© INTERNATIONAL JOURNAL FOR RESEARCH PUBLICATION & SEMINAR
ISSN: 2278-6848 | Volume: 09 Issue: 03 | April - June 2018
Paper is available at www.jrps.in | Email : info@jrps.in

THE SCOPE OF OLED TECHNOLOGY: A REVIEW

[1]Swati , [2]Swati Bhasin
Research Scholar, Department of ECE, GIET, kanipla (Kurukshetra)**Chhayaswati94@gmail.com**
Assistant Professor, Department of ECE, GIET, kanipla (Kurukshetra **missbhasin@gmail.com**

ABSTRACT: *This is the review on the OLED technology. Here the evaluation of OLED has been discussed. Along with this the existing researches related to OLED has been discussed. Comparison of ORGANIC LIGHT EMITTING DIODE with LCD has been made here. More over the application of OLED TECHNOLOGY along with its future scope has been discussed.*

Keywords: OLED, LED, EQE, HTL,EML, HIL

[1] EVOLUTION OF OLED

The first report of a simple and efficient OLED structure was presented by Tang and Van Slyke in 1987 [1]. While working at Eastman Kodak, they were able to show electroluminescence from a two-layer organic stack, between an ITO bottom anode and silver cathode. Their organic structure consisted of the aromatic amine TAPC as a hole conductor and AlQ_3 as the electron transport material and emitter. This fluorescent device produced an external quantum efficiency (EQE) of 1%, a power efficiency of 1.5 lm/W and achieved a maximum luminance of over 1,000 cd/m^2**.** Electroluminescence from organic materials had been presented in the past but this structure was the first to achieve an EQE above 1% and produce high luminance values. Fluorescent emitters remained the state-of-the-art until 1998, when Forrest and Thompson reported the first use of iridium and platinum complexes to harvest triplet state excitons for phosphorescent emission. This breakthrough allowed the industry to realize 100% internal quantum efficiency (IQE) and paved the way for the development of highly efficient OLEDs [19]. Since their report, a wide variety of iridium and platinum based emitters have been developed that produce EQE's over 25% for blue-, green- and red emitting doped structures, with both vacuum and solution processed techniques.

These state-of-the-art OLED structures are multi-layer organic hetero structures. Each material/layer is chosen to reduce the energetic barrier between the electrodes and the recombination zone, and also improve carrier balance in the device. This design phase is critical in developing high efficiency devices with low voltage operations. In general, these layers consist of injection and transport layers. Hole-injection and electron injection layers (HIL and EIL, respectively) are used to modify the work function of the adjacent electrode to improve injection of holes and electrons into the organic layers. Hole transporting and electron-transporting layers (HTL and ETL, respectively) aid in the transport of holes and electrons into the emissive layer (EML) of the device. The EML, or host, material is carefully chosen to promote efficient formation and radiative relaxation of excitons for light emission [24]. Because phosphorescent emitters are doped in this host material, careful consideration must be made to the triplet energies of both materials to ensure an efficient exothermic energy transfer between the two triplet states. In order to realize high EQE devices, the host material must have several key properties. It must have a larger triplet energy than the dopant material. This becomes difficult for blue dopants, where triplet energies greater than 2.75 eV are necessary. It must have suitable energy levels to match the cathode and anode for efficient charge injection.) It must ensure a balanced charge distribution across the EML. Charge balance is critical because charge accumulation at the interface leads and to exciton quenching and maximizes the exciton formation zone across the EML, while also reducing device efficiency roll-off . Am bipolar host materials are materials that have similar hole and electron mobility values, thus promoting carrier balance and recombination in the EML. The design and development of new am bipolar materials is very important for improving device performance. Hole-injection and electron injection layers (HIL and EIL, respectively) are used to modify the work function of the adjacent electrode to improve injection of holes and electrons into the organic layers. This becomes difficult for blue dopants, where triplet energies greater than 2.75 eV are necessary. It must have suitable energy levels to match the cathode and anode

ISSN : 2278-6848
© International Journal for Research Publication and Seminar

for efficient charge injection.) It must ensure a balanced charge distribution .

