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COMPARISON OF A NEW HOST MATERIAL FOR ORGANIC LIGHT EMITTING DIODES

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Abstract—**Organic light emitting diodes (OLEDs) are a new branch of LED technology which has in recent times gained a lot of attention. The major obstacle in organic light emitting diodes (OLEDs) is that it has low extraction efficiency. So here we are trying to concentrate on emissive materials to improve the extraction efficiency and it is also said that new emissive layer produces red light in OLED. We compare a new emissive material, Methyl ammonium lead iodide with a reference material NDP (afamelanotide) and obtained the graphical results of ex-traction efficiency and internal quantum efficiency (IQE).**

Keywords—produces red light, high IQE, high enhancement of extracted light at a particular wavelength.

I. INTRODUCTION

OLED is the abbreviation for light-emitting diode. The organic light emitting diode technology came into existence by the work of Eastman Kodak in the 1980s [1]. In general it is a special type of traditional LED (light emitting diode). It is called organic, because the emissive layer consists of a thin-film of certain organic compounds. By its definition it is a chemical compound whose molecules contain hydrogen and carbon. Organic light-emitting diode (OLED) consists of an electroluminescent layer which is a film of organic compound that emits light when current is passed through it. This layer is situated between two electrodes namely cathode and anode among which one is generally transparent.

OLEDs consists of several functional layers like glass substrate, transparent anode, hole transport layer, emissive layer, electron transport layer and metal cathode.

OLED technology is emerging rapidly and it will be the leading technology in years to come. A lot of research is being carried on OLEDs as it is expected to lead the digital market.

OLEDs are already used in mp3 players, cellular phones, digital cameras, television screens, computers and many other products. It is also believed that OLEDs will emerge as a leading next-generation technology for displays and lighting.

It can also be used as a light source for general space illumination. Some of the advantages of OLED technology rely on the easiness of chemically modifying the materials, to tune the colors, they can display deep black levels and are thinner and lighter when compared to LCD panels. OLED displays can also achieve higher contrast ratio [2]. This is the reason OLEDs are now commonly used in Televisions. The most common reason of OLEDs being in trend is their greater lifetime than LCDs or LEDs and the efficiency. Still there's a lot of scope in increasing efficiency and research is being done on the same.

In [3], the WOLED(White OLED) performance characteristics will not be reproducible as material properties varies from run to run.

In [4], they have discussed regarding the quantum efficiency of an OLED.Here it depends on the efficiency of carrier injection, recombination and electron-hole balancing. The efficiency of a three layered device is also higher and more stable than a bi-layer OLED device.

In [5], they have discussed regarding the previous OLED made of Benzo Carboxyl BCL(dopant) had 23.7 cd/A, 18.7 lm/W, which are one of the best efficiency values acquired from solution processed PHOLEDs (Phosphorous based OLEDs) without using mixed host system to date.

This paper presents the introduction of Methylammonium lead iodide as a new emissive material. We use Lumerical FDTD (Finite Difference Time Domain) to plot/simulate the results.

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II. METHODOLOGY

The basic components of the OLED are shown in the block diagram below:

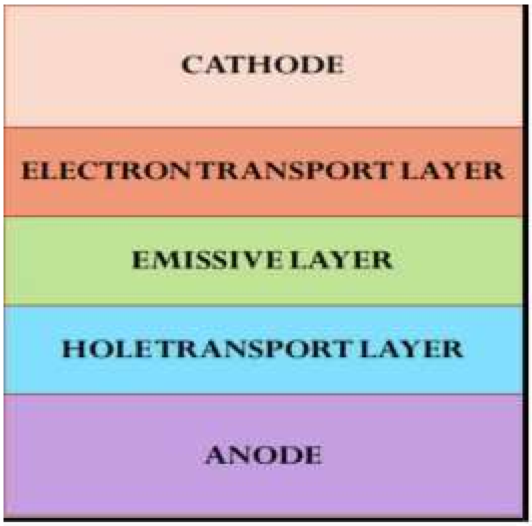

Fig. 1. OLED block diagram [6]

As current flows from the cathode to the anode through the organic layers, holes and electrons move from the corresponding conducting layers into the emissive layer where they recombine. As the electrons drop into the holes, they release extra energy as light, thus generating an organic light source.

