



US010147898B2

(12) **United States Patent**
Tang

(10) **Patent No.:** **US 10,147,898 B2**
(45) **Date of Patent:** ***Dec. 4, 2018**

(54) **ORGANIC LIGHT-EMITTING DEVICE AND DISPLAY DEVICE**

(71) Applicant: **Wuhan China Star Optoelectronics Technology Co., Ltd.**, Wuhan, Hubei (CN)

(72) Inventor: **Jinming Tang**, Guangdong (CN)

(73) Assignee: **Wuhan China Star Optoelectronics Technology Co., Ltd.**, Wuhan, Hubei (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 174 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/118,867**

(22) PCT Filed: **Jul. 20, 2016**

(86) PCT No.: **PCT/CN2016/090601**

§ 371 (c)(1),

(2) Date: **Aug. 13, 2016**

(87) PCT Pub. No.: **WO2017/219424**

PCT Pub. Date: **Dec. 28, 2017**

(65) **Prior Publication Data**

US 2018/0166646 A1 Jun. 14, 2018

(30) **Foreign Application Priority Data**

Jun. 21, 2016 (CN) 2016 1 0452465

(51) **Int. Cl.**

H01L 51/50 (2006.01)

H01L 51/00 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC **H01L 51/5024** (2013.01); **C09K 11/06** (2013.01); **H01L 27/3244** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01L 51/50; H01L 27/32; H01L 51/00; H01L 51/56; H01L 51/52

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,795,852 B2 8/2014 Asari et al.

9,166,184 B2 10/2015 Yang

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101867021 A 10/2010

CN 102983286 A 3/2013

(Continued)

OTHER PUBLICATIONS

Chen Hua, Design, Synthesis and Performance of Efficient Phosphorescent OLED Materials, Engineering Science first series in China Doctoral Dissertations Full-text Database, Sep. 15, 2014, paragraph 2 on p. 46 to last paragraph on p. 66, vol. 9, Suzhou China.

Primary Examiner — Sheikh Maruf

(74) *Attorney, Agent, or Firm* — Andrew C. Cheng

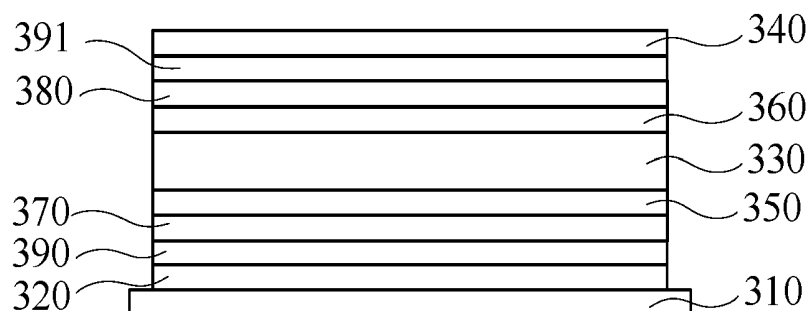
(57) **ABSTRACT**

An organic light-emitting device and a display device are disclosed. The organic light-emitting device includes a substrate layer, a first electrode layer, a light-emitting layer, a second electrode layer which are stacked; and a first barrier layer disposed between the first electrode layer and the light-emitting layer, a second barrier layer disposed between the second electrode layer and the light-emitting layer, wherein, each of the first and second barrier layers includes a light-emitting host material, a triplet energy level T1 of the light-emitting host material ≥ 2.5 ev. Because the organic

(Continued)

300

~



light-emitting device is disposed with first and second barrier layers including the light-emitting host material, the structure of the light-emitting device can increase the life-time and the luminous efficiency of the organic light-emitting device.

17 Claims, 2 Drawing Sheets

(51) **Int. Cl.**

H01L 51/52 (2006.01)
C09K 11/06 (2006.01)
H01L 27/32 (2006.01)
H01L 51/56 (2006.01)

(52) **U.S. Cl.**

CPC *H01L 51/001* (2013.01); *H01L 51/50* (2013.01); *H01L 51/5004* (2013.01); *H01L 51/5016* (2013.01); *H01L 51/5056* (2013.01); *H01L 51/5072* (2013.01); *H01L 51/5206* (2013.01); *H01L 51/5221* (2013.01); *H01L 51/56* (2013.01); *C09K 2211/1018* (2013.01); *C09K 2211/1029* (2013.01); *C09K 2211/185* (2013.01); *H01L 51/0052* (2013.01); *H01L 51/0054* (2013.01); *H01L 51/0067* (2013.01); *H01L 51/0072* (2013.01); *H01L 51/0074* (2013.01); *H01L 51/0085* (2013.01); *H01L 2251/5384* (2013.01); *H01L 2251/552* (2013.01); *H01L 2251/558* (2013.01)

(58) **Field of Classification Search**

USPC 257/40; 438/82, 99
 See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0021088 A1* 2/2002 Howard H01L 51/5215
 313/504

2003/0048072 A1* 3/2003 Ishihara H01L 51/5262
 313/506
 2004/0214041 A1* 10/2004 Lu B82Y 10/00
 428/690
 2007/0231503 A1* 10/2007 Hwang C09K 11/06
 428/1.1
 2008/0107919 A1* 5/2008 Hwang C07D 209/88
 428/691
 2008/0113216 A1* 5/2008 Inoue C07F 15/0086
 428/690
 2008/0286606 A1* 11/2008 Hwang C09K 11/06
 428/690
 2009/0200928 A1* 8/2009 Hwang C09K 11/06
 313/504
 2009/0226757 A1* 9/2009 Song H01L 51/5036
 428/690
 2010/0006830 A1* 1/2010 Hong C07D 495/04
 257/40
 2011/0168988 A1* 7/2011 Jeong H01L 27/3211
 257/40
 2011/0215301 A1* 9/2011 Forrest H01L 51/5036
 257/40
 2012/0001158 A1* 1/2012 Asari C07D 487/04
 257/40
 2014/0054570 A1* 2/2014 Yang H01L 51/5004
 257/40
 2015/0001506 A1* 1/2015 Kim H01L 51/5278
 257/40
 2015/0060791 A1* 3/2015 Shin H01L 51/0067
 257/40
 2015/0155515 A1* 6/2015 Kim H01L 51/5008
 257/40

