US 20120097926A1

(19) **United States**

(12) **Patent Application Publication**

PARK et al.

(10) **Pub. No.: US 2012/0097926 A1**

(43) **Pub. Date: Apr. 26, 2012**

(54) **OLED DISPLAY AND METHOD OF FABRICATING THE SAME**

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(21) Appl. No.: **13/154,929**

(22) Filed: **Jun. 7, 2011**

(30) **Foreign Application Priority Data**

Oct. 21, 2010 (KR) 10-2010-0103081

Publication Classification

(51) **Int. Cl.**
H01L 51/54 (2006.01)
H01L 51/56 (2006.01)

(52) **U.S. Cl.** **257/40**; 438/28; 257/E51.018

(57) **ABSTRACT**

An OLED (OLED) display is provided with a plurality of pixels in each of the OLEDs, each of the OLEDs comprising a first electrode, an organic emission layer, and a second electrode sequentially formed on a substrate, wherein the organic emission layer comprises a mixture of at least two organic materials, and wherein a difference of sublimation temperatures between the at least two organic materials is set to be less than about 50° C.

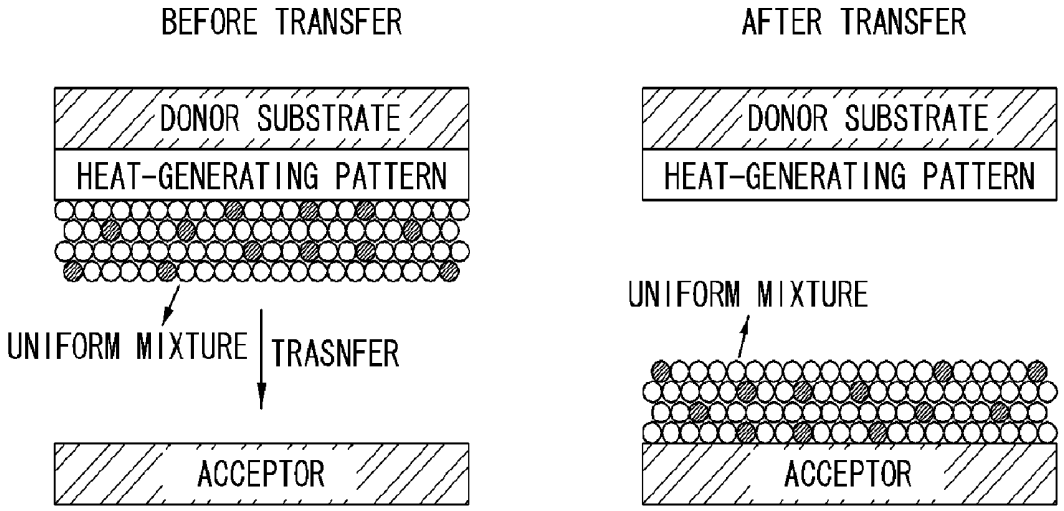


FIG. 1

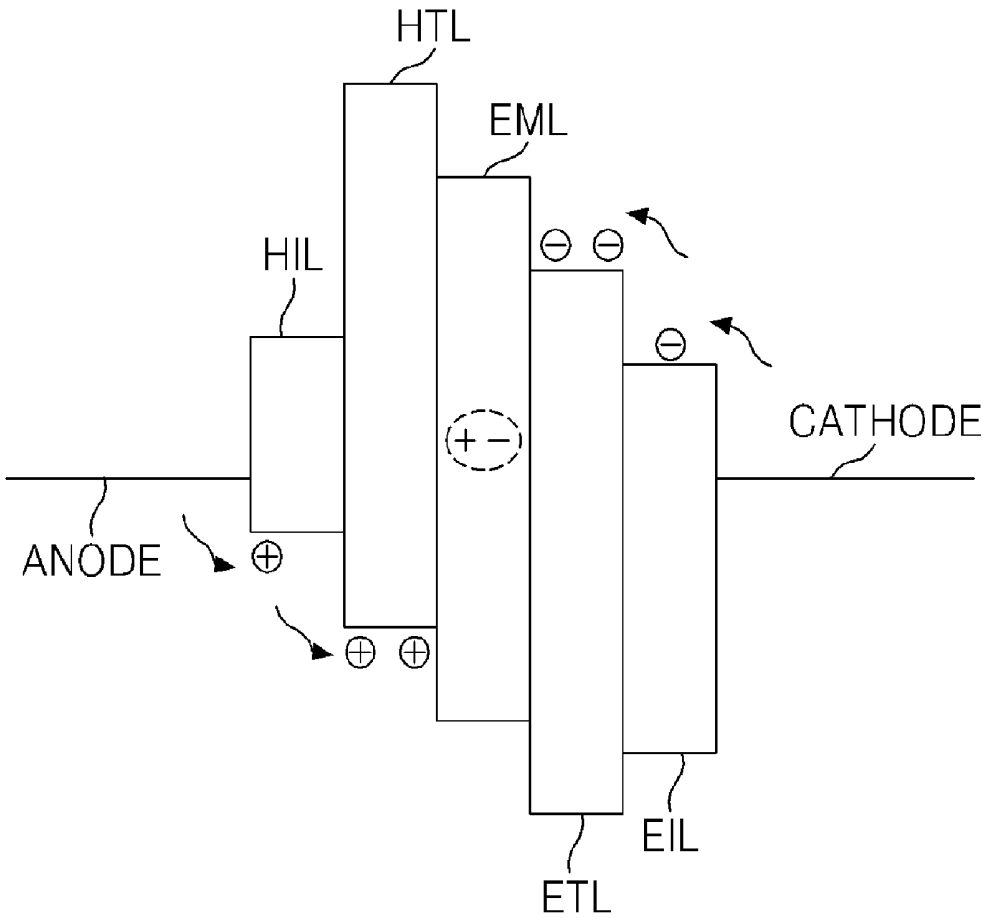


FIG. 2

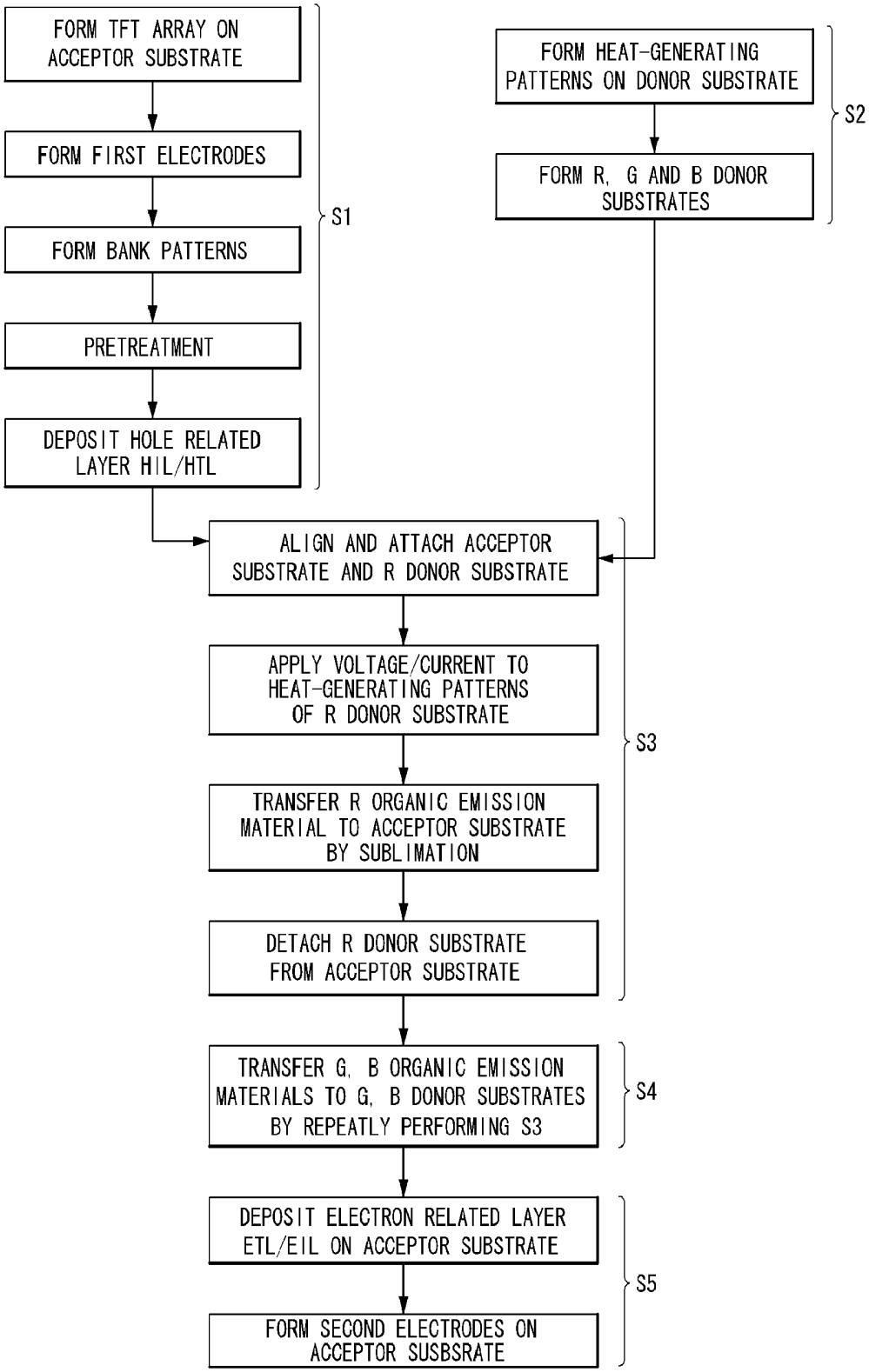

FORM TFT ARRAY ON ACCEPTOR SUBSTRATE
FORM FIRST ELECTRODES
FORM BANK PATTERNS
PRETREATMENT
DEPOSIT HOLE RELATED LAYER HIL/HTL
S1
FORM HEAT-GENERATING PATTERNS ON DONOR SUBSTRATE
FORM R, G AND B DONOR SUBSTRATES
S2
ALIGN AND ATTACH ACCEPTOR SUBSTRATE AND R DONOR SUBSTRATE
APPLY VOLTAGE/CURRENT TO HEAT-GENERATING PATTERNS OF R DONOR SUBSTRATE
TRANSFER R ORGANIC EMISSION MATERIAL TO ACCEPTOR SUBSTRATE BY SUBLIMATION
DETACH R DONOR SUBSTRATE FROM ACCEPTOR SUBSTRATE
S3
TRANSFER G, B ORGANIC EMISSION MATERIALS TO G, B DONOR SUBSTRATES BY REPEATLY PERFORMING S3
S4
DEPOSIT ELECTRON RELATED LAYER ETL/EIL ON ACCEPTOR SUBSTRATE
FORM SECOND ELECTRODES ON ACCEPTOR SUSBSRATE
S5

