-able and stretchable in the future. OLEDs represent the future of display technology. OLED have been seen as a key component of a promising display technology likely to challenge LCD (liquid-crystal displays). Cathode-Ray Tube (CRT) is one of that compared characteristics which layout of its active area consisting of pixels. The main feature of an OLED pixel is that it is an emissive device which can be switched off and be completely black where as a liquid crystal (LCD) pixel is a transmissive device which does not allow complete osculation of backlight.

XIII. COLOUR GENERATION

In conventional LEDs, light emission is achieved through inorganic semiconductor materials, but, in OLEDs, there are one or more multiple layers of organic compounds which are sandwiched between the anode and cathode for the generation of photon. The energy of the radiation depends upon the organic molecule architecture. There are two different ways to generate colour radiations in OLEDs [17, 18]. OLEDs emit light passing through self generated recombination of electrons and holes. Hence, OLEDs themselves can be made to produce various colours of light. In this method red, green and blue emitting organic materials is kept at the sub-pixel locations, and so produce RGB light directly. Another method is using a “white” OLED material across the whole display area, and using some sort of colour filters. This is commonly seen in colour LCDs. In this, patterning of pixels is not required. To build white light, two or more luminescent materials are used. This turns into red, green and blue because of colour filter film. There are various different ways to built OLED displays. In some designs, light is designed in such a manner that it emerges from the glass seal at the top; others send their light through the substrate at the bottom. In large displays, there is difference in the way pixels are built up from individual OLED elements.

XIV. DIFFERENT TYPES OF OLED

There are different types of OLED that vary on the basis of their design structure, matrix or end application. These are:

Passive-matrix OLED (PMOLED)

Passive-Matrix Display PMOLED relates to the way of controlling the display. A PMOLED display uses a simple control scheme in which the control is on each row in the display sequentially (one at a time). PMOLED electronics do not contain a storage capacitor and so the pixels in each row are actual off most of the time. A pixel is simply defined by the cross over area of linear electrodes deposited on each side of the liquid-crystal or in the emissive material in case of OLED. The electrodes are oriented 90 degree from each other. Principle and mechanism of passive- matrix display leads consequently to high power consumption and huge resistive losses in the column on one hand and stress and damage of the pixels (because of high current) [17]. The PMOLEDs are made up of matrix of electrically conducting rows and columns. On the sides of these rows and columns is a substrate where as in between these rows and columns are the organic layer. These rows and columns are called cathode and anode which are arranged perpendicularly to each other. The placing of cathode and anode make up the pixels where light emission takes place. The direct proportionality is seen between brightness and amount of current applied. In this, the on and off of pixel depends upon the external circuit application to selected strips of anode and cathode. The Pros of these PMLOEDs are that they are easy and economical to fabricate hence not burning a hole in the pocket. There power consumption is less in comparison with LCD and LEDs. However restriction comes in resolution and size depending on the number Of lines. The voltage consumption increases with increase in number of lines. Generally PMOLEDs are more effective in smaller screens due to which these are commonly used to display character data or small icons. They display maximum size of 5inches. Therefore their usage can be seen in MP3 players, mobile phone sub displays, etc.

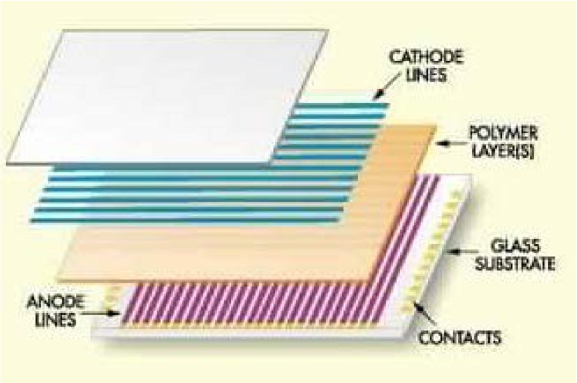

Figure 9: Diagram of Passive matrix OLED (Source: Google images)

Active-matrix OLED (AMOLED)

Active-matrix display is a display technology used in smart-watches, mobile devices, laptops, and televisions. OLED describes a specific type of thin- film-display technology in which organic compounds form the electroluminescent material, and active matrix refers to the technology behind. Here each matrix is defined by its own electrode and driven by circuitry comprising a thin-film-transistor (TFT) and capacitors (aimed at retaining the information during a frame period). This technology is already widespread in flat-panel-displays (FPDs) and is fulfilled by the growing demand for large and high resolution devices. An AMOLED display consists of an active matrix of OLED pixels generating light (luminescence) upon electrical activation that have been deposited or integrated onto a thin-film transistor (TFT) array, which functions as a series of switches to control the current flowing to each individual pixel.

