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SUSTAINABLE DEVELOPMENTS IN LIGHT EMISSIVE ORGANIC MATERIALS DEVICES: A REVIEW

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Abstract

The cutting edge development technology era, an organic material based electronics has surpassed the traditional semiconductor based light and display devices due to its promising features. The light emission from OLED are making it most attractive luminescent lighting and display technology because of low cost, easy fabrication at lower temperature and mechanical flexibility compared to CFL and LCD. It is therefore necessary to study the recent development in the field of OLEDs in order to understand its applicability towards the enhanced optical performance in the design of light and display devices. The device structures, color emission techniques, compatible materials and efficiency methods of considered. Organic LEDs create light with application of electricity; material is sandwiched between emissive layers of two electrodes. Recombination of hole or electron in these devices like OLED, WLED employed them in lighting and display technology.

Keywords- OLEDs, Luminescence, Display.

1. Introduction

Recently, a lot of researches have pointed to an electronic device called organic light emitting diode (OLEDs & WLEDs), which have been considered as a new generation lighting and display panels; and also for the room lighting devices. Comparing with the conventional display devices Such as CFL lamp, PDP& LCD display it possesses some attractive features, such as fast response time, wide viewing angle and low power consumption.The implementation of flexible electronics came into existence with the advent of organic semiconductors whose properties changes with change in organic materials (carbon based compound, available in both natural and engineered form). Both organic based devices are and inorganic based devices have some merits and demerits over each other [1] that are illustrated in Fig. 1. The study of organic electronics has been focusing as an emerging trend by various material researchers [2-6]. The light emissive performance of performance of organic based devices and circuits are far better than traditional material based devices [7-11].

The emission of light on account of electric field is termed as electroluminescence. In 1960s it was found in single crystal of anthracene [12]. First OLED (Organic Light Emitting Diode) was practically demonstrated in 1987 by an American scientist Ching W. Tang and his co-worker Steven Van Slyke at Eastman Kodak, USA [13]. OLED now attracted the interest of entire world for the purpose of flexible display technology and became commercialized. It dominated market over CRT, CFL and LCDs due to its advance feature and performance.

Inorganic Material	Organic Material
High Performance	Better Performance
High cost	Low cost
High temperature	Low Temperature Easy fabrication
Low output power	Mechanically Flexible
Makes pollution	Eco friendly

Fig. 1. Comparison inorganic and organic semiconductor material.

The first EL phenomenon was discovered in 1907 by using a piece of carbrundum (SiC) crystal by H. J. Round [14]; and, the first observation of electroluminescence from organic materials were made in the 1950s [15-16], applying high voltages in air to acridine orange. DC EL found in crystal of anthracene by Pope external E.F. is absent, light emited from anthracene crystals by recombination of electron and hole. Helfrich and Schneider reported bright EL from a single crystal and the device structure they used was ITO/diamine/tris(8-quinolinolate) aluminum (Alq_3)/MgAg [17-18], The stability, performance and illumination efficiency were comparatively low, based on this primary work, they suggested many important ideas for developing and enhancing the device performance. Like to enhance the device performance is the injection of many electrons and holes into the organic materials at low voltage level. Later on , Holonyak created the first inorganic LED which was based on Gallium Arsenide Phosphide (GaAsP) [19-20].

In 1975, the first organic electroluminescence devices made with the polymer polyvinyl carbazole (PVK) were demonstrated [21]. Electro luminescence of polymer films was observed by Roger Partridge at NPL,UK. It had a film of poly (n-vinyl carbazole) between two charged injecting electrons, recombination and light emission in middle of the organic layer, leading to OLED research and device production. Since the 1990s, most of the research in the OLED-fields has focused on polymers and small molecule materials like in sensors and photovoltaics [22]. At present large research fraternity working on development of EL polymers, such as Cambridge Display Technologies ,Covion Organic and UNIAX Corp, for progressive development and to enhance efficiency, long lifetime of organic light emissive materials.

2. Materials and structure

OLED is a electronic device consist of thin-film, monolithic semi-conductor device which emits light on account of potential difference. There are various ways to generate o light when electric filed is applied to organic materials, commonly known as EL (electroluminescence). OLED consists of series of high pressure vacuum deposited, organic thin films between two conducting film . An OLED device has hole-transporting layer (HTL) and electron– transporting layer (ETL)[23-24] sandwiched between two electrodes. OLEDs are different from inorganic LEDs for the basics reasons. Firstly, films of small molecules for OLEDs are wide energy gap semiconductors. Secondly singlet and triplet excitons which are neutral molecules in excited state are generated by recombination of charge and emission because of radiative transitions.