Like an LED, an OLED is a solid-state semiconductor device that is 100 to 500 nanometers thick or about 200 times smaller than a human hair. OLEDs can have either two layers or three layers of organic material [7]; in the latter design, the third layer helps transport electrons from the cathode to the emissive layer. In this article, we'll be focusing on the two-layer design. An OLED consists of the following parts:

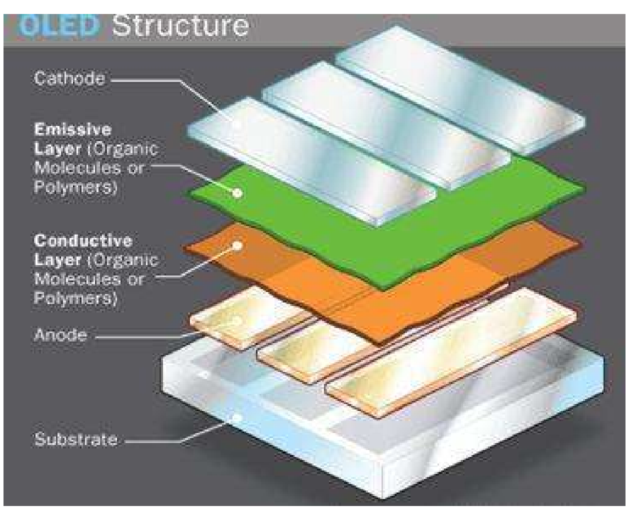

Fig. 2. OLED Layers [8]

a) ***Anode (transparent)*** - The anode is responsible forinjecting holes (adds "holes") when a current flows through the device. Silicon Nitride(SiN) is used as the anode. We use transparent glass(substrate) as the material above the anode so that the light exits the device.

b) ***Hole Transport Layer (HTL) and Electron Transport Layer (ETL)*** - Although similar materials are often used as HTL/ETL in both organic photovoltaics and OLED, their functions can be slightly different.

In the case of OLED, what we are trying to do is to avoid recombination close to the interface with the electrodes (usually the active materials are either mainly hole transporting or electron transporting) as it may quench their emission efficiencies. In order to move away from the interfaces with the electrodes and have a larger recombination area at the center of the active layers, using HTL/ETL can be very useful. We have chosen **Tin Oxide (ITO)** as the ETL because of its high electron affinity and electron mobility. Similarly we have also gone with **Barium Fluoride** as it is a widely used HTL layer.

c) ***Emissive layer***- This layer is made up of organic plastic molecules that transport electrons from the cathode; this is where light is made. The Organic layer is between the HTL and ETL layers. Holes and electrons recombine and emit light [9]. The emissive layer consisting of organic molecules that will efficiently emit fluoresce or phosphorescence at different wavelengths / colors. The biggest real breakthrough, was from Alq3AlqX3 which is an aluminum organometallic compound with remarkably bright emission.

We use **Methyl Ammonium Lead Iodide** as our emissive layer. Methylammonium lead halides are widely studied for their potential as low-cost, high-performance optoelectronic materials [10]. It has electron mobility between 0.**06 to 1.4 cm2/Vs at room** temperature, its refractive index varies from 1.3-1.5 at different wavelengths [11].

d) ***Cathode (may or may not be transparent depending on the type of OLED)*** - The cathode injects electrons when there is a current flowing through the device. We use **Tris(8-hydroxyquinolinato) aluminum(Alq3)** as the cathode layer. Currently Alq3 is the most widely used cathode material in OLEDs owing to the advantage on electrical and optical properties, such as high work function, low resistivity and high transparency. TCO (Transparent Conductive Oxides) materials, such as ZnO (Zinc Oxide) etc., as the anode candidates also have been discussed and analyzed. The energy level can be controlled by semiconductor doping which improve the carrier density and Hall mobility.