FIG. 3A

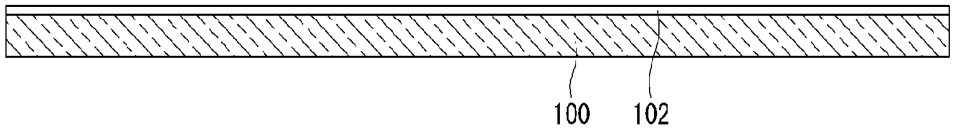


FIG. 3B

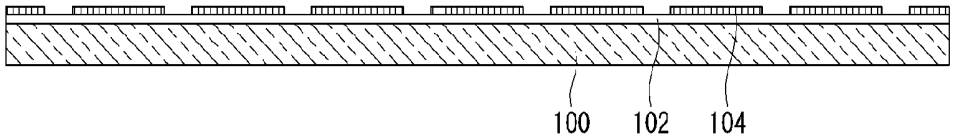


FIG. 3C

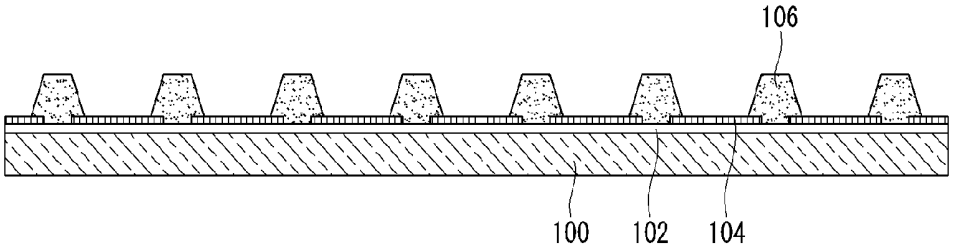


FIG. 3D

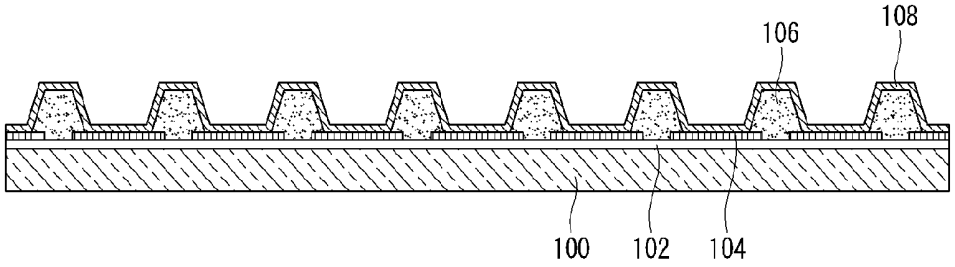


FIG. 4A

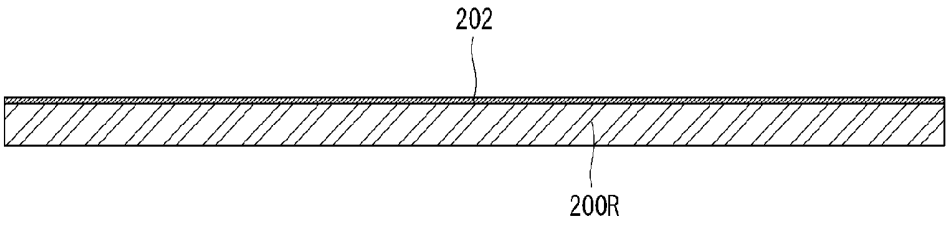


FIG. 4B

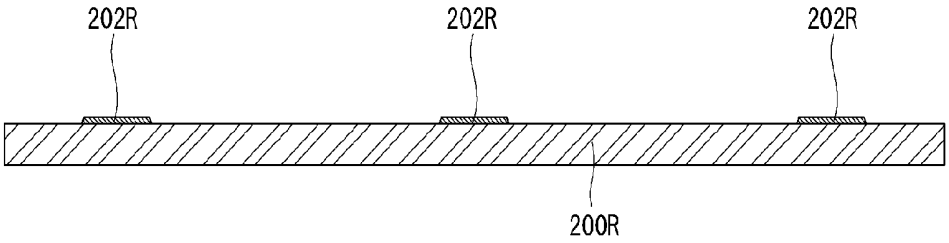


FIG. 4C

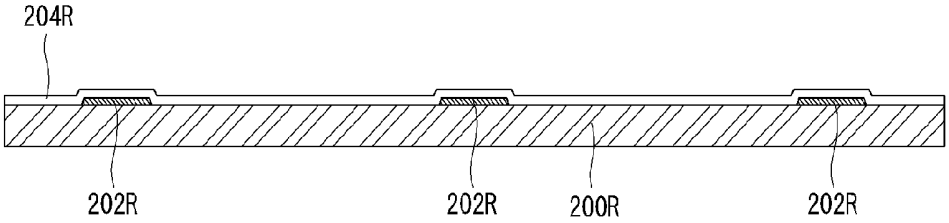


FIG. 4D

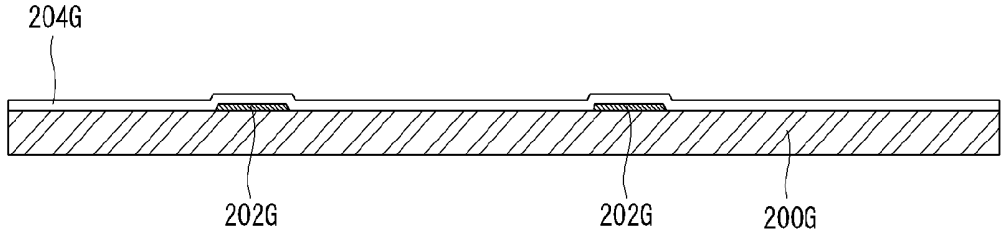


FIG. 4E

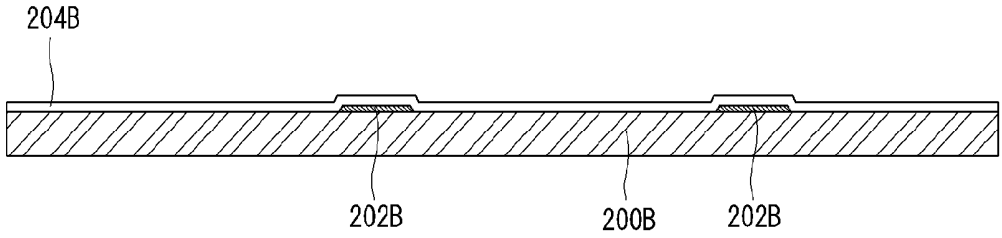