FOREIGN PATENT DOCUMENTS

CN 103227294 A 7/2013
 CN 103762317 A 4/2014
 CN 105870350 A 8/2016
 JP 2003133075 A 5/2003

* cited by examiner

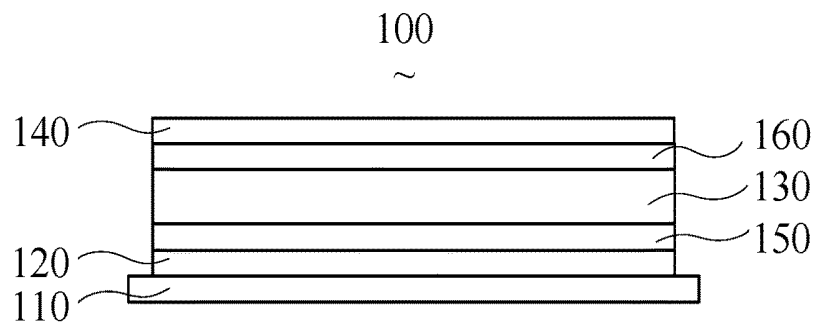


FIG 1

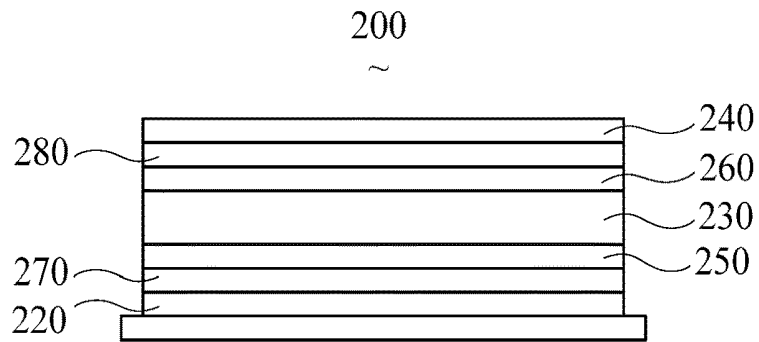


FIG 2

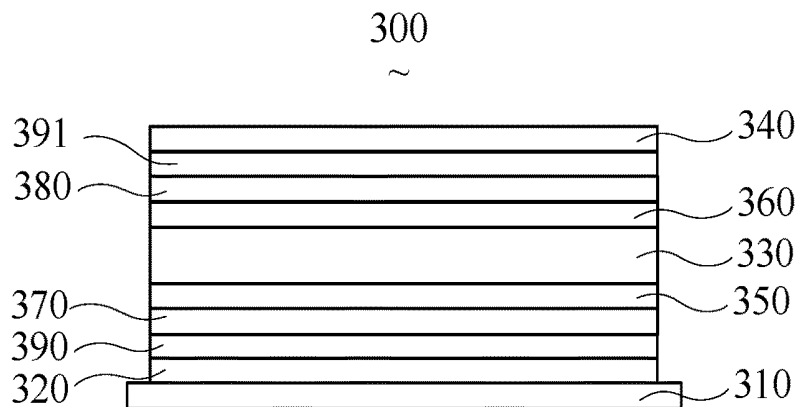


FIG 3

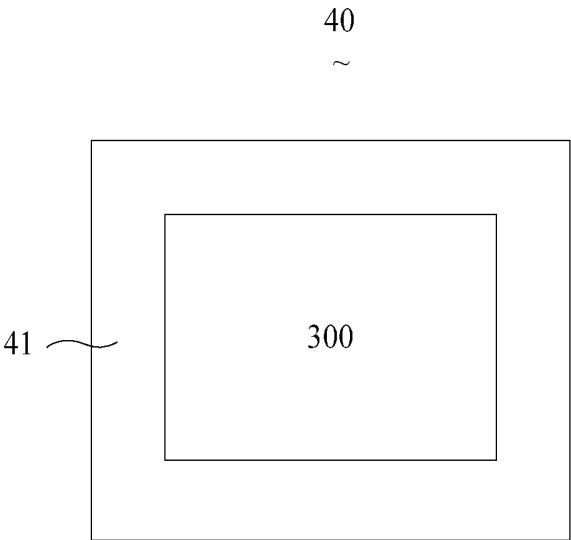


FIG 4

ORGANIC LIGHT-EMITTING DEVICE AND DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a display technology field, and more particularly to an organic light-emitting device and a display device.

2. Description of Related Art

Because the AMOLED (abbreviation of active-matrix organic light emitting diode) display panel has advantages of self-luminous, simple structure, low cost, fast response, wide viewing angle, color saturation, high contrast, thin, etc. comparing to an LCD panel so that more and more smart-phones and wearable devices begin to adopt the AMOLED panel.

Along with the large-scale application, more and higher requirements for the performance of the AMOLED are proposed such as low voltage, high brightness, high efficiency, low power consumption, long lifetime, etc.

SUMMARY OF THE INVENTION

The present invention provides an organic light-emitting device and a display device in order to solve the technology problems of short lifetime and low efficiency of the AMOLED device in the conventional art.

In order to solve the above technology problem, one technology solution adopted by the present invention is: providing an organic light-emitting device, comprising:

a substrate layer, a first electrode layer, a light-emitting layer, and a second electrode layer which are stacked;

a first barrier layer disposed between the first electrode layer and the light-emitting layer, a second barrier layer disposed between the second electrode layer and the light-emitting layer, wherein each of the first barrier layer and the second barrier layer includes a light-emitting host material, a triplet energy level T1 of the light-emitting host material ≥ 2.5 ev;

wherein, the first electrode layer and the second electrode layer are respectively an anode layer and a cathode layer;

wherein, the light-emitting host material of the first barrier layer is a hole-type host material, the energy level of the highest occupied molecular orbit and the energy level of the lowest unoccupied molecular orbit are respectively 5.3~5.7 ev and 1.8~2.3 ev;

wherein, the light-emitting host material of the second barrier layer is an ambipolar light-emitting host material, the energy level of the highest occupied molecular orbit and the energy level of the lowest unoccupied molecular orbit are respectively 5.5~6.0 ev and 2.5~3.5 ev; and

wherein, the light-emitting layer is made of a first light-emitting host material, a second light-emitting host material and a phosphorescent dopant, and the first barrier layer is made of the second light-emitting host material, and the second barrier layer is made of the first light-emitting host material.

Another technology solution adopted by the present invention is: providing an organic light-emitting device, comprising:

a substrate layer, a first electrode layer, a light-emitting layer, and a second electrode layer which are stacked;

a first barrier layer disposed between the first electrode layer and the light-emitting layer, a second barrier layer disposed between the second electrode layer and the light-emitting layer, wherein each of the first barrier layer and the

second barrier layer includes a light-emitting host material, a triplet energy level T1 of the light-emitting host material ≥ 2.5 ev.

According to an embodiment of the present invention, the first electrode layer and the second electrode layer are respectively an anode layer and a cathode layer;

the light-emitting host material of the first barrier layer is a hole-type host material, the energy level of the highest occupied molecular orbit and the energy level of the lowest unoccupied molecular orbit are respectively 5.3~5.7 ev and 1.8~2.3 ev; and

the light-emitting host material of the second barrier layer is an ambipolar light-emitting host material, the energy level of the highest occupied molecular orbit and the energy level of the lowest unoccupied molecular orbit are respectively 5.5~6.0 ev and 2.5~3.5 ev.

