ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

NEW ERA IN SOLID STATE LIGHTING: ORGANIC LIGHT EMITTING DIODE (OLED)

[1]Pahulpreet Kaur, [2]Harjeet Singh
[1,2]Guru Nanak Dev University, Regional Campus, Gurdaspur, Punjab-143521, INDIA
Email: [1]randhawa.pahulpreetkaur672@gmail.com, [2]hs_kahlona@yahoo.com

ABSTRACT

This paper highlights the momentous innovation behind optoelectronic gadgets that are demonstrating incredible potential as cutting edge solid state lighting innovation. In reality, organic devices have the potential for cost purposes of enthusiasm over inorganic devices. Besides, the organic materials are exceptionally suited for particular application regions, such as, fabricating on flexible substrate because of their certain characteristic properties. From the two given electroluminescence phenomena i.e. (fluorescence or phosphorescence) is made by materials that are used as a piece of organic light emitting diode. OLED device thickness is 100 to 500 nanometers which is roughly 200 times little than a human hair. This Self-luminous property of organic materials takes out the need of backlight in displays when contrasted with LCD displays. Thus, OLED devices are thinner, lighter and more flexible and are best suited due to their tremendous advantages.

Keywords: OLED, Electroluminescence, LCD, exciton, phosphorescence, LED.

I.INTRODUCTION

An OLED is an LED having an electroluminescent layer made of organic compounds. Small organic molecules or macro polymers are fit for conducting electricity of which electroluminescent layer is made. OLEDs are by and large considered as organic semiconductors because of their conductivity level going between insulators to conductors. One of the two electrodes between which the organic material layer is sandwiched is transparent. OLED devices need not bother with backlighting as contrasted with LCD resulting in compact and thinner

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

display [12]. In this paper, we are highlighting recent advances in OLED innovation with enhanced understanding of excitons utilizing different materials emitting light on utilization of electric current.

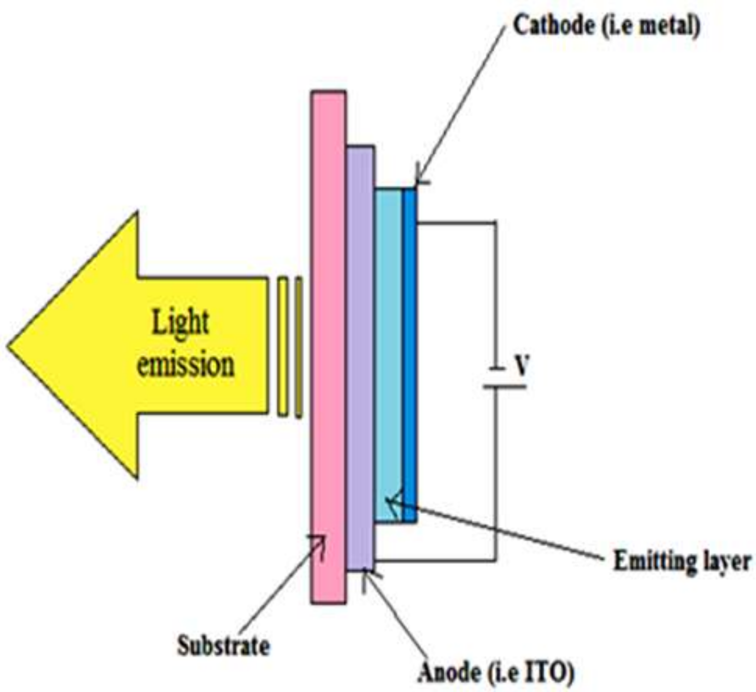

Fig 1. Typical Structure of OLED

II.BACKGROUND

In 1953, perception of electroluminescence in organic materials for the interestingly was seen by Andre Bernanos at Nancy-University in France [13]. High exchanging voltage was connected to materials such as acridine orange and produces Blue emission from LED on Li complex. After that, Martin Pope along with his associates in 1963 at New York University took a shot at the small anthracene crystals and developed an ohmic dark-injecting electrode [14]. Essential requirements for hole and electron infusing electrode contacts were examined. In all modern OLED devices, these contacts serve as basics of charge injection. In year 1976, Kalinowski initially watched direct current electroluminescence under vacuum from tetracene crystals [15].