FIG. 5A

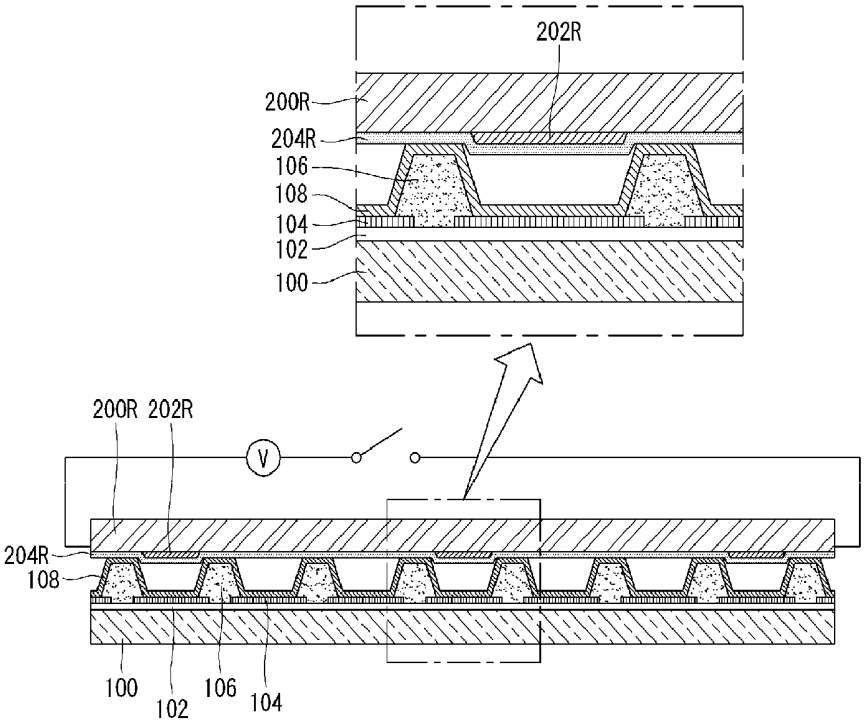

202R
200R
204R
106
108
104
102
100
200R 202R
V
204R
108
100
102
106
104

FIG. 5B

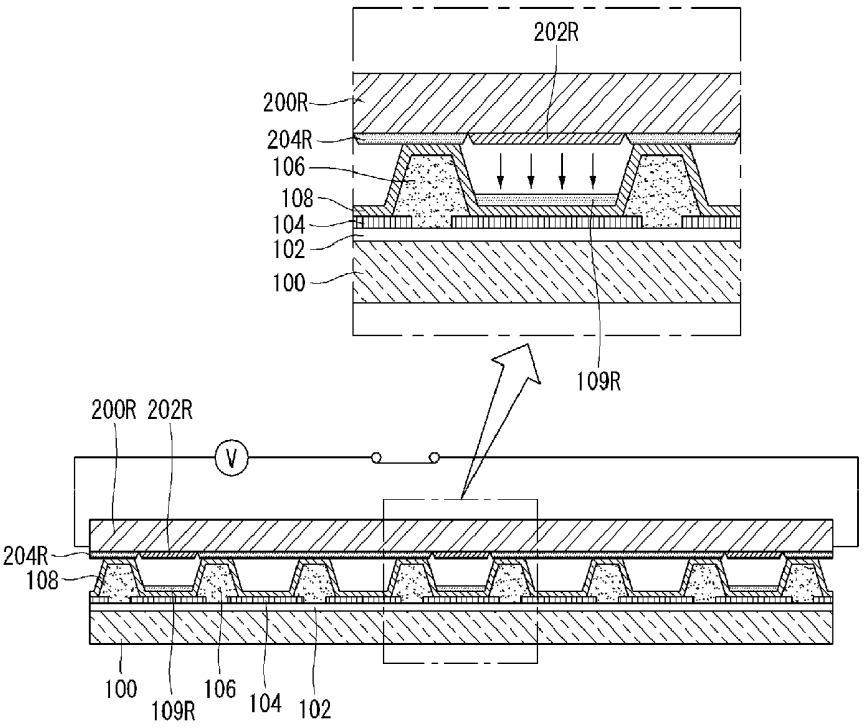

202R
200R
204R
106
108
104
102
100
109R
200R 202R
V
204R
108
100
109R
106
104
102

FIG. 6A

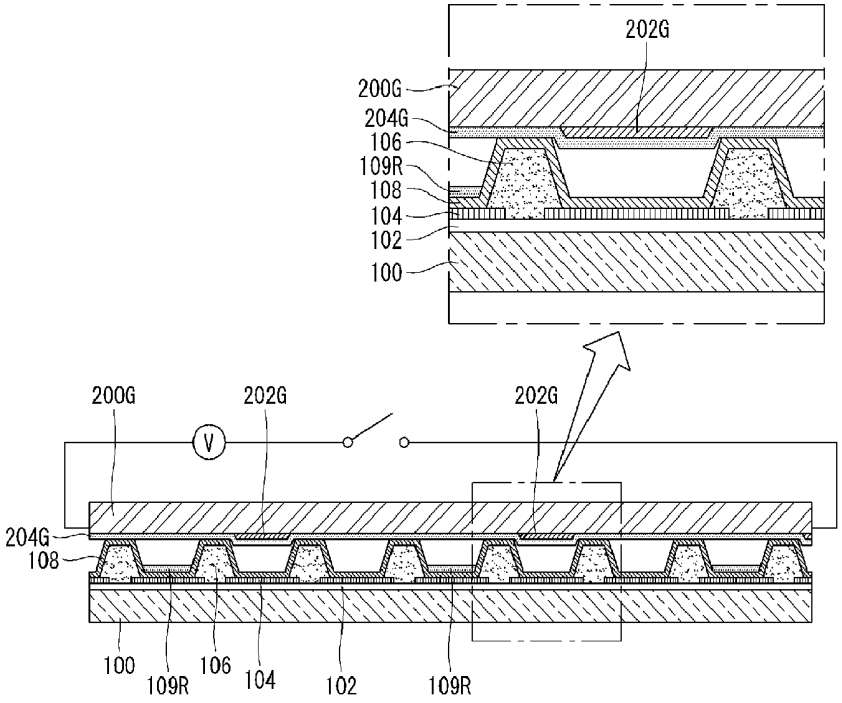

202G
200G
204G
106
109R
108
104
102
100
200G
202G
202G
V
204G
108
100
109R
106
104
102
109R

FIG. 6B

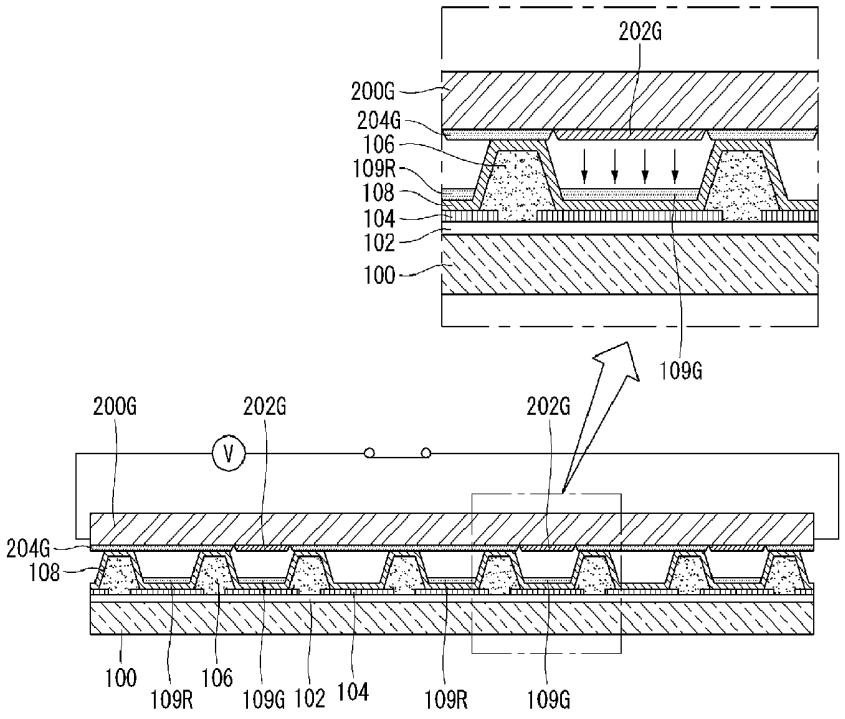