While the current display market is many billions of dollars by any estimate, it is this emerging new paradigm that really drives the effort to produce displays that are vastly smaller, lighter, cheaper and more environmentally benign than today's. Organic electroluminescence (EL), a phenomenon first observed and extensively studied in the 1960's, forms the basis for the most likely candidate to serve this role. Because crystalline order is not required, organic materials, both molecular and polymeric, can be deposited far more cheaply than the inorganic semiconductors of conventional LED's. Until recently, the only significant commercial application of organic materials as active elements in electronics or photonics was xerography. Essentially all photocopiers today use organic photoconductors. Pioneer Electronics was the first company to alter this landscape, by introducing in 1998 a 64 x 256 pixel organic EL monochrome display for automobiles. Several other companies, notably Philips, Seiko-Epson, and an alliance of Kodak and Sanyo, are close behind.

Several reviews have been published to which the reader should refer for more details. The best general discussion of physical aspects is still the monograph of Greenham and Friend. The review in Science by Sheats and co-workers, though slightly dated, is still quite useful as an introduction for a general scientific audience; two other more detailed (but more recent) reviews, concentrating on chemical aspects, are listed at the end of the bibliography. The relevant synthetic chemistry has been extensively described by Holmes et al. In the following discussion we will very briefly list the most salient technical issues and comment on the current state of the art in performance characteristics.

[2] CONVENTIONAL OLED

Conventional organic light emitting diode displays are formed by vapour thermal evaporation (VTE) and are patterned by shadow-mask. A mechanical mask has openings allowing the vapour to pass only on the desired location. Like ink jet material repositioning, inkjet etching (IJE) deposits precise amounts of solvent onto a substrate designed to selectively dissolve the substrate material and induce a structure or pattern. Inkjet etching of polymer layers inorganic light emitting diodes can be used to increase the overall out-coupling efficiency. Inorganic light emitting diodes light produced from the emissive layers of the organic light emitting diode is partially transmitted out of the device and partially trapped inside the device by total internal reflection (TIR). This trapped light is wave-guided along the interior of the device until it reaches an edge where it is dissipated by either absorption or emission. Inkjet etching can be used to selectively alter the polymeric layers of organic light emitting diode structures to decrease overall TIR and increase out-coupling efficiency of the organic light emitting diode. Compared to a non-etched polymer layer, the structured polymer layer in the organic light emitting diode structure from the IJE process helps to decrease the TIR of the organic light emitting diode device [28].

Inverted organic light emitting diodes

In contrast to a conventional organic light emitting diode, in which the anode is placed on the substrate, an Inverted organic light emitting diode uses a bottom cathode that can be connected to the drain end of an n-channel TFT especially for the low cost amorphous silicon TFT backplane useful in the manufacturing of AMOLED displays.

Transparent organic light emitting diodes

Transparent organic light emitting diode s use transparent or semi-transparent contacts on both sides of the device to create displays that can be made to be both top and bottom emitting (transparent). TOLEDs can greatly improve contrast, making it much easier to view displays in bright sunlight. This technology can be used in Head-up displays, smart windows or augmented reality applications.

[3] LITERATURE SURVEY

Here in this research the existing research related to OLED has been discussed.

R. Y. Yang, and X. A. Cao [40] in this paper the organic hole-transport material CBP has been doped with WO3 or MoO3 by co-deposition and sequential deposition. In this research doping effects have been evaluated and compared through characterization of HODs and simple green OLEDs. Doped CBP HTLs prepared using sequential deposition of alternative 0.5 nm oxide and 3 to10 nm un doped CBP layers enabled comparable or even more efficient hole transport than CBP HTLs uniformly doped by co-deposition, giving rise to a turn-on voltage as low as 1 V in HODs. SIMS measurements revealed extensive diffusion of the oxide dopants in CBP which appears to be thermally driven, that has lead to uniform doping profile with little spatial concentration fluctuations. Simple Alq3-based green OLEDs with a doped CBP HTL was showing a minimized voltage and markedly improved lifetime under constant-current stressing compared to un doped OLEDs. The results of existing research shows that repeated sequential deposition represents a simple and variable doping strategy for some organic semiconducting material.