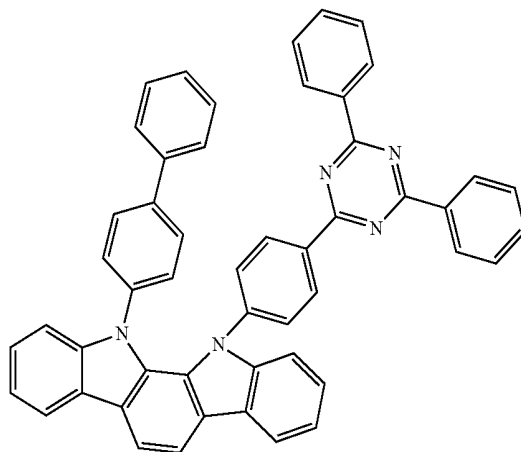
According to an embodiment of the present invention, the organic light-emitting device further includes a hole transporting layer disposed between the first barrier layer and the anode layer, and an electron transporting layer disposed between the second barrier layer and the cathode layer;

a difference of energy level of highest occupied molecular orbit of the first barrier layer and the hole transporting layer is less than 0.2 ev, a difference of energy level of lowest unoccupied molecular orbit of the first barrier layer and the hole transporting layer is greater than 0.2 ev; and

a difference of energy level of lowest unoccupied molecular orbit of the second barrier layer and the electron transporting layer is less than 0.2 ev, a difference of energy level of highest occupied molecular orbit of the second barrier layer and the electron transporting layer is greater than 0.2 ev.

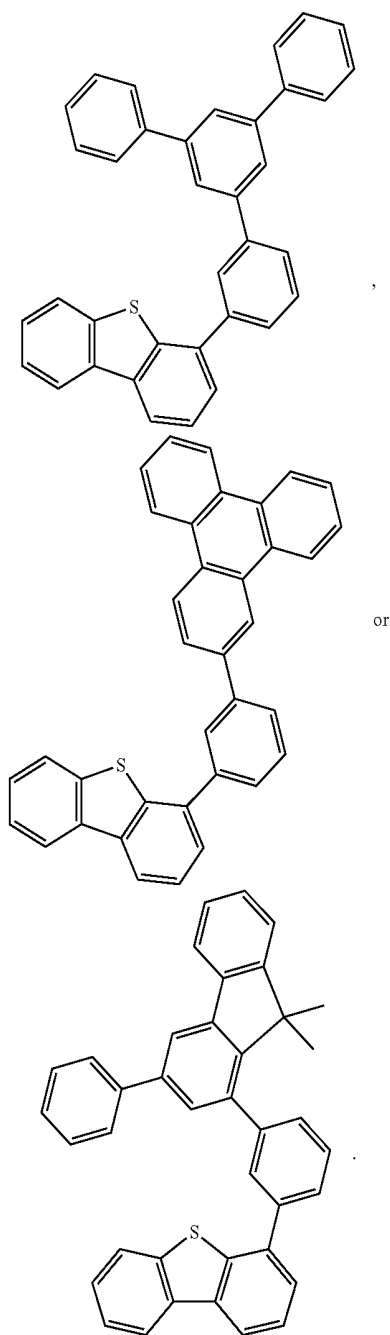
According to an embodiment of the present invention, the light-emitting layer is made of a first light-emitting host material, a second light-emitting host material and a phosphorescent dopant, and the first barrier layer is made of the second light-emitting host material, and the second barrier layer is made of the first light-emitting host material.

According to an embodiment of the present invention, the chemical structural formula of the first light-emitting host material is:



According to an embodiment of the present invention, the chemical structural formula of the second light-emitting host material is:

3



According to an embodiment of the present invention, a ratio of film thicknesses of the first light-emitting host material, the second light-emitting host material and the phosphorescent dopant is 5:5:1.

According to an embodiment of the present invention, a thickness of the first barrier layer is in a range of 1 nm~100 nm, and a thickness of the second barrier layer is in a range of 1 nm~50 nm.

According to an embodiment of the present invention, the thickness of the first barrier layer is in a range of 5 nm~50 nm, and a thickness of the second barrier layer is in a range of 5 nm~20 nm.

According to an embodiment of the present invention, the thickness of the first barrier layer is in a range of 10 nm~20 nm, and a thickness of the second barrier layer is in a range of 5 nm~10 nm.

4

According to an embodiment of the present invention, a thickness of the light-emitting layer is in a range of 10 nm~50 nm.

According to an embodiment of the present invention, a thickness of the hole transporting layer is in a range of 10 nm~30 nm.

According to an embodiment of the present invention, wherein, a thickness of the electron transporting layer is in a range of 10 nm~30 nm.

Another technology solution adopted by the present invention is: providing a display device comprising the organic light-emitting device described above.

The beneficial effects of the present invention is: comparing to the conventional art, the organic light-emitting device provided by the present invention, because the first barrier layer and the second barrier layer including the light-emitting host material is provided, and the light-emitting host material has a very high triplet energy level T1, when the light-emitting host material is used as the first barrier layer, the diffusion of the triplet exciton can be blocked in order to reduce the exciton quenching and increase the lifetime of the organic light-emitting device. Besides, when the light-emitting host material is used as the second barrier layer, the second barrier layer can effectively limit electrons and excitons at the light-emitting layer such that the electrons and holes are recombined in order to decrease the energy loss, increase the luminous efficiency of the organic light-emitting device.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to more clearly illustrate the technical solution in the present invention or in the prior art, the following will illustrate the figures used for describing the embodiments or the prior art. It is obvious that the following figures are only some embodiments of the present invention. For the person of ordinary skill in the art without creative effort, it can also obtain other figures according to these figures. In the figures:

FIG. 1 is a schematic diagram of an organic light-emitting device of a first embodiment of the present invention;

FIG. 2 is a schematic diagram of an organic light-emitting device of a second embodiment of the present invention;

FIG. 3 is a schematic diagram of an organic light-emitting device of a third embodiment of the present invention; and

FIG. 4 is a schematic diagram of a display device of an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following content combines with the drawings and the embodiment for describing the present invention in detail. It is obvious that the following embodiments are only some embodiments of the present invention. For the person of ordinary skill in the art without creative effort, the other embodiments obtained thereby are still covered by the present invention.

With reference to FIG. 1, and FIG. 1 is a schematic diagram of an organic light-emitting device of a first embodiment of the present invention.