202G
200G
204G
106
109R
108
104
102
100
109G
200G
202G
202G
V
204G
108
100
109R
106
109G
102
104
109R
109G

FIG. 7A

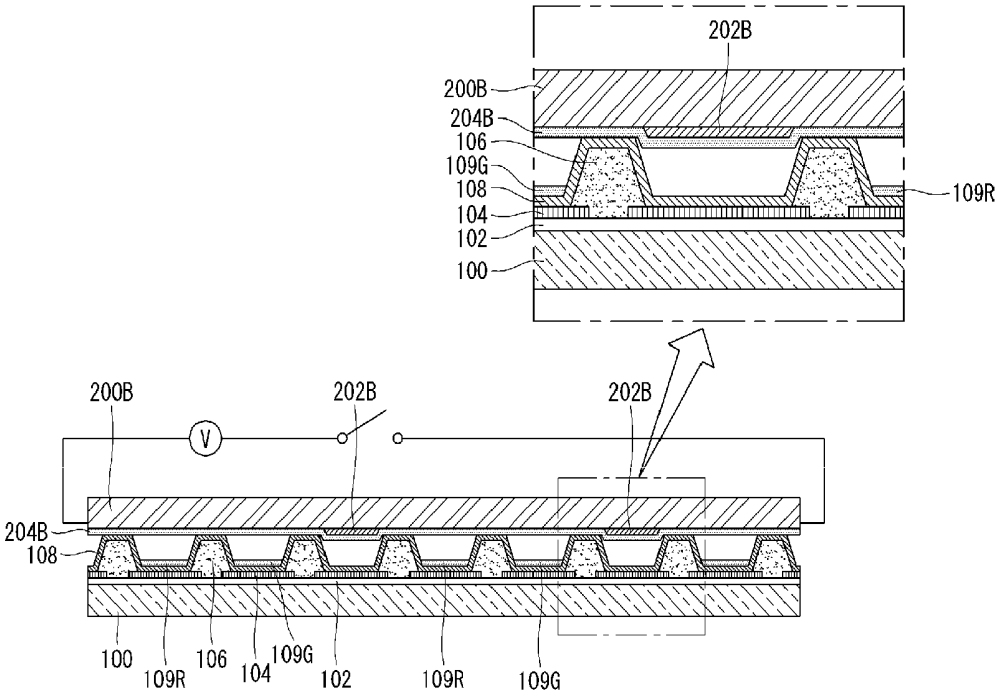

202B
200B
204B
106
109G
108
104
102
100
109R
200B
202B
202B
V
204B
108
100
109R
106
104
109G
102
109R
109G

FIG. 7B

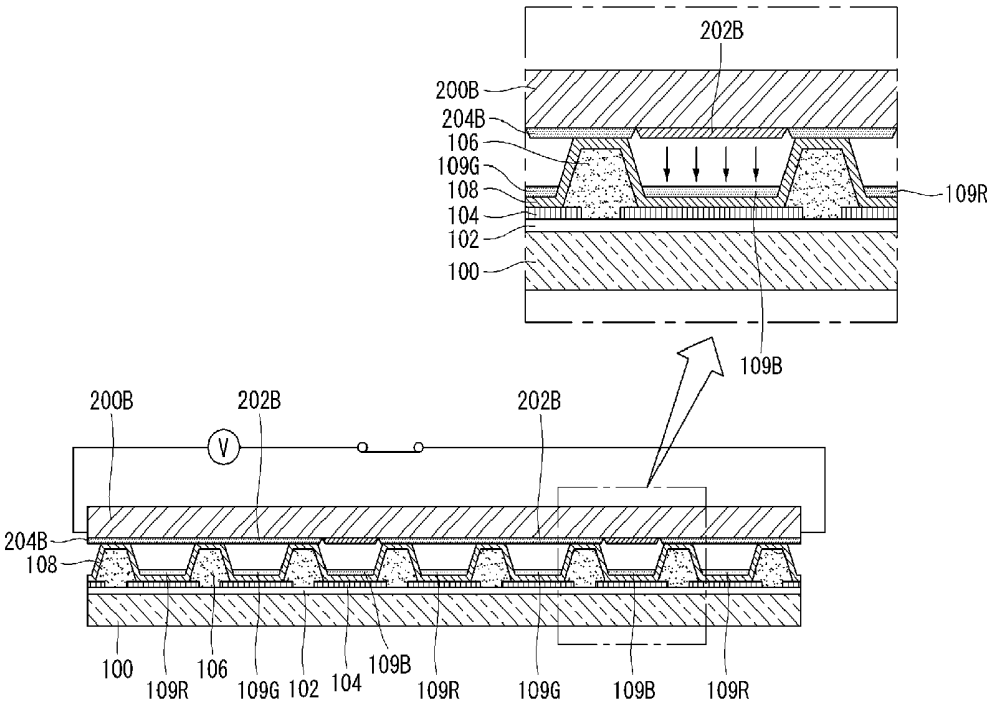

202B
200B
204B
106
109G
108
104
102
100
109R
109B
200B
202B
202B
V
204B
108
100
109R
106
109G
102
104
109B
109R
109G
109B
109R