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

TABLE I. Evolution of OLED

Year	**Author & References**	**Materials, Structure & Emission**
1953	Bernanose *et al*. [13]	Blue emission from LED on Li complex
1963	Pope *et al.* [14]	EL from anthracene crystals
1976	Kalinowski et al. [15]	EL from tetracene crystals
1983	Partridge [16]	EL from polymers
1987	Tang and Van Slyke [17]	Double- layer organic solid LED
1990	Burroughes et al. [18]	Single-layer PLED
1993	Greenham et al. [19]	Double-layer PLED
2007	M. Hack et al. [20]	Technology Flexible OLED display

This electroluminescence is now brought on by the recombination of thermalized electrons and holes having conductivity level higher than exciton energy level. In 1983, Roger Partridge at National Physical Laboratory in UK that observed electroluminescence from polymer films [16]. 2.2 micrometer thick layer of poly(n-vinyl carbazole) was sandwiched between the two infusing electrodes and consequence of that venture was licensed in 1975 and thus published in 1983. In 1987, Ching W.Tang and Steven Van Slyke developed first diode device that was accounted for at Eastman Kodak [17].The Double layer organic solid LED having separate hole and electron transporting layers bringing about recombination and emitting light in center of organic layer. Hence, this structure has point of preference of decreased operating voltage and effectiveness change. In the year 1990, research in source of the electroluminescence from polymers begins with J.H.Burroughes at Cavendish Laboratory in Cambridge bringing about efficient single layer polymer LED. 100nm thick film of the poly(p-phenylene vinylene) was utilized as coming about as a part of profoundly productive green PLED. Analysts at the Department of energy and

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

Pacific Northwest National Laboratory invented technologies for the flexible OLEDs: initially, flexible surface provided by flexible glass and second, Barix thin film coating to shield flexible display from environmental conditions [20]. Recently, the OLEDs are seen as a promising innovation for next generation flexible displays and lighting applications.

III.WORKING PRINCIPLE

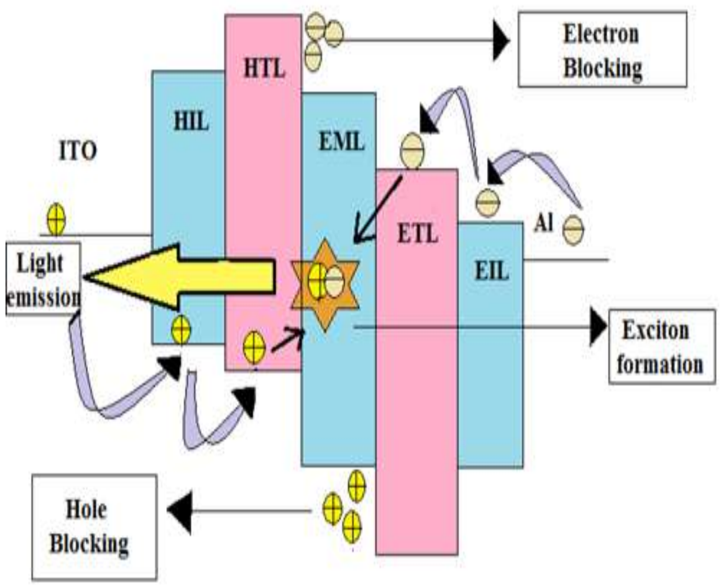

Fig.2 Working principle behind OLED

In an OLED, organic layer is sandwiched between two terminals (i.e. anode and cathode) deposited on substrate that may be rigid or flexible. Conductivity of organic molecules is for the most part as a result of delocalization of pi electrons caused by conjugation over particular part or entire molecule [4]. When we apply potential difference across anode and cathode such that anode is at having more positive electrical potential as compared to cathode then electrons are infused from anode to highest occupied molecular orbital (HOMO) of hole-transport layer (HTL), while infusion of electrons takes place from cathode to lowest unoccupied molecular orbital (LUMO) of electron-transport layer (ETL). Hopping transport mechanism is utilized by holes within HTL until they reach ETL interface where they build up at band edge mismatch. Mostly Emissive devices have conversion efficiency given by