Chieh-Wei Chen, Yin-Jui Lu and Chung-Chih Wua [3] In summary, we report an effective connecting structure for tandem OLEDs. The connecting structure consists of a thin metal layer as the common electrode, a hole-injection layer on one side of the common electrode and an electron injection layer on the other side. Such a connecting structure permits efficient opposite hole and electron injection into two adjacent emitting units and gives tandem devices superior electrical and optical performances. Furthermore, the present connecting structure involves no sputtering or handling of reactive metals during device fabrication and thus renders device processing more feasible.

Bernard Geffroy, Philippe le Roy and Christophe Prat [4] Since the breakthrough by Kodak in 1987, organic light-emitting diodes (OLEDs) have been seen as one of the most promising technologies for future displays. A number of materials have been developed and improved in order to fulfil the requirements of this application. The materials differ from one another by their structure but also by the mechanism involved in the electroluminescence produced (fluorescence versus phosphorescence). When properly stacked, these materials result in a device that can achieve the required high efficiency and long lifetime. Such red, green and blue devices can then be combined in matrices to become the core of a display. Building up these structures onto a display backplane is one of the challenges facing the industry. The circuitry for driving the pixels can be adapted to the OLED, sometimes at the expense of the simplicity of the display, but bearing in mind that the fabrication process must remain industrially viable.

W.X. Li, J. Hagen, R. Jones, J. Heikenfeld [7] In summary, we have reported a device structure that contains a co-evaporated emissive layer of NPB and Eu complex responsible for blue and red emission, respectively. Voltage-induced color tuning capability from saturated red to deep blue was demonstrated with this simple method. The Eu complex has an energy gap approximately equal to that of NPB. This results in minimized energy transfer from NPB to Eu complex. Accordingly, a strong contrast between the absolute intensity of blue and red emission is achieved. The maximum luminous efficiency of 0.7 cd/A is obtained for a Eu doping concentration of 20 wt.% in NPB. This doping concentration resulted in CIE coordinates which can be tuned over $Dx = 0.44$ and $Dy = 0.19$.

J. Godlewski and M. Obarowska [8] The presented results referring the electroluminescence in organic materials show that it is generally believed that OLEDs have all the attributes to effectively compete with conventional light sources. However, it should be pointed out that the prospects of wide application require deeper understanding of OLED operation. Further investigation of the processes like injection or problems specific for high fields should be done. It should be noticed that though OLEDs have already reached the level required for practical application, they are still far below their physical potential.

Shahul Hameed, P. Predeep [14] Polymer Light Emitting Diodes, the most promising name in the field of display technology has received tremendous attention from various research groups. Being an interdisciplinary area of research, there has been challenging experiments on material science, device physics and chemistry of this organic display. This review unveils the development of PLEDs from its inception, bringing out important milestones in the materials used and phenomenal variations observed. Starting from the classical single layer device with MEH-PPV as emissive layer, multilayer devices, use of polymer blends, incorporation of nano particles and electro phosphorescent devices are discussed. Attempts have been made to shed light into adoption of alternate design strategies, thickness dependence changes, impedance behavior and the degradation property of the device.

Mao-Kuo Wei, Chii-Wann Lin, Chih-Chung Yang [12] In this paper, we review the emission characteristics from organic light-emitting diodes (OLEDs) and organic molecular thin films with planar and corrugated structures. In a planar thin film structure, light emission from OLEDs was strongly influenced by the interference effect. With suitable design of micro cavity structure and layer thicknesses adjustment, optical characteristics can be engineered to achieve high optical intensity, suitable emission wavelength, and broad viewing angles. To increase the extraction efficiency from OLEDs and organic thin-films, corrugated structure with micro- and nanoscale were applied. Microstructures can effectively redirects the wave guiding light in the substrate outside the device. For nanostructures, it is also possible to couple out the organic and plasmonic modes, not only the substrate mode.

Vanessa Wood and Vladimir Bulovic [13] Colloidal quantum dot light-emitting devices (QD-LEDs) have generated considerable interest for applications such as thin film displays with improved color saturation and white lighting with a high color rendering index (CRI). We review the key advantages of using quantum dots (QDs) in display and lighting applications, including their colour purity, solution process ability, and stability. After highlighting the main developments in QD-LED technology in the past 15 years, we describe the three mechanisms for exciting QDs optical excitation, Forster energy transfer, and direct charge injection that have been leveraged to create QD-LEDs. We outline the challenges facing QDLED development, such as QD charging and QD luminescence quenching in QD thin films. We describe how optical down conversion schemes have enabled researchers to overcome these challenges and develop commercial lighting products that incorporate QDs to achieve desired colour temperature and a high CRI while maintaining efficiencies comparable to inorganic white LEDs (_65 lumens per Watt). We conclude by discussing some current directions in QD research that focus on achieving higher efficiency and air-stable QD-LEDs using electrical excitation of the luminescent QDs.