FIG. 8A

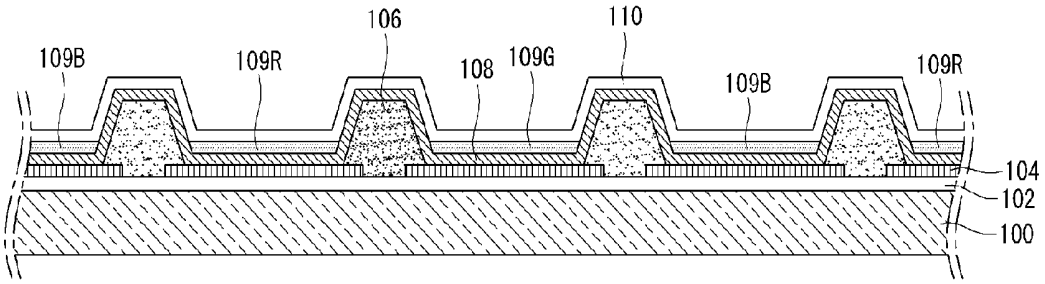

106
110
109B
109R
108
109G
109B
109R
104
102
100

FIG. 8B

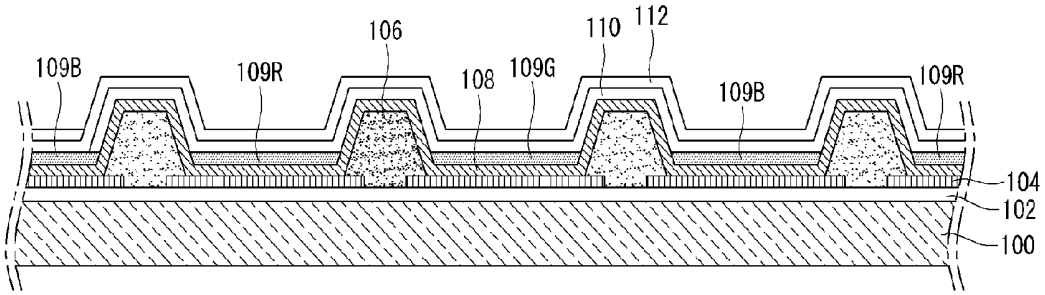

106
110
112
109B
109R
108
109G
109B
109R
104
102
100

FIG. 9A

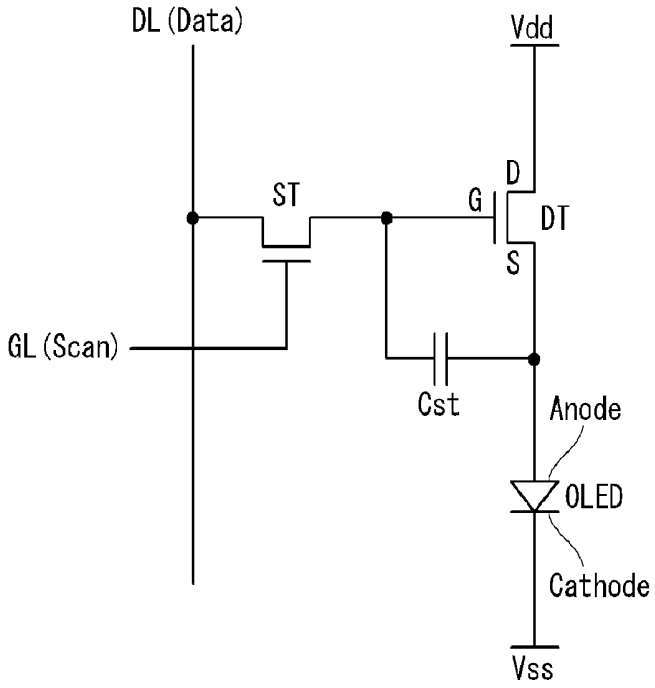

DL (Data)
Vdd
D
ST
G
DT
S
GL (Scan)
Cst
Anode
OLED
Cathode
Vss

FIG. 9B