Structural component of an OLED

1. Substrate- the substrate in an OLED may be a plastic foil or glass.
2. Anode- indium tin oxide (ITO) is the anode component for injection of holes.
3. Hole-transport layer (HTL) - The p-type materials for OLED are TPD and NPB.
4. Emissive layer- consists of organic plastic molecules like poly-fluorine holes are more mobile than electrons in organic semiconductors.

In organic material, emission of light (EL), taken place by process of charge injection, charge transportation, excitation, and thus OLEDs structures are based on various combinations of emitting, carrier transporting, carrier blocking and electrode materials. Sometimes, buffer layers are inserted and electron injection layer (EIL) and hole injection layers (HIL) may also be desirable to increase the illumination efficiency and extend the reliability of the OLED devices. Material required to fabricate OLEDs should have

(1) Suitable ionization potentials for the injection of charge carriers.

(2) Smoothness to uniform deposition films/layers without pinhole.

(3) Materials should be morphologically stable, which ensures the materials do not crystallize, melt or change phase during the fabrication and operation.

(4) Materials should be thermally stable; materials with high glass transition temperature (Tg) are desirable.

3. Common categories of OLEDs

1] Passive- matrix OLED (PMOLED):-

PMOLEDs basically consist of organic layers and anode and cathode strips .Intersection of strips makes pixels where light is emitted. For brighter pixel the more amount of current is applied. Found variety of applications in MP3 player, cell phones displays.

2] Active matrix OLED (AMOLED) :-

AMOLEDs include complete layers of cathode, organic components and anode. The layers of anode consists of TFT (thin film transistors) in parallel to form a matrix, which helps in switching each pixel to it‘s on or off state as required hence, forming an image. This is least power consuming type and has quick refresh rates. They found applicability in computer monitors, electronic signs or big TV screens.

3] White OLEDs

White OLEDs are characterized by emission of brighter white light than CFL and incandescent bulbs. Since they are manufactured in big sheets, are cost-effective and consumes less power, White OLEDs are thin and light-weight making vehicles more compact and efficient.

4] Transparent OLEDs

TOLEDs have only components which are transparent as the name suggests like substrate, cathode and anode. When a display of such kind is turned on, light is allowed to pass in both directions. It is applied in both active and passive matrix categories. TOLEDs are applied into a rear-view mirrors and transmitters or had-up information systems.

5] Top-emitting OLED

Such OLEDs have either an opaque or reflective substrates. They are preferred for active-matrix applications due to easily integrated with a non-transparent transistor backplane , found uses in smart cards.

6] Foldable OLEDs

FOLEDs have substrates out of flexible metallic foils or plastics. They have advantages of flexibility, durability and lightweight quality. Since the material has high strength, it decreases breakage and hence, are used in GPS devices, mobile phones and big curved screen TVs.

7] PHOLEDs

PHOLEDs decreases heat generation produce air conditioning, we find its application in computer monitors and TV screens or light panels.

7. Colour Generation In OLEDS

Colors are generated in full color display ,like red, blue, green and white [25]. All the three colors are generated individually, but have shorter life time as blue color degrades faster [25]. The approach is quite simpler, only single luminescent material is used and polished with color converter film to produce other colors. white color produce by mixing two or more different color polymers on a single layer which can generate a good quality of white light or segregating all the three colors red, blue and green on three separate emissive layer

8. Fabrication

The film forming properties OLEDs makes them attractive for easily applied over large surfaces using simple and economically viable coating techniques like inkjet printing.

1. Transfer- printing

Light adhesive polymer layers are placed to increase resistance to particles. OLED layers are applied to anode layer through conventional vapour deposition methods. It can print on target substrates till 500mmX400mm. it is used for fabrication of OLED / AMOLED displays.

2. Inkjet printing

This technology involves a solution which is dispensed onto substrate using inkjet nozzles. Drops of few Pico litres are injected at inkjet head. It has very high efficiency and decreases the cost of OLED manufacturing. With this, an OLED can print on very large films for big displays like dashboards, TV screens.

3. Vacuum thermal evaporation and shadow masking In this method, small organic Molecules are generally evaporated and condensed as thin films on cooled substrates. A 20-100 micrometers thick shadow mask is kept on crucible and substrate is set on top of it.

4. Organic vapour phase deposition (OVPD)

It‘s a technique which is very efficient as well as cheaper. In low pressure, hot-walled chamber, a gas shall transport heated organic molecules to cooled substrates where it condenses to thin films.