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

$$\eta(E) = \eta(\phi)\frac{\varepsilon(p)}{eV}$$

In meantime, same mechanism of hopping transport is utilized by electrons for infusion to ETL to same heterojunction where they also accumulate across it [14]. Here, portion of buildup electrons and holes can cross the heterojunction interface and make firmly bound the electron-hole (e-h) pairs on each individual molecule on either the HTL or the ETL. This e-h pair generated is referred as exciton and thought of as single particle [1]. These e-h pair generated relaxes either radiatively emitting light of optical band gap or non-radiatively, losing absorbed energy in form of heat.

IV.MATERIALS

Both efficiency and lifetime of the device is reliant on material used. In this manner, utilization of new materials permits a noteworthy change in efficiency of OLED device. The efficiency of OLEDs have grown tremendously from first generation fluorescent materials to novel transport and emissive layer host materials defeating LED's in terms of efficiency at wavelength close to 550nm. Besides, the operating lifetime of the devices has enhanced on account of nonstop improvement of the OLED materials [4]. Distinctive quantities of organic layers result in different components in an OLED. Commonly used are a single layer, two layers and also three layer OLEDs. Efficiency of the device enhances with expanding number of organic layers. This increment in number of layers likewise helps in blocking a charge from being dumped after reaching the opposite electrode as it helps in infusing charges at electrodes.

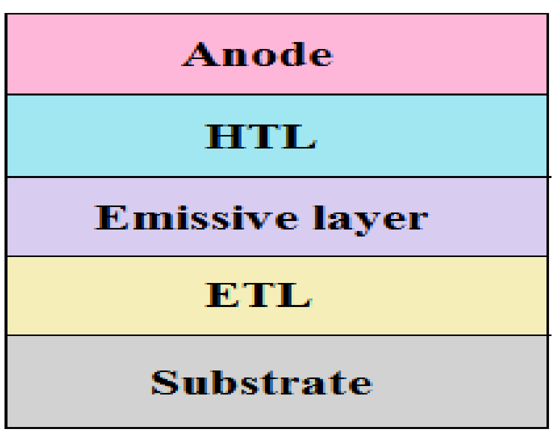

Fig.3 Basic OLED Architecture

Fundamental OLED structure consists of following components:

A. Substrate: Fundamental usefulness of utilizing substrate is to provide support to OLED devices. Plastic, foil or glass is commonly used substrate materials. Bottom emissive devices have transparent substrate for section of light out of structure.

B. Anode: Indium tin oxide (ITO) is transparent to visible light and is commonly used anode material. ITO has adequate conductivity and the high work function elevating infusion of holes to HOMO level of organic layer. PEDOT: PSS polymer is another used electrode having the HOMO level generally between work function of ITO and HOMO of other commonly used polymers. Graphene is also material that can be used as anode.

C. Emissive layer: Polyfluorene is a commonly used emissive layer material that is produce from organic plastic molecules. Holes are generally more versatile than electrons in organic semiconductors. The e-h pair generated generally decay from excited state to ground state resulting in emission of radiation having visible region frequency range [4]. Thus, band gap of material i.e. the difference between energy of HOMO and LUMO chooses the output frequency.

D. Electron transport layer: This layer encourages the infusion of electrons from cathode toward the emissive layer for recombination to take place. PBD, Alq3, TPBI and BCP are commonly used organic materials utilized as electron transport purpose [4].

E. Hole transport layer: This layer facilitate the infusion of holes from anode toward emissive layer for the recombination to take place. Mostly p-type materials such as TPD and NPB are used as hole transport materials.

