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Research on Organic Light-emitting Diode

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***Abstract*—As a new generation of light source, the organic light-emitting diode (OLED) has many advantages, and Apple has adopted OLEDs display on the latest version of mobile phones. However the low light output rate is an important factor restricting its performance. In this paper, FDTD solutions software is used to design the new OLEDs device structure and carry out optical simulation. The light extraction efficiency (LEE) enhancement is investigated. The results provide theoretical guidance for the preparation of high-efficiency material films OLEDs devices.**

Keywords—OLED; FDTD; efficiency

I. INTRODUCTION

The OLED, as a new generation of light-emitting device, has the advantages of energy-saving, flexible, non-glare, wide-color-gamut, electroluminescence, high -efficiency, and have achieved great development [1-7].

OLED has low power consumption, fast response, low lighting voltage, wide source of materials, flexible and other advantages, is recognized as the most potential application in future lighting and display Technology. There are many OLEDs technology applications in the market, such as OLED TV, car control screen, Apple iwatch, mobile phone screen, etc. At present, mobile phone display is developing towards the use of OLEDs display technology.

The total reflection of photons produced by OLEDs occurs due to the different absorption and refractive index of each layer of materials in the device. This part of light is lost in the process of propagation in the device, and the lost part accounts for 80% in the traditional OLEDs device [2]. Therefore, how to release this part of light loss has become a hot research topic. In the past decade, the continuous research on the light output rate has been carried out. Researchers have tried to improve the output efficiency of OLEDS from various aspects. The optical coupling output efficiency of OLEDs means to reduce energy consumption. Therefore, we investigate the light extraction efficiency (LEE) enhancement of OLEDS.

II. THEORETICAL MODEL

The finite time domain difference method (FDTD) uses Yee network to discretize the space and solve the difference. Maxwell's equations are used to simulate the interaction between the electron pulse and the conductor in the time domain in a discrete way. The full spectrum results can be obtained, which can save time for simulation. It provides a unique perspective to consider various problems of electromagnetic field. Therefore, OLEDs can be simulated optically.

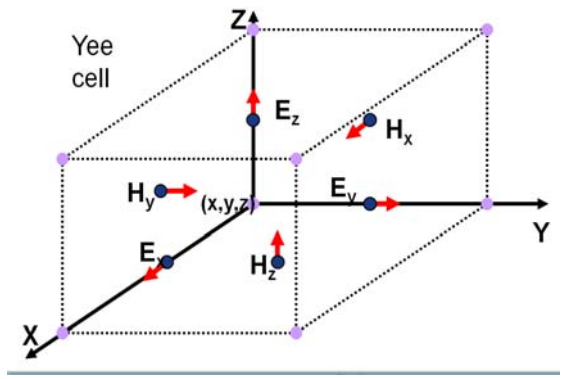

FIGURE I. YEE CELL USED FOR FDTD SIMULATIONS

Figure 2 shows the diagram of OLED, which includes metal cathode, electron transport layer, organic light-emitting layer, hole transport layer, transparent anode, glass substrate.

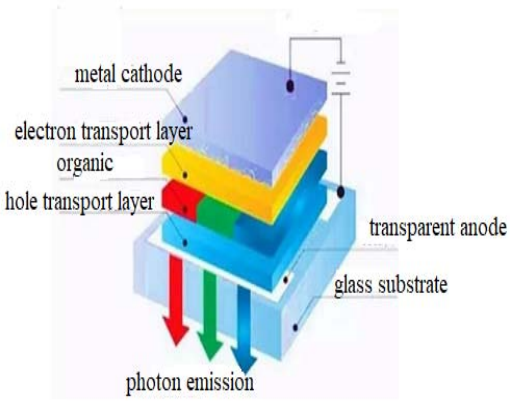

FIGURE II. THE DIAGRAM OF OLED

$$\mathrm{LEE} = \frac{\Upsilon_{rad}}{\Upsilon_{loss}} \tag{1}$$

$$\text{LEE enhancement} = \frac{\mathrm{LEE}_{pattern}}{\mathrm{LEE}_{no\_pattern}} \tag{2}$$

where LEE is the fraction of optical power generated in the active layer of the OLED[7], Υ_{rad} is the decay rate of

excitations to photons [7], Υ_{loss} is the decay rate of excitations to photons [7].

Compared Figure 3 and Figure 4 with Figure 5, we can see the LEE enhancement is obviously different because of different metal cathode. We can obtain high and effective luminous output by designing appropriate OLEDs.