9. Superiority of OLEDs compare to other Technologies

1) Simple and Easy process operate at low temperature using inkjet printing, vacuum thermal evaporation etc.
2) Large scale production is possible roller vapour deposition technique.
3) Cost effective, energy efficient, environment friendly.
4) OLEDs light weighted and flexible
5) With ambient conditions they produce high resolution, high contrast ratio with 360 degree viewing angle, as pixel of OLEDs are accessed with faster response time.

10. Conclusions:

The organic material employed lighting and display devices are emerging trends in the area of advance electronics applications, and becomes one of the most influential and attractive field of research in overseas years. The power generation and demand of market is almost compensated by the OLEDs because of its promising features. Progressive Research and development in OLEDs have focusing the future applications like flexible displays and dashboards etc. As the trends and stylish Urban/Metro life, OLEDs are being drastically commercialized and this technology is almost adopted by Electronics producers. Much thing are happen in OLEDS and many more to come but surely OLED have a potential to lead in future lighting and display market .However, these organic materials still need a complete turn in order to make highly stable equally efficient with long journey.

11. References:

[1] B. Kumar, B.K. Kaushik, Y.S Negi, Microelectron. Rel. 54, vol. 12, pp. 2801–2812, 2014.

[2] B. Kumar, B. K. Kaushik and Y. S. Negi, IET Circuits, Devices & Systems, vol. 8, no. 2, pp. 131–140, 2014.

[3] B. Kumar, B.K. Kaushik, Y.S. Negi and V. Goswami, Microelectron. Rel., vol. 54, no. 1, pp. 100–109, 2014.

[4] Kaushik, B. K., Kumar, B., Mittal, P., Prajapati, S., CRC Press, 2016.

[5] B. Kumar, B. K. Kaushik, Y. S. Negi, Polymer Reviews, vol. 54. no.4, pp. 33–111, 2014.

[6] B. Kumar, B. K. Kaushik, Y. S. Negi, “J. Mater. Sci. Mater. Electron. 25 (1), pp. 1–30, 2014.

[7] P. Mittal, B. Kumar, Y.S. Negi, B.K. Kaushik and R.K.Singh, Microelectronics Journal, vol. 43, pp. 985-994, 2012.

[8] B. Kumar, B. K. Kaushik and Y. S. Negi, Journal of Computational Electronics, vol. 13, no. 3, pp. 1-12, Sept. 2014.

[9] B. Kumar, B. K. Kaushik, Y. S. Negi, S. Saxena, and G. D. Varma, Microelectronics Journal, vol. 44, no. 9, pp. 736–143, Sept. 2013.

[10] B. Kumar, B. K. Kaushik, and Y. S. Negi, Journal of Computational Electronics, vol. 12, no. 4, pp. 765–774, Dec. 2013.

[11] B. Kumar, B. K. Kaushik, and Y. S. Negi, “IEEE, Journal of Vacuum Science and Technology B: Microelectronics and Nanometer Structures, vol. 31, no. 1, pp. 012401-1–012401-7, Jan. 2013.

[12] Helfrich, W. and Schneider, W. G., Phys. Rev. Lett. Vol. 14**,** No**.**7**,** pp**.** 229-231, Feb. 1965.

[13] Tang, C. W. and VanSlyke, S. A., Appl. Phys. Lett Vol. 51**,** No. 12**,** pp**.** 913-915, 1987.

[14] HJ Round, A note on carborundum, Electron. World, 19:309–310, 1907.

[15] A Bernanose, M Comte, and P Vouaux, J. Chim. Phys., 50:64–68, 1953.

[16] A Bernanose, J. Chim. Phys., 52:396–400, 1955.

[17] Helfrich, W. and Schneider, W.G., Phys. Rev. Lett., 14, 229, 1965.

[18] Helfrich, W. and Schneider, W.G., J. Chem. Phys., 44, 2902, 1966.

[19] N Holonyak Jr. and SF Bevacqua, Appl. Phys. Lett., 1:82–83, 1962.

[20] Elschner, F. Jonas, S. Kirchmeyer, W. Lövenich, N. Koch, K. Fehse, M. Pfeiffer, K. Walzer, K. Leo, Proc of the 13th Int. Display Workshop, Otsu, Japan, 6 - 8 (2006)

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

[22] TS Perry, Red hot, IEEE Spectrum, June 3, 2003.

[23] RH Partridge, Radiation Sources, U.S. Patent 3,995,299, 1976.

[24] CW Tang, Two-layer organic photovoltaic cell, Appl. Phys. Lett., 48:183–185,1986.

[25] Geffroy, Bernard, Le Roy, Philippe and Prat, Christophe, Polymer International Vol**.** 55, No. 6, pp. 572-582, 2006.