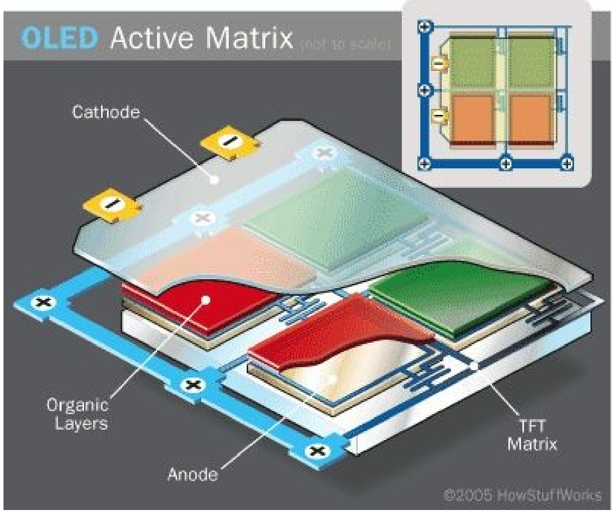

Figure 10: Graphical diagram of Active Matrix OLED (Source: Google images, Courtesy and copyright: 'How stuff work')

AMOLEDs are similar to passive but they have full layers of cathode, organic molecules and anode. Anode layers are structured parallel to thin film transistor (TFT) which helps to form a matrix. Such arrangements help in image formation by switching each pixel to its desired state of on and off.

The arrangement conveniently switches off the pixel whenever they are not required or there is a black image on the display, which thereby increases the battery life of the device. The star point of AMOLED lies in its least power consumption type as compared to other OLEDs like PMOLED etc. AMOLED are found to be more suitable for videos due to their quick refresh rates. The best uses for AMOLEDs are seen in computer monitors, large-screen TVs and electronic signs or billboards. Besides this the current usage of AMOLED can be seen in some APPLE watches display and IPHONE X screen.

Transparent OLED

Transparent OLEDs (TOLEDs) have only transparent components called substrate, cathode and anode (figure 11). When a Transparent OLED display is turned on, it functions by allowing light to pass in both directions (Top and Bottom). This type of OLED can be included in both the active and passive matrix categories. As they have transparent parameters on both of the sides, which can create displays that are top as well as bottom emitting surfaces. This device has a good contrast even in bright sunlight so it is applicable in head-up displays, laptops, mobile phones and smart windows as well [21].

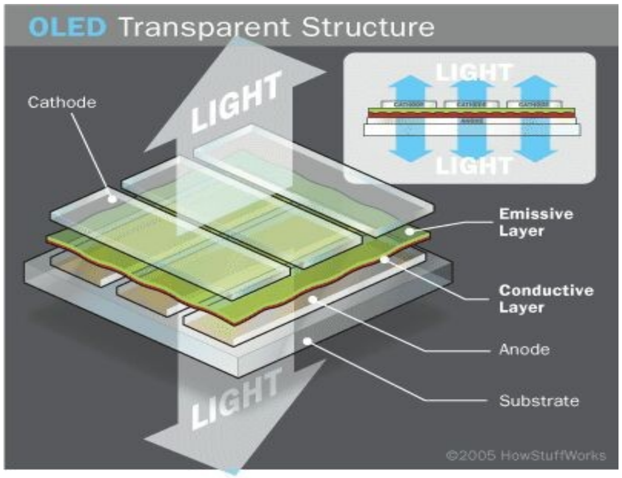

Figure 11: Transparent OLED (Source: Google images Courtesy and copyright: 'How stuff work'))

Top and Bottom Emission Light is generated by the emissive layers in all directions. In top-emitting devices, light flows through cathode whose transparency limits the external luminance of the device. In bottom-emitting devices, light flows through anode (active backplane). In this case the light is not only limited by the anode transparency but also partially blocked by the circuitry.