As shown in FIG. 1, the organic light-emitting device 100 includes a substrate layer 110, a first electrode layer 120, a light-emitting layer 130, and a second electrode layer 140 which are stacked. Besides, the organic light-emitting device 100 further includes a first barrier layer 150 disposed between the first electrode layer 120 and the light-emitting layer 130, and a second barrier layer 160 disposed between

5

the second electrode layer **140** and the light-emitting layer **130**. Each of the first barrier layer **150** and the second barrier layer **160** includes a light-emitting host material. A triplet energy level T1 of the light-emitting host material ≥ 2.5 eV. Wherein, the triplet energy level T1 can maximally reach 3.0 eV or above. Wherein, in a specific application example, the triplet energy level T1 can be 2.8 eV.

The organic light-emitting device **100** provided by the present invention, because the first barrier layer **150** and the second barrier layer **160** including the light-emitting host materials are provided, and each of the light-emitting host materials has a very high triplet energy level T1, when the light-emitting host material is used as the first barrier layer **150**, the diffusion of the triplet exciton can be blocked in order to reduce the exciton quenching and increase the lifetime of the organic light-emitting device. Besides, when the light-emitting host material is used as the second barrier layer **160**, the second barrier layer **160** can effectively limit electrons and excitons at the light-emitting layer such that the electrons and holes are recombined in order to decrease the energy loss, increase the luminous efficiency of the organic light-emitting device **100**.

In a more specific embodiment, the first electrode layer **120** and the second electrode layer **140** are respectively an anode layer and a cathode layer. The light-emitting host material of the first barrier layer **150** is a hole-type host material, the energy level of the highest occupied molecular orbit (HOMO) and the energy level of the lowest unoccupied molecular orbit (LUMO) are respectively 5.3~5.7 eV and 1.8~2.3 eV; the light-emitting host material of the second barrier layer **160** is an ambipolar light-emitting host material, the energy level of the highest occupied molecular orbit (HOMO) and the energy level of the lowest unoccupied molecular orbit (LUMO) are respectively 5.5~6.0 eV and 2.5~3.5 eV.

The substrate layer **110** is a transparent substrate, a glass substrate or a flexible substrate. Wherein, the flexible substrate is made of one or multiple materials of polyester compound and polyimide-based compound.

The anode layer **120** can adopt an inorganic material or an organic conductive polymer. Wherein, the inorganic material is metal or metal oxide. The metal is a metal having a higher work function including gold, copper, silver, etc. The metal oxide specifically is indium tin oxide (ITO), zinc oxide, zinc tin oxide, etc. The conductive polymer is one material of polythiophene, polyvinyl benzene sulfonate, and polyaniline.

The cathode layer **140** can adopt metal or metal alloy. Wherein, the metal is a metal that has a lower work function including lithium, magnesium, calcium, strontium, aluminum, zinc, etc. The metal alloy is a metal alloy that has a lower work function or an alloy of the metal alloy and gold, silver or copper. In another embodiment, a cathode layer adopting a metal and a metal fluoride disposed alternatively can be provided. For example, the cathode layer is formed by lithium fluoride, metal silver, lithium fluoride and metal aluminum.

A thickness of the first barrier layer **150** is in a range of 1 nm~100 nm, and a thickness of the second barrier layer **160** is in a range of 1 nm~50 nm.

Further, the thickness of the first barrier layer **150** is in a range of 5 nm~50 nm, and a thickness of the second barrier layer **160** is in a range of 5 nm~20 nm.

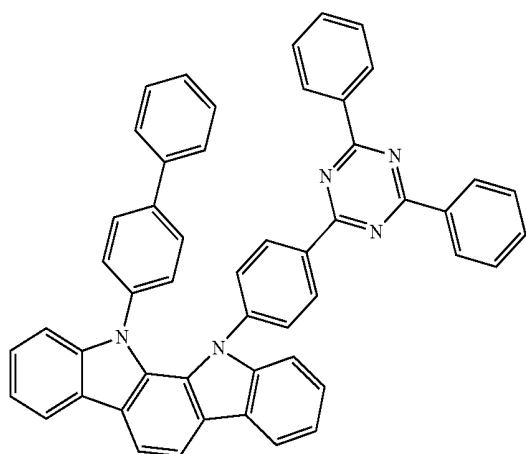
Furthermore, the thickness of the first barrier layer **150** is in a range of 10 nm~20 nm, and a thickness of the second barrier layer **160** is in a range of 5 nm~10 nm.

6

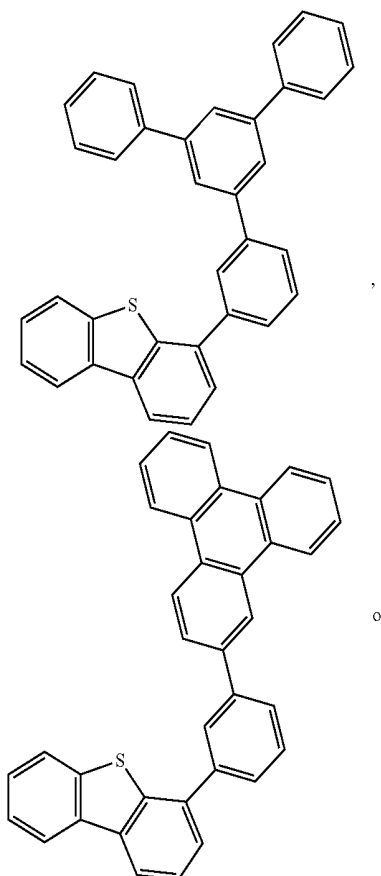
The light-emitting layer **130** is made of a first light-emitting host material and a phosphorescent dopant. The first barrier layer **150** is made of the second light-emitting host material, and the second barrier layer **160** is made of the first light-emitting host material.

A ratio of film thicknesses of the first light-emitting host material, the second light-emitting host material and the phosphorescent dopant is 5:5:1.

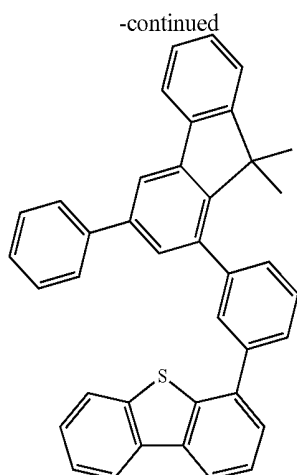
The chemical structural formula of the first light-emitting host material HOST1 is:



The chemical structural formula of the second light-emitting host material HOST2 is:

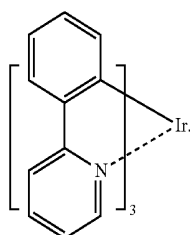


7



wherein, the names are respectively Co-host1, Co-host2 and Co-host3.