III. Numerical Simulation Results

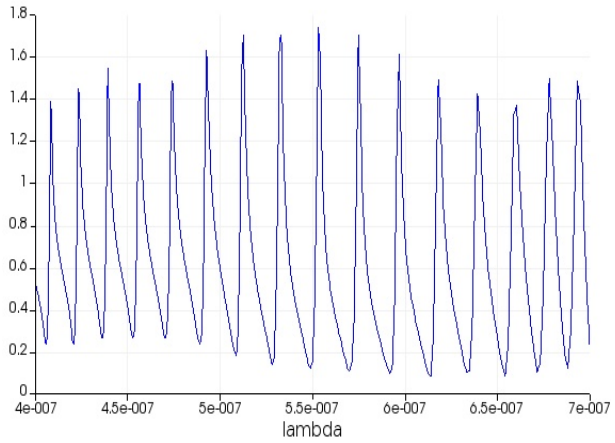

FIGURE III. THE LEE ENHANCEMENT WITH AG CATHODE

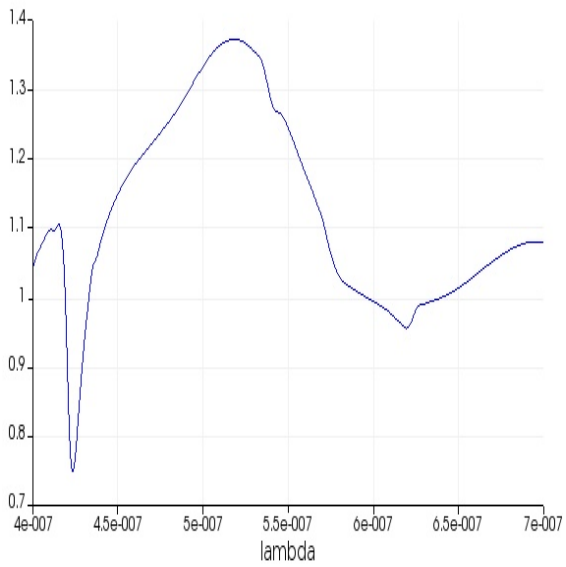

FIGURE IV. THE LEE ENHANCEMENT WITH AU (GOLD) CATHODE

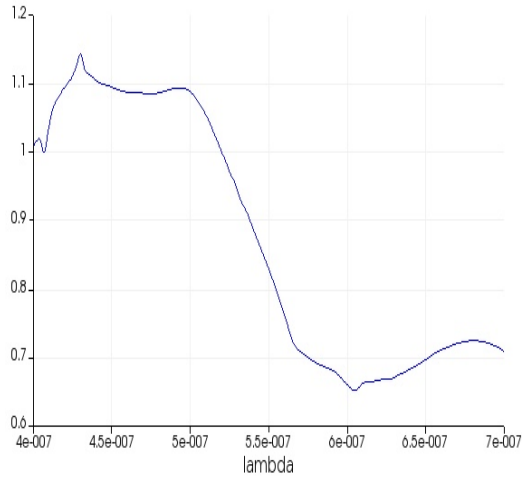

FIGURE V. THE LEE ENHANCEMENT WITH AL CATHODE

IV. Conclusion

As a new generation of light source, OLEDs have many advantages, such as wide gamut, electroluminescence, good flexibility, etc. In order to prepare a flexible display screen, realize self-illumination and save electric energy consumption, which has great advantages in mobile consumer electronics products, the light source prepared by OLEDs can be designed into different shape surface light source which has soft light. OLED can be used in families, classrooms, offices, etc., for its near natural light which can realize healthy lighting. FDTD simulation is widely used in performing optical simulation which plays an important role in designing new structure of OLEDs.

In conclusion, the OLEDs device model is designed by FDTD Solutions software and light extraction efficiency (LEE) enhancement is analyzed in this paper. The simulation results provide a theoretical basis for realizing high performance and flexible OLEDs devices..

Acknowledgement

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References

[1] Li Y Q , Tang J X , Xie Z Y , et al. An efficient organic light-emitting diode with silver electrodes[J]. Chemical Physics Letters, 2004, 386(1-3):128-131.

[2] Greiner H . Light Extraction from Organic Light Emitting Diode Substrates: Simulation and Experiment[J]. Japanese Journal of Applied Physics, 2007, 46(7A):4125-4137.

[3] ZHANG Jian hua, CHEN Zhang fu, XU Xiao xue,等. Analysis of Organic Light Emitting Diode Under Electrostatic Discharge Stresses[J]. Chinese Journal of Luminescence, 2018.

[4] Han T H , Choi M R , Chun C W , et al. High-Efficiency Solution-Processed Small-Molecule Organic Light-Emitting Diodes with Simple Structure[C]// Solid-state & Organic Lighting. 2015.

[5] Yin Y , Ali M U , Xie W , et al. Evolution of white organic light-emitting devices: from academic research to lighting and display applications[J]. Materials Chemistry Frontiers, 2019, 3.

[6] Shiang J , Faircloth T , Duggal A R . Light extraction from OLEDs using volumetric light scattering[J]. Proc Spie, 2004.

[7] Oleds_simulation_methodology(OL) ,https://apps.lumerical.com.