Top-emitting OLED

Top-emitting OLEDs have a substrate that is either opaque or reflective (figure 12). A thick, highly reflective bottom contact is used and a semi- transparent contact is deposited on top of the organic layers.Top emitting OLEDs are having two highly reflective contacts,

White OLED

White OLEDs emit white light and have the true colour qualities of incandescent lighting. The white light emitted by white OLED is brighter, more energy efficient and more uniform than that emitted by fluorescent lights and incandescent bulbs. White OLEDs can be manufactured in large sheets. Due to this, these are cost effective and also consume less power. They can replace fluorescent lamps and could reduce energy costs for lighting. They are lightweight and very thin because of which it can be used in cars in order to make more compact, efficient vehicles. For the same amount of light displayed, OLED uses less power than LCD and LED. With the usage of less power, OLED offers a brighter screen with more viewable angles [19].

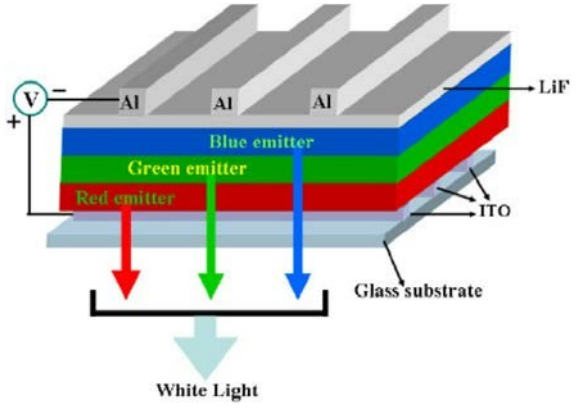

Figure 14: Structural design of White light OLED (Source: Google images Courtesy and copyright: 'How stuff work')

Due to their potentially high level of energy efficiency, even when compared to other OLEDs, PHOLEDs are being used in large-screen displays such as computer monitors or television screens, as well as general lighting needs. PHOLED panels are much more efficient and the colors are stunning. One potential use of PHOLEDs as lighting devices is to cover walls with large area PHOLED light panels. This would allow entire rooms to glow uniformly, rather than require the use of light bulbs which distribute light unequally throughout a room [21].

XV. APPLICATIONS OF OLED

1. OLED is a new generation technology and is already used in handheld instruments, automotive displays, portable media players, audio visual display systems and mobile phones.
2. The ultra thin lightweight nature OLED displays and their extremely low power consumption make them popular for handheld products such as data loggers and monitors, pistol grip thermometers, laser range finders, handheld instruments and meters.
3. Many medical applications such as defibrillators require bright displays with low power consumption. These can also serve as light source in scientific instruments [19]. OLEDs are also ideal for the emerging trend of wearable technology, such as mp3 players, recent additions to our OLED range include several modules with diagonal size less than an inch. These bright emissive displays perform well in diving watches, performance swimming monitors and other underwater applications - in the waterproof housing.
4. OLEDs perform exceptionally well at low temperatures with little degradation of response time, whereas TFT LCD displays will not function at lower temperature. This means OLED is now a viable alternative to LCD in many industrial applications [20].

XVI. CONCLUSION

An organic light emitting diode (OLED) emits light in response to an electric current. In order to improve OLED performance, progress has been made in organic electro luminescent materials and devices in terms of synthesis, development and application of electron transport materials. OLEDs are of different number of layers of the organic material. There is a basic single layer OLED; two layers; and also three layers OLED. The efficiency of the device depends on the number of layers of the organic material. The efficiency of the device increases with the increase in number of layers. The materials used or OLED device must fulfill some requirements such as suitability for specific fabrication procedure, good film-forming properties sufficiently high glass transition temperature to avoid crystallization of the layer material within desired lifetime of the device and chemical and photochemical stability. Another requirement is the lower triplet state of the host material of EML than the triplet of the emitting complex. Main feature of an OLED pixel is not that itis an emissive device which can be switched off and can be completely black, but in liquid crystal pixel it is transmissive device which does not allow complete occultation of backlight. OLEDs are offering many advantages over both LCDs and LEDs due to low power, light weight and rugged displays. The substrate and organic layers of an OLED are thinner, lighter more flexible and brighter than the crystalline layers in LED or LCD. OLEDs consume much less power than LCDs because it do not require backlighting. Today we can see vast use of OLEDs to create digit displays in various devices such as computer monitors, television screens, mobile phones, digital media players, digital cameras, and many more.

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