The phosphorescent dopant is a green phosphorescent dopant Dopant1, and the chemical structural formula of the Dopant1 is:



(1) APPLICATION EXAMPLE 1

In the present application example, the light-emitting layer **130** of the organic light-emitting device **100** is made of a first light-emitting host material HOST1, a second light-emitting material Co-host1 and the phosphorescent dopant Dopant1. Wherein, a ratio of film thicknesses of the first light-emitting host material HOST1, the second light-emitting host material Co-host1 and the phosphorescent dopant Dopant1 in the light-emitting layer **130** is 5:5:1. The first barrier layer **150** is made of the second light-emitting host material Co-host1, and the second barrier layer **160** is made of the first light-emitting host material HOST1.

(2) APPLICATION EXAMPLE 2

The structure of the organic light-emitting device in the present application example is the same as the application example 1, the difference is, the second light-emitting host material is Co-host2.

(3) APPLICATION EXAMPLE 3

The structure of the organic light-emitting device in the present application example is the same as the application example 1, the difference is, the second light-emitting host material is Co-host3.

In another application example, the first barrier layer **150** without the second light-emitting host material and the second barrier layer **160** without the first light-emitting host material can be adopted.

8

Parameters of the energy level and the mobility of the first light-emitting host material and the second light-emitting host material are shown in Table. 1

TABLE1

parameters of the energy level and the mobility of the first light-emitting host material and the second light-emitting host material						
Material	HOMO/ ev	LUMO/ ev	S1/ev	T1/ev	Hole mobility cm ² /Vs	Electron mobility cm ² /Vs
HOST1	-5.9	-2.7	3.2	2.8	3 * 10 ⁻⁵	7.1 * 10 ⁻⁵
Co-host1	-5.5	-2.3	3.2	2.7	2.4 * 10 ⁻⁴	1.3 * 10 ⁻⁷
Co-host2	-5.4	-2.0	3.4	2.4	4.4 * 10 ⁻⁴	2.3 * 10 ⁻⁷
Co-host3	-5.6	-2.1	3.5	2.5	2.8 * 10 ⁻⁴	1.8 * 10 ⁻⁷

Wherein, HOMO (abbreviation of Highest Occupied Molecular Orbital) is the highest occupied molecular orbit, LUMO (abbreviation of Lowest Unoccupied Molecular Orbital) is the lowest unoccupied molecular orbit. Singlet energy level S1 is a difference value of the energy level of the lowest unoccupied molecular orbit (LUMO) and the energy level of the highest occupied molecular orbit (HOMO).

From the data shown in the Table. 1 the first light-emitting host material HOST1 has a good ambipolar property which is beneficial to the injection and recombination of the electron and the hole such that a recombination area of the exciton is wide so as to improve the lifetime of the organic light-emitting device. Besides, the second light-emitting host material Co-host1, Co-host2 or Co-host3 has a very good hole mobility and a very good energy level of the lowest unoccupied molecular orbit (LUMO), which can effectively block the electrons. Besides, the second light-emitting host material has a very high triplet energy level T1 so as to effectively block the excitons in order to effectively limit electrons and excitons at the light-emitting layer such that the electrons and holes are recombined in order to decrease the energy loss, increase the luminous efficiency of the organic light-emitting device.

With reference to FIG. 2, and FIG. 2 is a schematic diagram of an organic light-emitting device of a second embodiment of the present invention.

As shown in FIG. 2, an organic light-emitting device **200** further includes a hole transporting layer **270** disposed between a first barrier layer **250** and an anode layer **220**, an electron transporting layer **280** disposed between a second barrier layer **260** and a cathode layer **240**; a difference of energy level of highest occupied molecular orbit (HOMO) of the first barrier layer **250** and the hole transporting layer **270** is less than 0.2 eV, a difference of energy level of lowest unoccupied molecular orbit (LUMO) of the first barrier layer **250** and the hole transporting layer **270** is greater than 0.2 eV; a difference of energy level of lowest unoccupied molecular orbit (LUMO) of the second barrier layer **260** and the electron transporting layer **280** is less than 0.2 eV, a difference of energy level of highest occupied molecular orbit (HOMO) of the second barrier layer **260** and the electron transporting layer **280** is greater than 0.2 eV.

In the organic light-emitting device of the present invention, the substrate layer, the anode layer, the light-emitting layer, the cathode layer and the barrier layer are necessary layers, however, except the necessary layers, a hole injecting and transporting layer and an electron injecting and transporting layer can be provided. Wherein, the hole injecting and transporting layer means anyone or both of a hole injecting layer and a hole transporting layer, and the electron

injecting and transporting layer means anyone or both of the electron injecting layer or the electron transporting layer.

With reference to FIG. 3, and FIG. 3 is a schematic diagram of an organic light-emitting device of a third embodiment of the present invention.

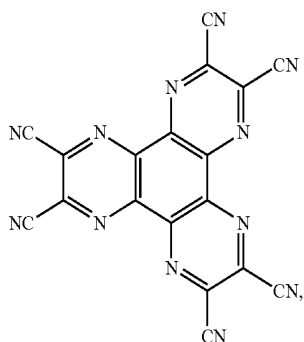
As shown in FIG. 3, the organic light-emitting device 300 further includes a hole injecting layer 390 and an electron injecting layer 391, and the structure of the organic light-emitting device of the following embodiments can refer to the above.

Specifically, the organic light-emitting device 300 includes a substrate layer 310, an anode layer 320, a hole injecting layer 390, a hole transporting layer 370, a first barrier layer 350, a light-emitting layer 330, a second barrier layer 360, an electron transporting layer 380, an electron injecting layer 391 and a cathode layer 340.

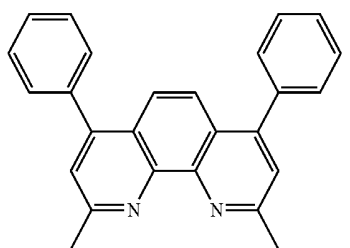
(4) APPLICATION EXAMPLE 4

The substrate layer 310 adopts a glass substrate, the anode layer 320 adopts indium tin oxide (ITO), the hole injecting layer 390 adopts a material of HAT(CN)₆, the hole transporting layer 370 adopts a material of HTM081 manufactured by the Merck company, the first barrier layer 350 adopts the second light-emitting host material Co-host1, the light-emitting layer 330 adopts the first light-emitting host material HOST1, the second light-emitting host material Co-host1 and the phosphorescent dopant Dopant1, the second barrier layer 360 adopts the first light-emitting host material HOST1, the electron transporting layer 380 adopts a material of BPhen, the electron injecting layer 391 adopts lithium fluoride (LiF), and the cathode layer 340 adopts aluminum.