Mohamad Saleh Al Salhi , Javed Alam [16] A recent advance in the field of light emitting polymers has been the discovery of electroluminescent conjugated polymers, that is, kind of fluorescent polymers that emit light when excited by the flow of an electric current. These new generation fluorescent materials may now challenge the domination by inorganic semiconductor materials of the commercial market in light-emitting devices such as light-emitting diodes (LED) and polymer laser devices. This review provides information on unique properties of conjugated polymers and how they have been optimized to generate these properties. The review is organized in three sections focusing on the major advances in light emitting materials, recent literature survey and understanding the desirable properties as well as modern solid state lighting and displays. Recently, developed conjugated polymers are also functioning as roll-up displays for computers and mobile phones, flexible solar panels for power portable equipment as well as organic light emitting diodes in displays, in which television screens, luminous traffic, information signs, and light-emitting wallpaper in homes are also expected to broaden the use of conjugated polymers as light emitting polymers. The purpose of this review paper is to examine conjugated polymers in light emitting diodes (LEDs) in addition to organic solid state laser. Furthermore, since conjugated polymers have been approved as light-emitting organic materials similar to inorganic semiconductors, it is clear to motivate these organic light-emitting devices (OLEDs) and organic lasers for modern lighting in terms of energy saving ability. In addition, future aspects of conjugated polymers in LEDs were also highlighted in this review.

Kihyon Hong and Jong-Lam Lee [15] Organic light emitting diodes (OLEDs) have rapidly progressed in recent years due to their potential applications in flat panel displays and solid-state lighting. In spite of the commercialization of OLEDs, they still have a low out-coupling efficiency of about 20% due to factors such as the total internal reflection, absorption, and surface Plasmon coupling. This light out-coupling efficiency is a major limitation on the high efficiency levels of OLEDs. Hence, enhancing the light out-coupling efficiency of OLEDs offers the greatest potential for achieving a substantial increase in the external quantum efficiency and power efficiency of OLEDs. Accordingly, significant advancements in OLEDs have driven the development of light extraction technologies as well as highly transparent conducting electrode materials. Recent efforts to combine light extraction structures with the improved out-coupling efficiency of OLEDs have produced OLEDs with an efficiency level that matches the efficiency of a fluorescent tube (>100 lm/W). This paper reviews the technical issues and recent progress in light extraction technologies and discusses ways of enhancing the out-coupling efficiency of OLEDs.

Khaty N.T., Muley A.A., Ugemuge N.S. [17] The polymer LEDs have many inherent properties that eliminates the need of backlight such as a) all colours are of the visible spectrum b)high brightness at low voltage a/current density c)no angle dependence e)operating life time 10000hrse)high response speed. In this technology there is much scope for the improvement and cost reduction The printing OLEDs on to flexible substrate opens the door to new application such as roll up display and displays embedded in fabrics or clothing .The biggest problem in OLEDs is limited lifetime .The intrusion of water into display can damage or destroy the organic molecule, improved sealing is required and may limit the longevity of the flexible display.

Dalip Singh Mehta, and Kanchan Saxena [18] In this paper we present various light out coupling techniques that have been implemented to enhance the external efficiency of OLEDs. Various internal and external OLED device modification techniques have been reviewed and discussed. Some of the most efficient techniques, such as, substrate modification, use of micro-lens array, two-dimensional photonic crystal structure, nano patterned and nano porous films are reviewed, and discussed.