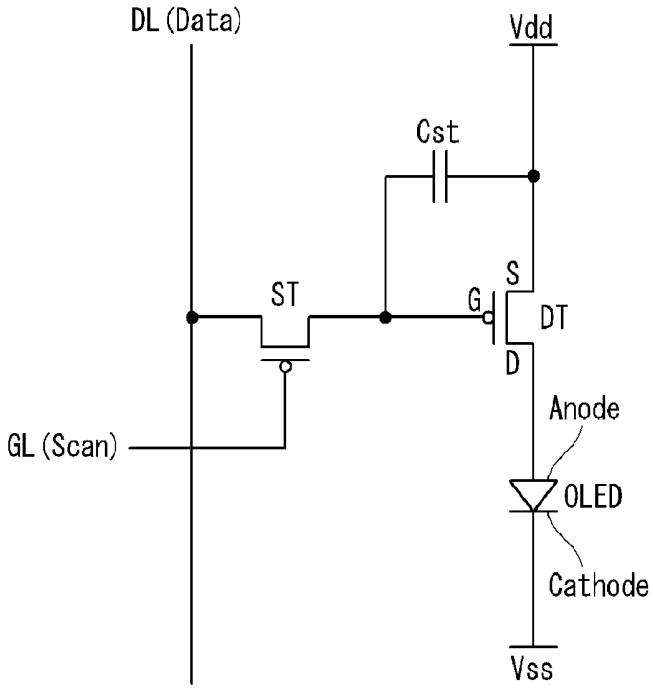

DL (Data)
Vdd
Cst
S
ST
G
DT
D
Anode
GL (Scan)
OLED
Cathode
Vss

FIG. 9C

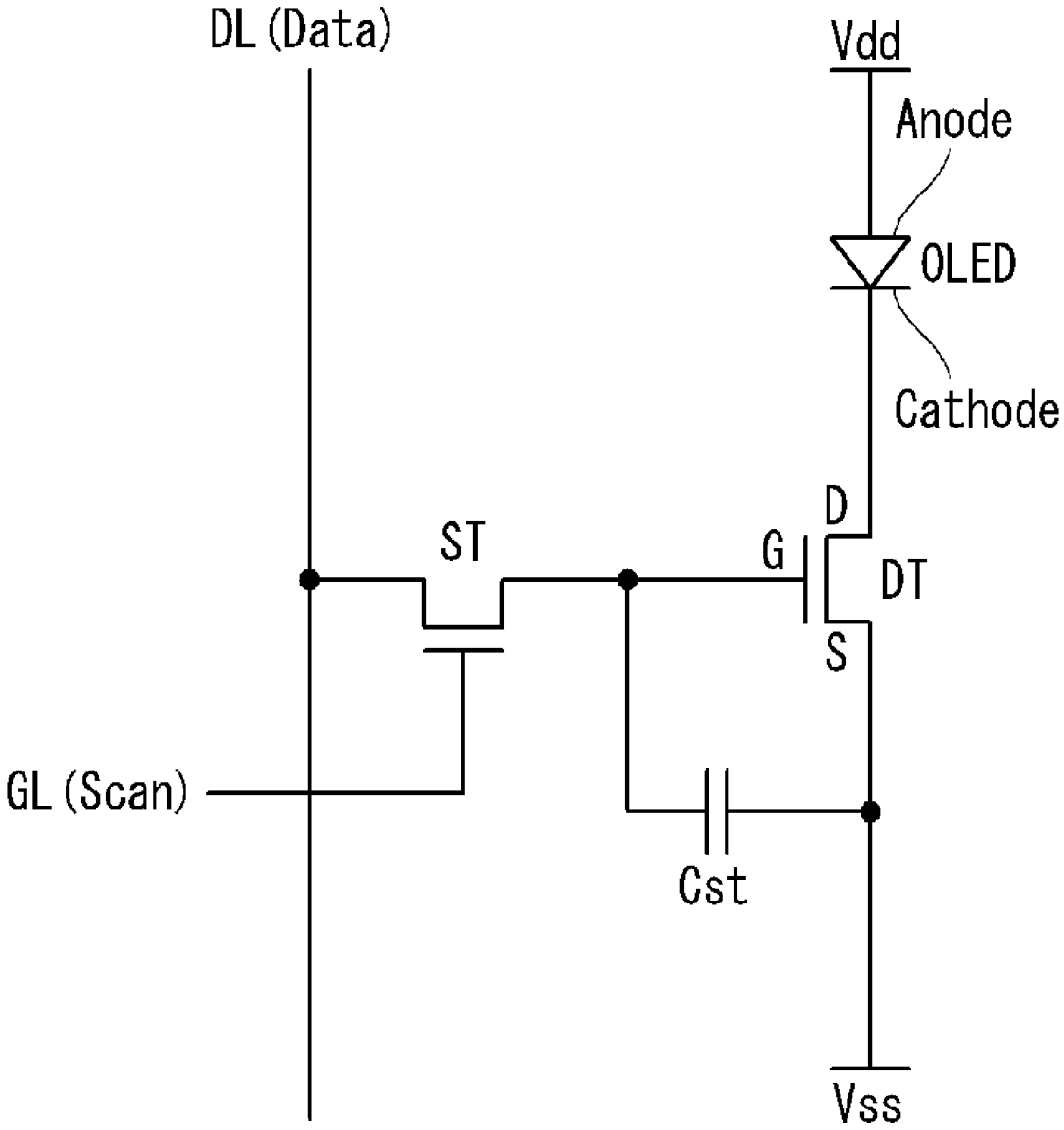


FIG. 10A

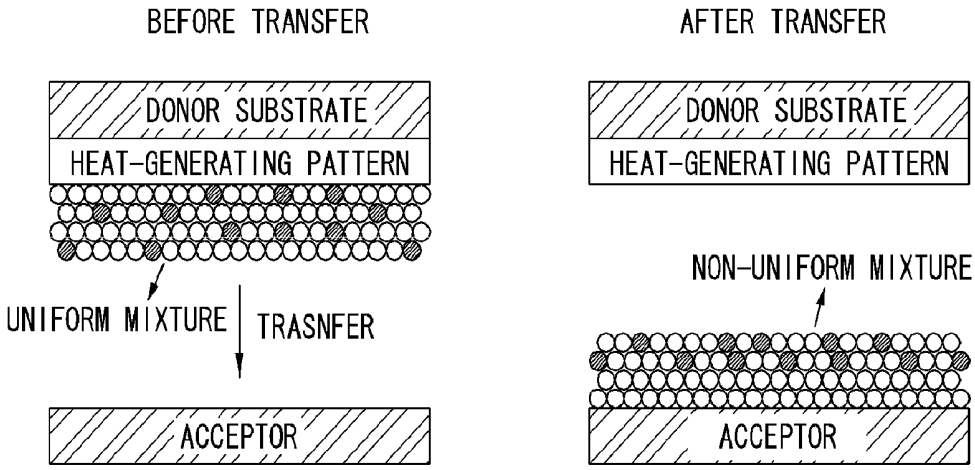


FIG. 10B

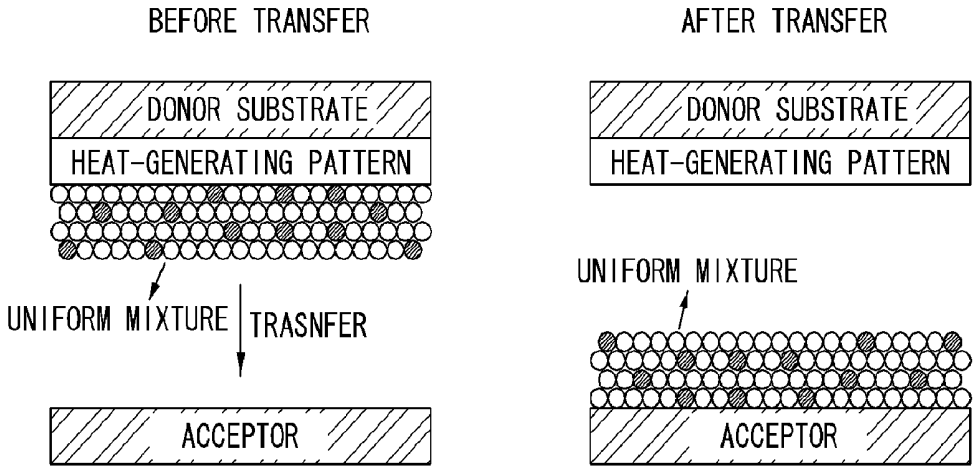


FIG. 11A

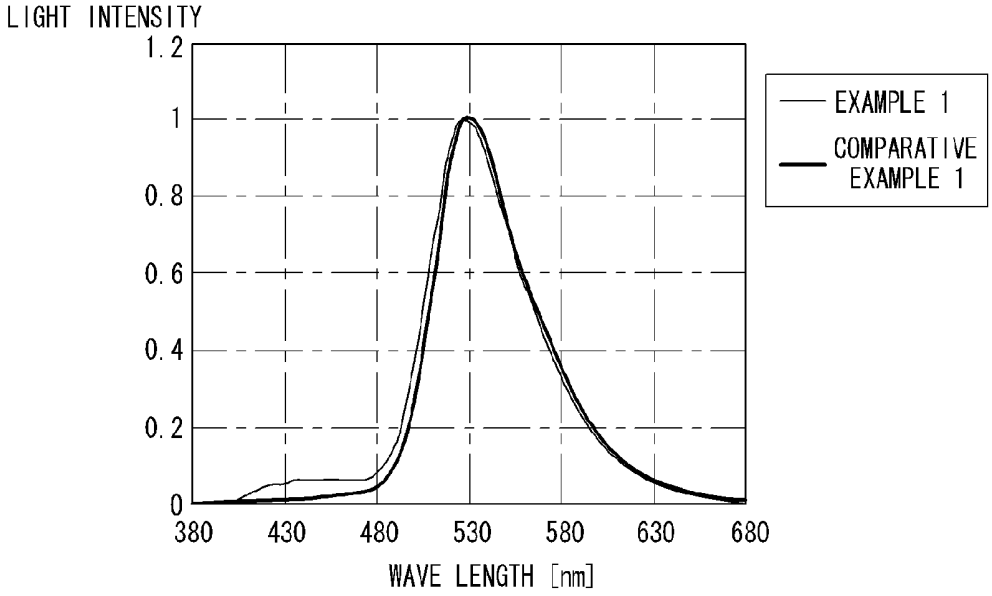
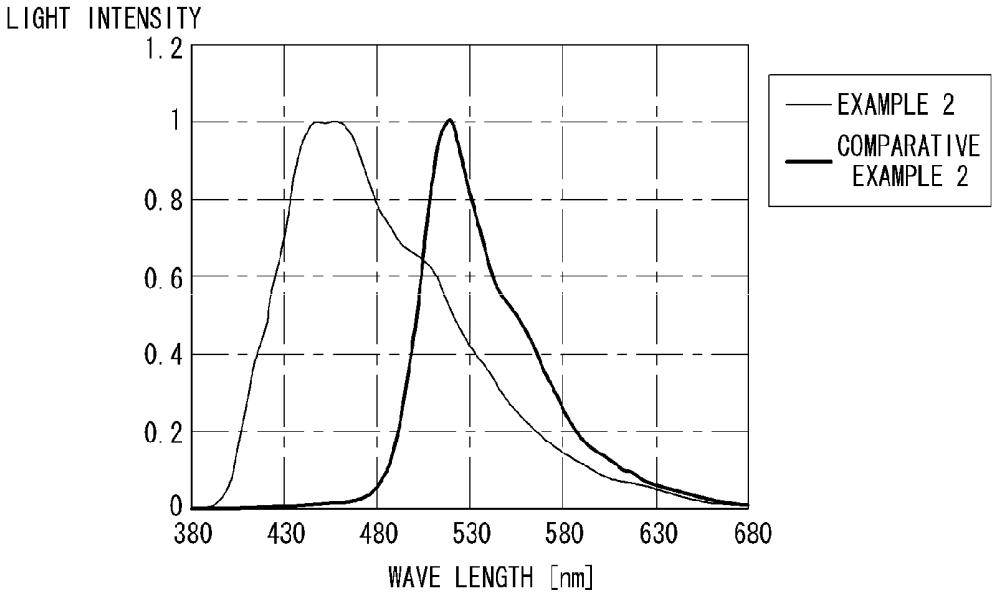