Wherein, the chemical structural formula of HAT(CN)₆ is



the specific composition of HTM081 is a trade secret of the Merck company. The chemical structural formula of BPhen is



The main manufacturing method for the organic light-emitting device 300 is the evaporation method, and the manufacturing process comprises:

Step 1: Cleaning the Substrate Layer 310 and the Anode Layer 320

Performing an ultrasonic cleaning to the glass substrate 310 coated with ITO in a detergent. Then, washing in the deionized water. Performing an ultrasonic cleaning in a mixed solvent of a volume ratio of acetone to ethanol being 1:1. Baking in a clean environment, wherein, a baking temperature is in a range of 130° C.~220° C. and a time period is from one hour to two hours. Cleaning by using ultraviolet light and ozone. Then, using a low energy cation beam to bombard a surface of the ITO such that the ITO of the glass substrate 310 forms the anode layer 320.

Step 2: Evaporating Other Layers

Placing the glass substrate 310 coated with ITO in a vacuum chamber. Evacuating to 1×10^{-6} Pa~ 2×10^{-4} Pa. On an anode surface of the ITO, evaporating HAT(CN)₆ as a hole injecting layer 390. Wherein, an evaporation rate is in a range of 0.01 nm/s~0.1 nm/s, an evaporation thickness is in a range of 1 nm~10 nm. In the present application example, the evaporation rate adopts 0.05 nm/s and the evaporation thickness adopts 5 nm.

Evaporating HTM081 on a surface of the hole injecting layer 390 as a hole transporting layer 370. Wherein, the evaporation rate is in a range of 0.01 nm/s~0.2 nm/s, an evaporation thickness is in a range of 10 nm~30 nm. In the present application example, the evaporation rate adopts 0.1 nm/s and the evaporation thickness adopts 20 nm.

Evaporating the second light-emitting host material Co-host1 on a surface of the hole transporting layer 390 as the first barrier layer 350, wherein, the evaporation rate is in a range of 0.01 nm/s~0.2 nm/s, an evaporation thickness is in a range of 5 nm~20 nm. In the present application example, the evaporation rate adopts 0.1 nm/s and the evaporation thickness adopts 10 nm.

Evaporating the first light-emitting host material HOST1, the second light-emitting host material Co-host1 and the phosphorescent dopant Dopant1 as the light-emitting layer 330. Wherein, a ratio of film thicknesses of the first light-emitting host material HOST1, the second light-emitting host material Co-host1 and the phosphorescent dopant Dopant1 is 5:5:1. A tri-source co-evaporation method is adopted to evaporate the first light-emitting host material HOST1, the second light-emitting host material Co-host1 and the phosphorescent dopant Dopant1. Wherein, an evaporation rate of the first light-emitting host material HOST1 is in a range of 0.05 nm/s~0.5 nm/s, an evaporation rate of the second light-emitting host material Co-host1 is in a range of 0.05 nm/s~0.5 nm/s, an evaporation rate of the phosphorescent dopant Dopant1 is in a range of 0.005 nm/s~0.05 nm/s. A total evaporation thickness is in a range of 10 nm~50 nm. The thicknesses of the materials are proportionally distributed according to the evaporation rates. In the present application, the evaporation rate of the first light-emitting host material HOST1 adopts 0.1 nm/s, the evaporation rate of the second light-emitting host material Co-host1 adopts 0.1 nm/s, the evaporation rate of the phosphorescent dopant Dopant1 adopts 0.02 nm/s and the total evaporation thickness adopts 30 nm.

Evaporating the first light-emitting host material HOST1 on a surface of the light-emitting layer 330 as the second barrier layer 360, wherein, the evaporation rate is in a range of 0.01 nm/s~0.2 nm/s, an evaporation thickness is in a range of 1 nm~10 nm. In the present application example, the evaporation rate adopts 0.1 nm/s and the evaporation thickness adopts 5 nm.

Evaporating Bphen on a surface of the second barrier layer 360 as an electron transporting layer 380. Wherein, the

evaporation rate is in a range of 0.01 nm/s~0.2 nm/s, an evaporation thickness is in a range of 10 nm~30 nm. In the present application example, the evaporation rate adopts 0.1 nm/s and the evaporation thickness adopts 20 nm.

Evaporating lithium fluoride on a surface of the electron transporting layer **380** as an electron injecting layer **391**. Wherein, the evaporation rate is in a range of 0.005 nm/s~0.1 nm/s, an evaporation thickness is in a range of 0.1 nm~5 nm. In the present application example, the evaporation rate adopts 0.01 nm/s and the evaporation thickness adopts 0.5 nm.

Evaporating aluminum on a surface of the electron injecting layer **391** as a cathode layer **340**. Wherein, the evaporation rate is in a range of 0.005 nm/s~0.5 nm/s, an evaporation thickness is in a range of 100 nm~200 nm. In the present application example, the evaporation rate adopts 0.1 nm/s and the evaporation thickness adopts 150 nm. The thickness of the cathode layer **340** is far greater than the thickness of the other layers because the cathode layer **340** is required to reach a total reflection condition.

The evaporation process of the above layers can be at different vacuum chambers, each vacuum chamber is evacuated to 1×10^{-6} Pa to 2×10^{-4} Pa.

(5) APPLICATION EXAMPLE 5

The evaporation rate and thickness of the present application example is the same as the application example 4, the difference is, the second light-emitting host material Co-host1 of the first barrier layer **350** and the light-emitting layer **330** is replaced as the second light-emitting host material Co-host2.

(6) APPLICATION EXAMPLE 6

The evaporation rate and thickness of the present application example is the same as the application example 4, the difference is, the second light-emitting host material Co-host1 of the first barrier layer **350** and the light-emitting layer **330** is replaced as the second light-emitting host material Co-host3.

(7) COMPARISON EXAMPLE 1

The evaporation rate and thickness of the present application example is the same as the application example 4, the difference is, the first barrier layer **350** made of the second light-emitting host material Co-host1 and the second barrier layer **360** made of the first light-emitting host material HOST1 is not adopted.

Performance parameters of the organic light-emitting device **300** obtained in each application example and the comparison example are shown as Table. 2

TABLE 2

performance parameters of the organic light-emitting device					
Device	Brightness cd/m ²	Voltage V	Current efficiency cd/A	Color coordinates (x, y)	Lifetime LT90
Comparison example 1	5000	4.0	45.6	(0.32, 0.61)	200
Application example 4	5000	3.8	54.7	(0.32, 0.61)	400
Application example 5	5000	3.8	55.9	(0.32, 0.61)	430

TABLE 2-continued

performance parameters of the organic light-emitting device					
Device	Brightness cd/m ²	Voltage V	Current efficiency cd/A	Color coordinates (x, y)	Lifetime LT90
Application example 6	5000	3.9	56.2	(0.32, 0.61)	445

From the data shown in Table. 2, using the color coordinates (0.32, 0.61) as a reference, comparing among the application example 4, the application example 5, the application example 6 and the comparison example 1 (without the first barrier layer **350** and the second barrier layer **360**), the voltage and the current efficiency are basically the same, and the lifetime of the organic light-emitting device **300** is extended to be double. The reason is that each of the first light-emitting host material and the second light-emitting host material has a very high triplet energy level T1, when the first light-emitting host material and the second light-emitting host material are used as the materials of the barrier layers, the diffusion of the triplet exciton can be blocked in order to reduce the exciton quenching and increase the lifetime of the organic light-emitting device **300**. Besides, the present invention can effectively limit electrons and excitons at the light-emitting layer such that the electrons and holes are recombined in order to decrease the energy loss, increase the luminous efficiency of the organic light-emitting device **300**.