Interfacial engineering between the anodes and the overlying organic layers is an important process to obtain the high performance of the devices [12]. Physical, chemical and the combined treatment methods to modify the TCO/organic interfaces are reviewed. The property of anode/organic interfaces can be modified and enhanced by introducing the buffer layers between anodes and hole transport layer.

III. FORMULAE

i. ***Internal Quantum Efficiency(IQE) -*** Internal quantum efficiency (IQE) is defined as the proportion of all the electron-hole recombination in an OLED active region that are radiative and producing photons.

$$IQE = (power * \lambda * e)/(I * h * c)$$

Where I is the Forward Current

h is Plank's Constant

c is speed of light

ii. ***Enhancement of Extracted light -*** Enhancement of Extracted light is the proportion of photons generated in the active region that escape from the device.

$$\text{Enhancement of extracted Light} = A_{EMISSION} / A_{TOTAL}$$

$$A_{EMISSION} = 2r^2 (1-\cos\theta_c)$$

$$A_{TOTAL} = 4r^2$$

Where θ_c is the Critical Angle

IV. RESULTS

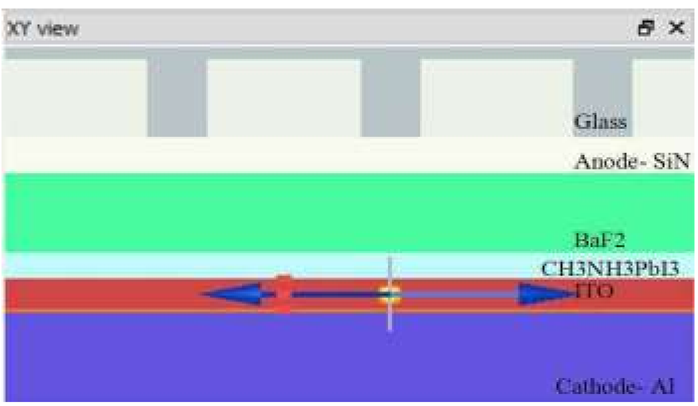

Fig. 3. OLED simulation with Methyl Ammonium Lead Iodide

The above figure shows the schematic layering of the OLED using FDTD Solutions.

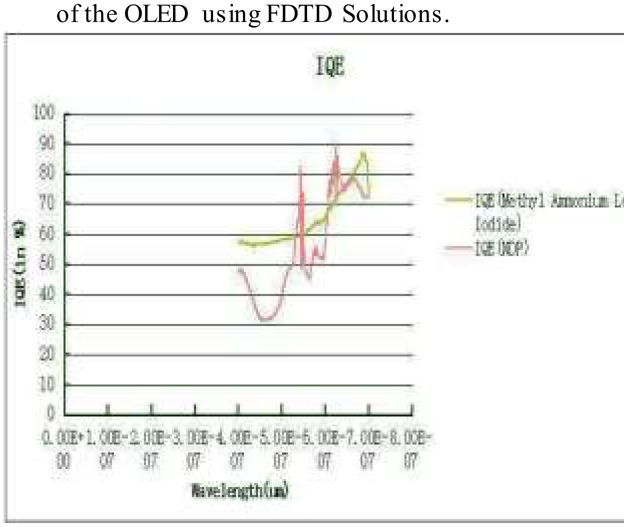

Fig. 4. IQE vs Wavelength Comparison between NDP and Methyl

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From the above graph we can see that the IQE for methyl ammonium lead iodide is relatively higher than NDP and peaks at 635 nm wavelength which corresponds to red light.