V.FABRICATION METHODS

By and large, ordinarily utilized procedures for manufacturing of OLEDs are: thermal evaporation, spin coating and inkjet printing. Method of thermal evaporation is completed in vacuum having pressure 10-6 torr or better generally used to deposit cathode materials. Thermal evaporation is worthwhile as it allow thickness of each and every layer to be monitored effectively and provide us multi-color displays [6]. The Polymer based LEDs utilize the technique of spin coating that allows polymer layers to be deposited directly from the solution but is impossible to monitor thickness. Inkjet printing have point of preference of mask-less patterning and applicability on wide variety of substrates, non-contact processing etc.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

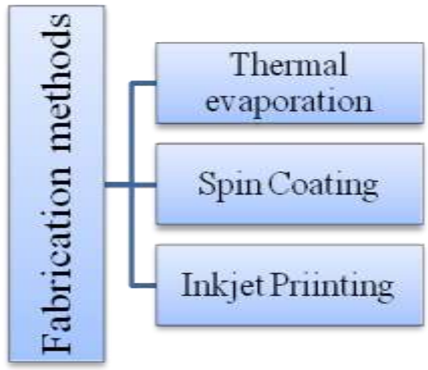

Fig.4 Fabrication methods

VI.CONCLUSION

Enhanced productivity of OLED devices makes electronic technology more convenient. In present time, OLED technology is relied upon to contribute substantial in the flat and large panel displays and is expected to grow further in near future with development of flexible displays [12].Thus, OLED offer numerous favorable circumstances over LEDs and LCDs as they are more slender, flexible and lighter having larger field of view as they generate their own light instead of backlighting.

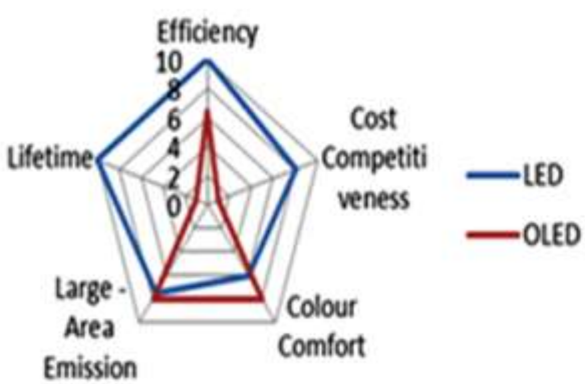

Fig 5. LED vs. OLED

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

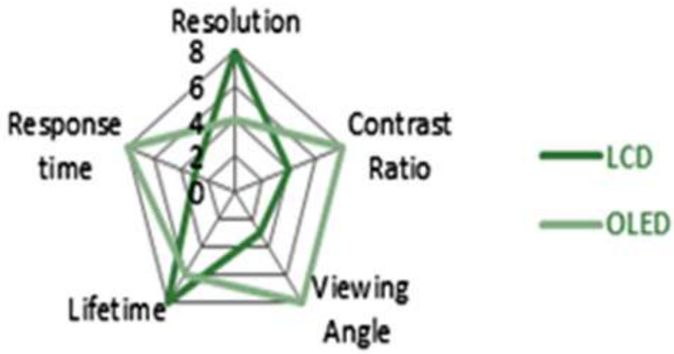

Fig 6 OLED VS LCD

VII. FUTURE SCOPE

Continuous improvements in innovation work of OLEDs are being made that in near-future may lead to such numerous applications: head up displays, automotive dash boards, billboard type displays etc. Video images in OLED could be more sensible with steady updation [12]. Due to tremendous advantages of this technology, OLEDs can replace LCDs in near future.