With reference to FIG. 4, and FIG. 4 is a schematic diagram of a display device of an embodiment of the present invention.

As shown in FIG. 4, the display device **40** includes a substrate **41** and the organic light-emitting device **300** described above. Wherein, the organic light-emitting device **300** is disposed on the substrate **41**.

Wherein, the structure of the organic light-emitting device **300** can refer to the content of the above, no more repeating.

In summary, the person skilled in the art can easily understood, because the organic light-emitting device provided by the present invention is disposed with the first barrier layer and the second barrier layer including the light-emitting host material, the light-emitting host material has a very high triplet energy level T1. When the light-emitting host material is used as the first barrier layer, the diffusion of the triplet exciton can be blocked in order to reduce the exciton quenching and increase the lifetime of the organic light-emitting device, and when the light-emitting host material is used as the second barrier layer, the second barrier layer can effectively limit electrons and excitons at the light-emitting layer such that the electrons and holes are recombined in order to decrease the energy loss, increase the luminous efficiency of the organic light-emitting device.

The above embodiments of the present invention are not used to limit the claims of this invention. Any use of the content in the specification or in the drawings of the present invention which produces equivalent structures or equivalent processes, or directly or indirectly used in other related technical fields is still covered by the claims in the present invention.

13

What is claimed is:

1. An organic light-emitting device, comprising:

a substrate layer, a first electrode layer, a light-emitting layer, and a second electrode layer which are stacked; 5

a first barrier layer disposed between the first electrode layer and the light-emitting layer, a second barrier layer disposed between the second electrode layer and the light-emitting layer, wherein each of the first barrier layer and the second barrier layer includes a light-emitting host material, a triplet energy level T1 of the light-emitting host material ≥ 2.5 eV; 10

wherein, the light-emitting layer is made of a first light-emitting host material having a first film thickness, a second light-emitting host material having a second film thickness and a phosphorescent dopant having a third film thickness which are stacked in a layer by layer way, and the first barrier layer is made of the second light-emitting host material, and the second barrier layer is made of the first light-emitting host material; 15 20

wherein the first light-emitting host material having the first film thickness is adjacent to the first barrier layer; and 25

wherein the phosphorescent dopant having a third film thickness is adjacent to the second barrier layer.

2. The device according to claim 1, wherein,

the first electrode layer and the second electrode layer are respectively an anode layer and a cathode layer; 30

the light-emitting host material of the first barrier layer is a hole-type host material, the energy level of the highest occupied molecular orbit and the energy level of the lowest unoccupied molecular orbit are respectively 5.3~5.7 eV and 1.8~2.3 eV; and 35

the light-emitting host material of the second barrier layer is an ambipolar light-emitting host material, the energy level of the highest occupied molecular orbit and the energy level of the lowest unoccupied molecular orbit are respectively 5.5~6.0 eV and 2.5~3.5 eV. 40

3. The device according to claim 2, wherein,

the organic light-emitting device further includes a hole transporting layer disposed between the first barrier layer and the anode layer, and an electron transporting layer disposed between the second barrier layer and the cathode layer; 45 50

a difference of energy level of highest occupied molecular orbit of the first barrier layer and the hole transporting layer is less than 0.2 eV, a difference of energy level of lowest unoccupied molecular orbit of the first barrier layer and the hole transporting layer is greater than 0.2 eV; and 55

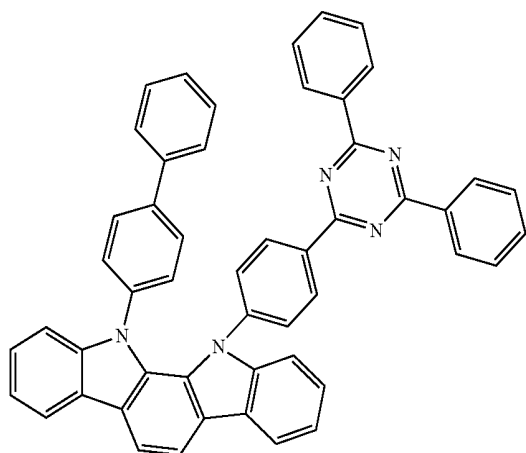
a difference of energy level of lowest unoccupied molecular orbit of the second barrier layer and the electron transporting layer is less than 0.2 eV, a difference of energy level of highest occupied molecular orbit of the second barrier layer and the electron transporting layer is greater than 0.2 eV; 60

wherein a material of the first barrier layer and a material of the hole transporting layer are different; and 65

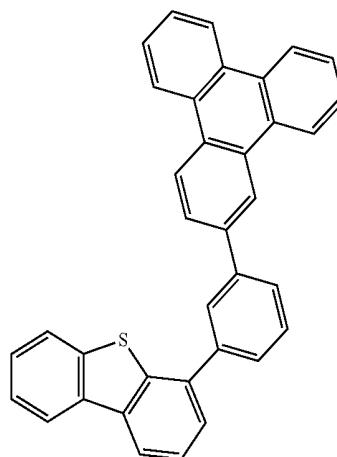
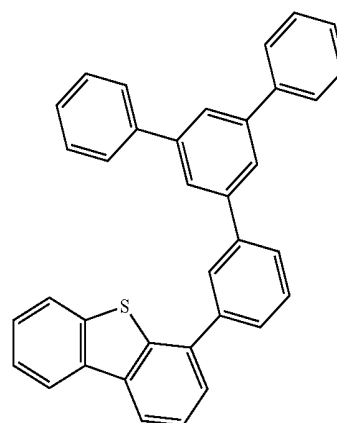
wherein a material of the second barrier layer and a material of the electron transporting layer are different.

14

4. The device according to claim 1 wherein, the chemical structural formula of the first light-emitting host material is:



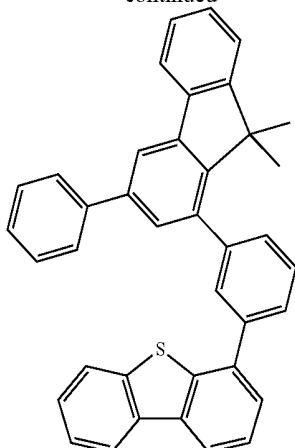
5. The device according to claim 1, wherein, the chemical structural formula of the second light-emitting host material is:



or

15

-continued



6. The device according to claim 1, wherein, a ratio of the first, second and third film thicknesses of the first light-emitting host material, the second light-emitting host material and the phosphorescent dopant is 5:5:1.