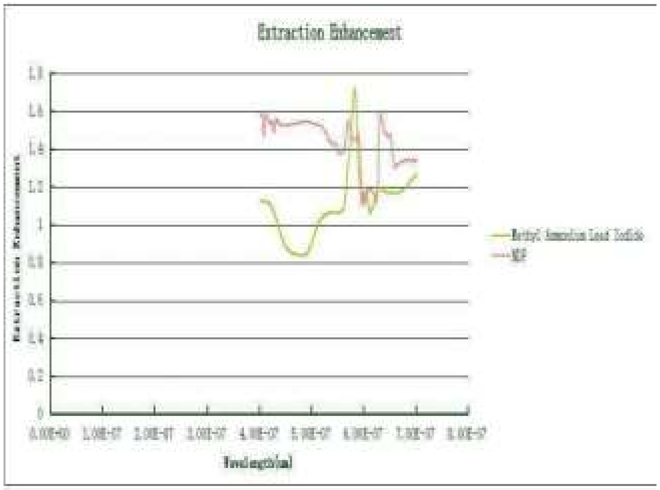

Fig. 5. Extraction Enhancement vs Wavelength Comparison between NDP and Methyl Ammonium Lead Iodide

From the above graph we can conclude that the highest extraction for methyl ammonium lead iodide is at 1.71 which is higher than the value obtained by NDP.

	Wavelength (nm)	IQE (%)	Enhanceent of extracted light
Methyl ammonium lead iodide	635 nm	91%	1.71
NDP	635nm	75%	1.43

Ammonium Lead Iodide

Fig. 6 Comparisson table between Methyl ammonium lead iodide and NDP

V. CONCLUSION

In this work a new host materials are introduced and compared with an already existing OLED design. We see the improvement in both enhancement of extracted light and internal quantum efficiency.

We conclude that at wavelength (635nm) corresponding to red light the new emissive layer has IQE 91% which is better than the IQE of NDP 75% and also has 1.71 in enhancement of extracted light as compare to NDP's 1.43.

VI. ACKNOWLEDGMENT

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VII. REFERENCES

[1] Tony Manidron, "OLED: Theory and Principles" Feancois Templier Publishers, 2014.

[2] Georges Zissis, Paolo Bertoldi ,"2014 Status Report on Organic Light Emitting Diodes (OLED)",JRC 2014.

[3] D'Andrade, B. W., Forrest, S. R. (2004), "White Organic Light-Emitting Devices for Solid-State Lighting", Advanced Materials. 16 (18): 1585–1595. doi:10.1002/adma.200400684.

[4] Akanksha Uniyal, Srishti and Poornima Mittal. "Performance Comparison of Monolayer, Bilayer and Multilayer Organic Light Emitting Diodes", International Conference on Computing, Communication and Automation ,(ICCCA2016).

[5] Min Chul Suh, So-Ra Park, Ye Ram Cho, Dong Heon Shi,"Synthesis of Soluble Host Materials for Highly Efficient Red Phosphorescent Organic LightEmitting Diodes",American Chemistry Society (2016).

[6] Akanksha Uniyal, Srishti and Poornima Mittal. "Performance Comparison of Monolayer, Bilayer and Multilayer Organic Light Emitting Diodes", International Conference on Computing, Communication and Automation ,(ICCCA2016).

[7] Badisa Sai Ram Krsihna, Angadi Suresh, Karavadi Siva Karthik,"Organic Light Emitting Diodes", IJIRD 2013.

[8] http://www.circuitstoday.com/workng-of-organic-led-oled

[9] Sandro Lattante,"Electron and Hole Transport Layers: Their Use in Inverted Bulk Heterojunction Polymer Solar Cells",Electromics, 2014.

[10] Benjamin T. Diroll, Peijun Guo, and Richard D. Schaller,"Unique Optical Properties of Methylammonium Lead Iodide Nanocrystals Below the Bulk Tetragonal-Orthorhombic Phase Transition",Nano Letters,2018.

[11] Brian Maynard, Qi Long, Eric A. Schiff1, Mengjin Yang, Kai Zhu, Ranjith Kottokkaran, Hisham Abbas, and Vikram L. Dalal."Electron and hole driftmobility measurements on methylammonium lead iodide perovskite solar cells",Applied Physics Letters 2016.

[12] Yan M, Zhang Q, Zhao Y, Yang J, Yang T, Zhang J, Li X,"Applications of Transparent Conducting Oxides In Organic Light Emitting Devices", NCBI 2015.