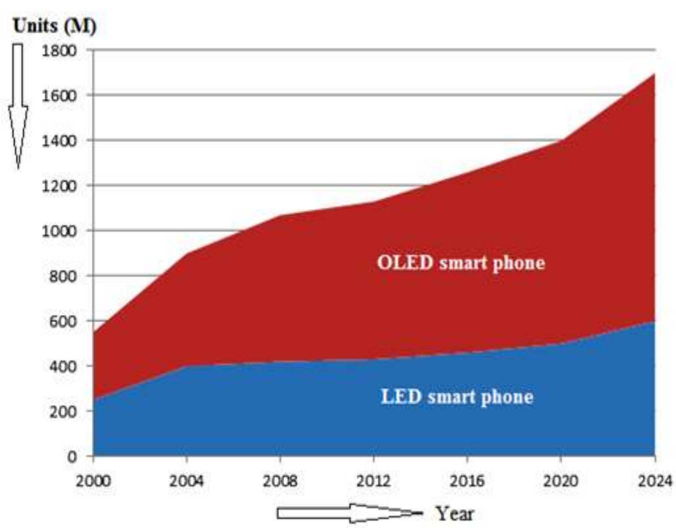

Fig.7 Future of OLED

REFERENCES

[1] Tang C.W, VanSlyke S.A; Chen C.H, J.Appl. Phys., 65(1989)3610.

[2] Braun D, Heeger a, J Appl. PhScott J.C, Malliaras G.G, Semiconducting Polymers, Chap. 13, Ed. Hadziioannou G, van Hutten P.F, Willey, 2000.ys.Lett, 58(1991)1982.

[3] Stephen R Forrest, “The road to high efficiency organic light emitting devices” Proceeding of Sciencedirect-2003.

[4] Wolfgang Brutting and Chihaya Adachi, “Physics of Organic Semiconductors” Proceedings of Wiley-VCH Verlag & Co. KGaA, Germany.

[5] Hamilton M.C, Martin S, Kanicki J, IEEE Trans. Electron DEVICES, 51(2004)877.

[6] Kulkarni A.P, Tonzola C.J, Babel A, Jenekhe S.A, Chem. Mater., 16(2004)4556.

[7] Yan H, Huang Q, Scott B.J, Marks T, J. Appl. Phys. Lett., 84(2004).

[8] Yao-Shan Wu, Tswen-Hsin Liu, Hsian-Hung Chen, Chin H. Chen, “ A new yellow fluorescent dopant for high-efficiency organic light-emitting devices” Proceeding of Sciencedirect-2006.

[9] Walzer K, Maenning B, Pfeiffer M, Leo K, Chem Rev, 107(2007)1233.

[10] Kim S, Kwon H.J, Lee S, Shim H, Chun Y, ChoiW, Kwack J, Han D, Song M.S, Kim S, Mohammadi S, Kee I.S, Lee S. Y, Adv. Mater, 23 (2011)3511.

[11] Bower C.A, Menard E, Bonafede S, Hamer J.W, Cok R.S, IEEE Transactions on Component packaging and manufacturing Technology, 1(2011)1916.

[12] Y.Karzari, J.Mater. Environ. Sci. 5(1)(2014) 1-12.

[13] B.Bemanose M.Comte, P. Vouaux, Blue emission from light-emitting diodes based on lithium complex, Journal of Chemical Physicsique 50(1953)64-69(in French).

[14] M.Pope, H.Kallmann, PMangnate, Electroluminescence in organic crystals, Molecular Crystals and Liquid Crystals 38(1963).

ISSN: 2348 9510

International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

[15] J.Kalinowski, J.Godlewski, R.Signerski, Electroluminescence in organic crystals, Molecular Crystals and Liquid Crystals 33(1963)247-259.

[16] R.H.Partrige, Electroluminescence from polyvinylcarbazole films, Polymer 24 (1983) 733-762.

[17] C.W.Tang, S.A.Van Slyke, Organic electroluminescent diodes, Applied Physics Letters 51(1987)913-915.

[18] M.Hack, R.Hewitt, K.Urbanik, A.Chwang, J.J.Brown, Full colour top emission AMOLED displays on flexible metal foil, Proceeding of the IMID/IDMC'06 Digest Conference, Daegu, South Korea, 2006, 305-307.