Yibin Jiang a, Jiarong Lian c, Shuming Chen [21] In summary, by combining b-NBOLED and o-IBOLED together, we have achieved the fabrication of side-by-side color tunable OLEDs without mask alignment. The intensity of b-NBOLED and o-IBOLED can be independently controlled by the positive and the negative pulses of the square wave voltage source. Continuous color tuning has been demonstrated by simply adjusting the amplitude ratio of the positive and negative pulses. Due to elimination of mask alignment, the process TAC time may be reduced, yield may be improved and therefore manufacturing cost may be cut down. The performance of the demonstrated colour tuneable OLEDs can be further improved with finer metal mask and efficient electron injection layer for the o-IBOLED.

[4] ORGANIC LIGHT EMITTING DIODE VS LCD

An Organic Light emitting diode display had following advantages over an LCD display:

1. Improved image quality - better contrast, higher brightness, fuller viewing angle, a wider colour range & much faster refresh rates.
2. Lower power consumption
3. Simpler design that enables ultra-thin, flexible & transparent displays
4. Better durability ORGANIC LIGHT EMITTING DIODEs are very durable & could operate in a broader temperature range.

ORGANIC LIGHT EMITTING DIODEs are organic because they are made from carbon & hydrogen. There's no connection to organic food or farming - although ORGANIC LIGHT EMITTING DIODEs are very efficient & do not contain any bad metals - so it's a real green technology. Where could I find an Organic Light emitting diode display today. ORGANIC LIGHT EMITTING DIODEs are used today in mobile phones, digital cameras, VR headsets, tablets, laptops & TVs. SAMSUNG is clear leader in Organic Light emitting diode production for mobile devices, & company uses ORGANIC LIGHT EMITTING DIODEs in all of their flagship devices such as Galaxy S6, Note 5 & very latest Tablet Pro S. Other companies, including Apple, Motorola, Dell, Sony, Microsoft, and LG & Lenovo are also using ORGANIC LIGHT EMITTING DIODEs in some of their mobile devices [4,8].

[5] APPLICATIONS OF OLED

ORGANIC LIGHT EMITTING DIODEs represent a new generation in display technology & are already found in handheld instrumentation, automotive displays, media players, audio visual display systems & mobile phones shown in Fig 1.10. Organic Light emitting diode technology would increasingly become an alternative choice to Monochrome LCD in applications such as instrumentation, measurement equipment, current analyzers, bench top equipment, industrial handheld monitors, ticketing machines & vending machines. The ultra-thin lightweight nature of Organic Light emitting diode displays & their extremely low power consumption make them popular for handheld products such as data loggers & monitors, pistol grip thermometers, laser range finders, & handheld meters shown in Fig 1.10. New round shapes have opened up applications like wearables, watches, motorbike or bike instrument displays. Letterbox Organic Light Emitting Diodes work well for rack based units & AV equipment.

[6] FUTURE SCOPE

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

REFERENCES

[1] W. Hu, K. Manabe, T. Furukawa, M. Matsumura, ―Lowering of operational voltage of organic electroluminescent devices by coating indium-tin-oxide electrodes with a thin CuOx layer‖, in Applied Physics Letters 80 (2002) 2640-2643

[2] Hamilton M. C., Martin S., Kanicki J. *IEEE Trans. Electron Devices*, 51 (2004) 877.

[3] Chieh-Wei Chen, Yin-Jui Lu and Chung-Chih Wua (2005) "Effective connecting architecture for tandem organic light-emitting devices", digital object identifier 11.1108/TED.2005.2963699

[4] Bernard Geffroy, Philippe le Roy and Christophe Prat (2006) "Organic light-emitting diode (OLED) technology: materials, devices and display technologies".

[5] Ashtiani, Shahin J.; Reza Chaji, G.; Nathan, Arokia. "AMOLED Pixel Circuit With Electronic Compensation of Luminance Degradation". Journal of Display Technology 38: 36. DOI:10.1109/JDT.2006.890711

[6] E. Menard, M. A. Meitl, Y. Sun et al., "Micro- and nanopatterning techniques for organic electronic and optoelectronic systems," Chemical Reviews, vol. 107, no. 4, pp. 1117–1160, 2007.

[7] W.X. Li, J. Hagen, R. Jones, J. Heikenfeld (2007) "Color tunable organic light emitting diodes using Eu complex doping",

[8] J. GODLEWSKI and M. OBAROWSKA (2007) "Organic light emitting diodes", International Journal of Knowledge Engineering, 15/4 (2007) 179-183.