FIG. 11B



OLED DISPLAY AND METHOD OF FABRICATING THE SAME

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of Korea Patent Application No. 10-2010-0103081 filed on Oct. 21, 2010, which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to an organic light emitting diode (OLED) display and a method of fabricating the same.

BACKGROUND OF THE INVENTION

[0003] In recent years, various kinds of flat panel display devices ("FPDs") have been developed to replace the heavy and voluminous cathode ray tube. Such FPDs include, for example, liquid crystal displays ("LCDs"), field emission displays ("FEDs"), plasma display panels ("PDPs"), and electroluminescence displays ("ELDs").

[0004] In particular, the PDPs are known to be the most advantageous in implementing a slim, light-weight and large-sized screen because its structure and fabrication process are simple. Nonetheless, the PDPs are also known to be disadvantageous in that they have low luminous efficiency and luminance, and large power consumption. Thus, the thin film transistor (TFT) LCDs instead have been most widely used but are disadvantageous in that they have a narrow viewing angle and a low response speed. The ELDs are largely classified into an inorganic light emitting diode display and an organic light emitting diode display according to materials used in an emission layer. Of the two, the organic light emitting diode display is a self-emitting element and is more advantageous in that it has faster response speed, higher luminous efficiency, and a larger viewing angle.

[0005] As shown in FIG. **1**, the OLED, which is an organic electron element converting an electric energy into a light energy, has a structure in which organic emission materials for emitting light are placed between an anode electrode ANODE and a cathode electrode CATHODE. Holes are injected from the anode electrode, and electrons are injected from the cathode electrode. The holes and electrons are injected from the electrodes to an organic emission layer EML to form excitons. Specifically, the holes are recombined with the electrons in the organic emission layer EML, and the OLED emits light due to energy generated when the excitons returns to a bottom level. In order to smoothly inject the holes and electrons into the emission layer EML from the electrodes, typically, a hole transport layer HTL and a hole injection layer HIL are placed between the emission layer EML and the anode electrode. Further, an electron transport layer ETL and an electron injection layer EIL are placed between the emission layer EML and the cathode electrode.

[0006] For a smooth hole injection, the hole injection layer HIL and the hole transport layer HTL have an HOMO (highest occupied molecular orbital) level which corresponds to the middle level between the emission layer EML and the anode electrode. In addition, for a smooth electron injection, the electron transport layer ETL and the electron injection layer EIL have a LUMO (lowest unoccupied molecular orbital) level which corresponds to the middle level between the cathode electrode and the emission layer, EML. Brightness and efficiency characteristics of the OLED element are determined by the amount of the holes and electrons injected from the anode electrode and cathode electrode into the emission layer EML. The amount of the holes injected from the anode electrode into the emission layer EML and the amount of the electrons injected from the cathode into the emission layer EML are varied depending on an energy level of the organic emission material.

[0007] Meanwhile, in the OLED display, for implementation of full colors, the emission layer EML is formed at a position where the OLED is disposed in each of red, green, and blue pixels. The emission layer EML is patterned for each pixel. As methods of forming the emission layer EML, there have been known methods of using a fine metal mask (FMM), an ink jet method, a laser induced thermal imaging (LITI), or the like.

[0008] In particular, in the FMM method, red, green, and blue emission materials are patterned for each pixel using a metal fine mask to form red, green, and blue pixels. This method has superiority in terms of element characteristics. It, however, has a low yield due to the phenomenon of the mask blocking, and is hardly applied to a large-sized display device since a large-sized mask is difficult to develop.

[0009] The ink jet method is advantageous in that large-sized screen and high definition characteristics and high luminous efficiency can be implemented since the emission layer can be easily formed at selected regions and there is no damage to materials. In the ink jet method, however, there is a need of an accurate adjustment of the amount, the speed, the uniform jetting angle of ink jetted from nozzles. Also, there is a need of development of ink jet heads with a higher speed jetting and an increased number of heads for implementing lower cost and larger-sized screen. Furthermore, quality and thickness of the emission layer must be uniform so as to secure uniform emission in pixels. There, however, appears a so-called coffee stain effect where a periphery portion of the emission layer becomes thicker than a middle portion of the emission layer in a process of drying ink drops, and thus the periphery is thickened.

[0010] The laser induced thermal imaging (LITI) is a method in which a light source like a laser is irradiated to a transfer substrate including an organic emission material pattern, a light-to-heat conversion layer, and a support film to transfer the organic emission material pattern on the transfer film onto another substrate, thereby forming an emission layer. Describing this further in detail, in the laser induced thermal imaging, the transfer film provided with red, green, and blue organic emission material patterns is disposed on a substrate provided with black matrices, and thereafter the substrate and the transfer film are aligned and attached to each other. Next, the substrate to which the transfer film is attached is positioned on a stage of a laser irradiation device, and then the stage or a laser head moves from one end of the substrate to the other end thereof to perform a laser scanning. Thereby, a laser beam is sequentially irradiated to the red, green, and blue organic emission material patterns. Accordingly, the organic emission material patterns are sequentially transferred to the respective pixel regions on the substrate.

[0011] In the cases where the organic emission layers are formed on the substrate by the use of the laser induced thermal imaging in this way, a series of processes are repeated to form the red, green, and blue organic emission layers, where the respective transfer films corresponding to the red, green, and blue are attached to the substrate, the laser is irradiated

thereto in the scanning manner, and then the transfer films are detached. Thus, the repeated fabrication processes cause the process time to be lengthened and the processes to be complicated. Further, there is a problem in that bad patterns are sometimes generated due to micro bubbles in the course of attaching and detaching the respective transfer films of red, green, and blue to the substrate. Also, there is another problem in that edges of the organic emission layers become rough by the repeated irradiation of the laser beam, and the attachment and detachment of the transfer films.

[0012] As discussed above, it is difficult to implement an organic emission layer having a high precision to a large-sized screen display using the FMM method, the ink jet or the LITI method.

SUMMARY

[0013] Embodiments of the present invention provides an OLED display and a method of fabricating the OLED display capable of implementing large-sized screen and high resolution, in particular improving efficiency, color-property and life-time of an OLED by uniformly mixing at least two materials when the at least two materials is used to make an organic emission layer.