7. The device according to claim 1, wherein, a thickness of the first barrier layer is in a range of 1 nm~100 nm, and a thickness of the second barrier layer is in a range of 1 nm~50 nm.

8. The device according to claim 7, wherein, the thickness of the first barrier layer is in a range of 5 nm~50 nm, and a thickness of the second barrier layer is in a range of 5 nm~20 nm.

9. The device according to claim 8, the thickness of the first barrier layer is in a range of 10 nm~20 nm, and a thickness of the second barrier layer is in a range of 5 nm~10 nm.

10. The device according to claim 1, a thickness of the light-emitting layer is in a range of 10 nm~50 nm.

11. The device according to claim 3, wherein, a thickness of the hole transporting layer is in a range of 10 nm~30 nm.

12. The device according to claim 3, wherein, a thickness of the electron transporting layer is in a range of 10 nm~30 nm.

13. A display device, comprising an organic light-emitting device as claimed in claim 1.

14. The display device according to claim 13, wherein, the first electrode layer and the second electrode layer are respectively an anode layer and a cathode layer;

the light-emitting host material of the first barrier layer is a hole-type host material, the energy level of the highest occupied molecular orbit and the energy level of the lowest unoccupied molecular orbit are respectively 5.3~5.7 eV and 1.8~2.3 eV; and

the light-emitting host material of the second barrier layer is an ambipolar light-emitting host material, the energy level of the highest occupied molecular orbit and the energy level of the lowest unoccupied molecular orbit are respectively 5.5~6.0 eV and 2.5~3.5 eV.

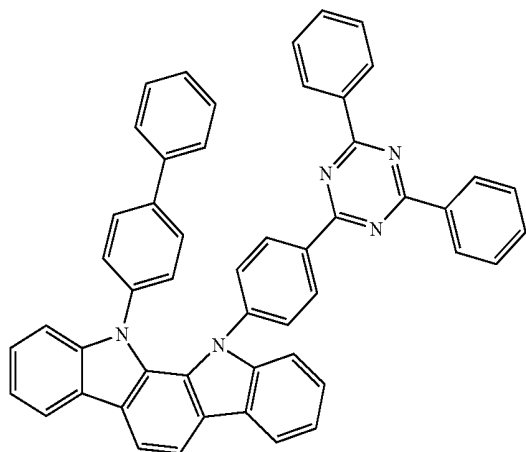
15. The display device according to claim 14, wherein, the organic light-emitting device further includes a hole transporting layer disposed between the first barrier layer and the anode layer, and an electron transporting layer disposed between the second barrier layer and the cathode layer;

16

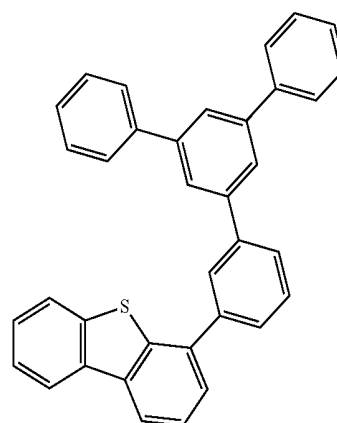
a difference of energy level of highest occupied molecular orbit of the first barrier layer and the hole transporting layer is less than 0.2 eV, a difference of energy level of lowest unoccupied molecular orbit of the first barrier layer and the hole transporting layer is greater than 0.2 eV; and

a difference of energy level of lowest unoccupied molecular orbit of the second barrier layer and the electron transporting layer is less than 0.2 eV, a difference of energy level of highest occupied molecular orbit of the second barrier layer and the electron transporting layer is greater than 0.2 eV.

16. The display device according to claim 13, wherein, the chemical structural formula of the first light-emitting host material is:

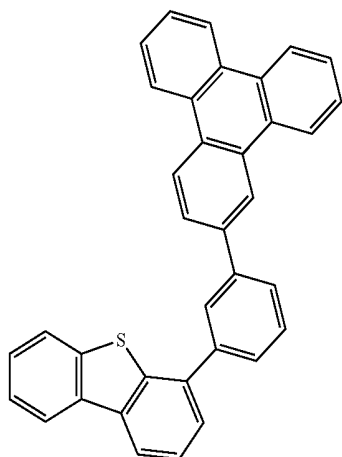


17. The display device according to claim 13, wherein, the chemical structural formula of the second light-emitting host material is:



17

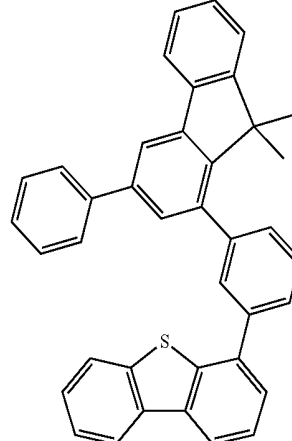
-continued



or

18

-continued



5

10

15

* * * * *

专利名称(译)	有机发光装置和显示装置		
公开(公告)号	US10147898	公开(公告)日	2018-12-04
申请号	US15/118867	申请日	2016-07-20
[标]申请(专利权)人(译)	武汉华星光电技术有限公司		
当前申请(专利权)人(译)	中国武汉恒星光电科技有限公司		
[标]发明人	TANG JINMING		
发明人	TANG, JINMING		
IPC分类号	H01L51/50 H01L51/00 H01L51/52 C09K11/06 H01L27/32 H01L51/56		
CPC分类号	H01L51/5024 H01L27/3244 H01L51/001 H01L51/50 H01L51/5004 H01L51/5016 H01L51/5056 H01L51/5072 H01L51/5206 H01L51/5221 H01L51/56 C09K11/06 H01L2251/558 C09K2211/1018 C09K2211/1029 C09K2211/185 H01L51/0052 H01L51/0054 H01L51/0067 H01L51/0072 H01L51/0074 H01L51/0085 H01L2251/5384 H01L2251/552 H01L51/5096 H01L2251/308		
代理人(译)	程, ANDREW C.		
优先权	201610452465.X 2016-06-21 CN		
其他公开文献	US20180166646A1		
外部链接	Espacenet		

摘要(译)

公开了一种有机发光装置和显示装置。有机发光装置包括堆叠的基板层, 第一电极层, 发光层, 第二电极层; 第一阻挡层设置在第一电极层和发光层之间, 第二阻挡层设置在第二电极层和发光层之间, 其中, 第一和第二阻挡层中的每一个包括发光主体材料, 发光主体材料的三重态能级 $T_1 \geq 2.5\text{eV}$ 。因为有机发光装置设置有包括发光主体材料的第一和第二阻挡层, 所以发光装置的结构可以增加有机发光装置的寿命和发光效率。