[9] W. A. MacDonald, M. K. Looney, D. Mackerron et al., "Latest advances in substrates for flexible electronics," Journal of the Society for Information Display, vol. 15, no. 12, pp. 1075–1083, 2007

[10] W. A. MacDonald, M. K. Looney, D. Mackerron et al., "Latest advances in substrates for flexible electronics," Journal of the Society for Information Display, vol. 15, no. 12, pp. 1075–1083, 2007

[11] D.-H. Lee, J. Choi, H. Chae, C.-H. Chung, and S. M. Cho, (2008) "Single-layer organic-light-emitting devices fabricated by screen printing method," Korean Journal of Chemical Engineering, vol. 25, no. 1, pp. 176–180, 2008.

[12] Mao-Kuo Wei, Chii-Wann Lin, Chih-Chung Yang (2010) "Emission Characteristics of Organic Light-Emitting Diodes and Organic Thin-Films with Planar and Corrugated Structures", Int. J. Mol. Sci. 2010,

[13] Vanessa Wood and Vladimir Bulovic´ *(2010) "Colloidal quantum dot light-emitting devices",

[14] Shahul Hameed, P. Predeep (2010) “Polymer Light Emitting Diodes - A Review on Materials and Techniques”,

[15] Kihyon Hong and Jong-Lam Lee (2011) “Review Paper: Recent Developments in Light Extraction Technologies of Organic Light Emitting Diodes”, Electronic Materials Letters, Vol. 7, No. 2 (2011), pp. 77-91

[16] Mohamad Saleh AlSalhi, Javed Alam (2011) “Recent Advances in Conjugated Polymers for Light Emitting Devices”, Int. J. Mol. Sci. 2011

[17] Khaty N.T., Muley A.A., Ugemuge N.S. (2012) “A Review -The Development In Organic Light Emitting Diodes The Future Of Displays”, International Journal of Knowledge Engineering, Volume 3, Issue 1, 2012, pp.-89-90.

[18] Dalip Singh Mehta, and Kanchan Saxena (2012) “Light out-coupling strategies in organic light emitting devices”, Proc. of ASID’06, 8-12 Oct, New Delhi .

[19] Bower C. A., Menard E., Bonafede S., Hamer J. W., Cok R. S., IEEE Transactions on Components packaging and manufacturing Technology, 1 (2013) 1916

[20] M. Aleksandrova, G. Kolev, I. Cholakova, G. Dobrikov, and G. Bodurov, “Photolithography versus lift off process for patterning of sputtered indium tin oxide for flexible displays,” International Journal of Thin Films Science and Technology, vol. 2, no. 2, pp. 67–75, 2013.

[21] Yibin Jiang a, Jiarong Lian c, Shuming Chen (2013) “Fabrication of color tunable organic light-emitting diodes by an alignment free mask patterning method”.

[22] Hakim Choukri, Alexis Fischer, Sébastien Forget (2013) “White Organic Light-Emitting Diodes with fine chromaticity tuning via ultrathin layer position shifting”.

[23] Mr. Bhrijesh N. Patel, Mr. Mrugesh M. Prajapati (2014) “ OLED: A Modern Display Technology”, International Journal of Scientific and Research Publications, Volume 4, Issue 6, June 2014

[24] Junichi Tanaka, Mitsuru Morimoto, Takashi Kawai, Fujio Kajikawa (2014) “Development and Mass-Production of OLED Lighting Panels with High Luminance, Long Lifetime and High Efficiency”, Mitsubishi Heavy Industries Technical Review Vol. 51 No. 3

[25] Askari Mohammad Bagher (2014) “OLED display technology”, American Journal of Optics and Photonics 2014

[26] Y. Karzazi (2014) “Organic Light Emitting Diodes: Devices and applications”, J. Mater. Environ. Sci. Laboratory of Applied chemistry CNRST-URAC-18, Faculty of Sciences ISSN, B.P. 4808, 60 046 5 (1) (2014).

[27] Hyun-Su Choi, Hye-Kyung Kwon, Keun-Soo Kim, Joon-Sik Park And CHoel-Hee Moon IEEE TRANSACTION Packaging And Manufacturing Technology, Vol 4, No 7 , July 2014