[0014] According to an exemplary embodiment of the present invention, there is provided an OLED display provided with a plurality of pixels in each of the OLEDs, each of the OLEDs comprising a first electrode, an organic emission layer, and a second electrode sequentially formed on a substrate, wherein the organic emission layer comprises a mixture of at least two organic materials, and wherein a difference of sublimation temperatures between the at least two organic materials is set to be less than about 50° C.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated herein and constitute a part of this specification, illustrate exemplary embodiments of the invention and together with the description serve to explain the principles of the invention. In the drawings:

[0016] FIG. **1** is a schematic diagram illustrating a structure of an OLED;

[0017] FIG. **2** is a flowchart illustrating a method of fabricating an OLED display according to one exemplary embodiment of the present invention;

[0018] FIGS. **3**A to **3**D are sectional views illustrating exemplary procedures of forming a thin film transistor (TFT) array, first electrodes of the OLED, bank patterns, and a hole related layer on an acceptor substrate;

[0019] FIGS. **4**A to **4**E are sectional views illustrating exemplary procedures of forming red, green and blue donor substrates having heat-generating patterns and organic emission material layers, respectively;

[0020] FIGS. **5**A to **5**B are sectional views illustrating exemplary procedures of forming a red emission layer by the attachment and transfer;

[0021] FIGS. **6**A to **6**B are sectional views illustrating exemplary procedures of forming a green emission layer by the attachment and transfer;

[0022] FIGS. **7**A to **7**B are sectional views illustrating exemplary procedures of forming a blue emission layer by the attachment and transfer;

[0023] FIGS. **8**A to **8**B are sectional views illustrating exemplary procedures of forming an electron related layer and second electrodes of the OLED;

[0024] FIGS. **9**A to **9**C are equivalent circuit diagrams of pixels according to some embodiments of the present invention;

[0025] FIG. **10**A is a conceptual view illustrating mixing states before and after a mixture of two organic materials (e.g. host material and dopant material) is transferred onto an acceptor substrate when a difference of sublimation temperatures between the two organic materials is equal or large than about 50° C.;

[0026] FIG. **10**B is a conceptual view illustrating mixing states before and after a mixture of two organic materials (e.g. host material and dopant material) are transferred onto an acceptor substrate when a difference of sublimation temperatures between the two organic materials is less than about 50° C.;

[0027] FIG. **11**A is a graph illustrating spectra of organic emission layer according to an example 1 and a comparative example 1; and

[0028] FIG. **1**B is a graph illustrating spectra of organic emission layer according to an example 2 and a comparative example 2.

DETAILED DESCRIPTION

[0029] Exemplary embodiments of the present invention will now be described with reference to FIGS. **2** to **12**.

[0030] The following figures, embodiments and Examples have been included to provide guidance to one of ordinary skill in the art for practicing representative embodiments of the presently disclosed subject matter. In light of the present disclosure and the general level of skill in the art, those of skill can appreciate that the following Examples are intended to be exemplary only and that numerous changes, modifications, and/or alterations can be employed without departing from the scope of the presently disclosed subject matter.

[0031] As shown in FIG. **2**, the present invention relates to a fabricating method of the OLED display comprising process S**1** of forming an acceptor substrate including a first electrode, process S**2** of forming red, green or blue donor substrate, process S**3** of first attaching substrates and transferring organic emission material, process S**4** of secondly attaching substrate and transferring organic emission material, and process S**5** of forming an electron related layer and a second electrode. In below detailed description, the process S**2** forming the donor substrates and the first and second attachment and transferring processes S**3** and S**4** are described where red, green and blue organic emission layers are sequentially formed on the acceptor substrate. This invention, however, is not limited thereto. The sequence of forming red, green and blue organic emission layers can be appropriately changed.

[0032] In the process S**1** of forming the acceptor substrate according to some embodiments of the present invention, a thin film transistor array, the first electrode of the OLED, a bank pattern and hole related layers (e.g. a hole injection layer HIL and hole transport layer HTL) are formed on a first substrate.

[0033] In the process S**2** of forming the donor substrates according to additional embodiments of the present invention, three substrates are prepared. Heat-generating patterns are formed on each of second to fourth substrates. The red,

green and blue donor substrates are manufactured by forming red, green and blue organic emission materials on the second to fourth substrate.

[0034] In the first attachment and transferring process S**3** according to yet additional embodiments of the present invention, the acceptor substrate is aligned with and attached to the red donor substrate. If voltage or current is applied to the heat-generating patterns of the red donor substrate, the heat-generating patterns generate joule heat to sublimate the red organic emission material. The sublimated red organic emission material is transferred to the acceptor substrate to form a red organic emission layer.

[0035] In the second attachment and transferring process S**4** according to further embodiments of the present invention, the green and blue organic emission materials are formed on the acceptor substrate on which the red organic emission layer using the same process as forming the red organic emission layer.

[0036] In the process S**5** of forming the electron related layer and the second electrode according to yet further embodiments of the present invention, the electron related layer and the second electrode are sequentially formed on the acceptor substrate on which the red, green and blue organic emission layer.

[0037] Hereinafter, the process S**1** of forming the acceptor substrate is described further in detail with reference to FIGS. **3**A to **3**D.

[0038] As shown in FIG. **3**A according to some embodiments of the present invention, a TFT array **102** is formed on an acceptor substrate **100** made of a transparent material(s), including, but not limited to, glass and plastic. The TFT array **102** may comprise, as shown in FIGS. **9**A to **9**C, a gate line GL, a data line DL, a switching TFT ST, a driving TFT DT, a storage capacitor Cst, a voltage supply line Vdd, and a ground voltage supply line Vss. Further, the switching and driving TFTs ST and DT may be implemented by N type MOSFETs, but is not limited thereto. For example, the TFTs may be implemented by P type MOSFETs as shown in FIG. **9**B. The equivalent circuits of pixels shown in FIGS. **9**A to **9**C are formed by two transistors and one capacitor as an example, but the TFT array structure according to the present invention is not limited thereto. The TFT array **102** may comprise a passivation layer for protecting the TFT array from the external environment, an overcoat layer for removing a step difference caused by the TFTs ST and DT, and a buffer layer for shielding out-gasing from the overcoat layer, but, for simplicity of the description, they are omitted from the figures.

[0039] As shown in FIG. **3**B according to additional embodiments of the present invention, first electrodes **104** of the OLED are formed on the acceptor substrate **100** provided with the TFT array **102**. Each of the first electrodes **104** is connected to one electrode of the driving TFT DT through the buffer layer, the overcoat layer and the passivation layer (not shown). The first electrodes **104** may be anode electrodes having reflective layers, or cathode electrodes depending on a structure connected with the driving TFT DT. For example, in FIG. **9**A, the first electrode **104** is an anode electrode Anode connected to a source electrode S of the driving TFT DT, and, in FIG. **9**B, the first electrode **104** is an anode electrode connected to a drain electrode D of the driving TFT DT. In addition, in FIG. **9**C, the first electrode **104** is a cathode electrode connected to the drain electrode D of the driving TFT DT.

[0040] Hereinafter, the first electrode **104** is assumed to be the anode electrode having a reflective layer. The first electrode **104** is a transparent conductor formed of an oxide, including, but not limited to, Indium Tin Oxide (ITO) and Indium Zinc Oxide (IZO), and is patterned for each pixel on the reflective layer containing opaque metal materials. The first electrode **104** supplies holes, which are supplied via the driving TFT. DT, to organic emisssion layers via hole related layers HIL and HTL described later.

[0041] As shown in FIG. **3**C according to yet additional embodiments of the present invention, bank patterns **106** are formed on the acceptor substrate **100** provided with the anode electrodes **104**. The bank patterns **106** are formed at boundary regions between pixels to partition opening regions of the pixels. After the bank patterns **106** are formed on the acceptor substrate **100**, a pretreatment process is performed using plasma. The pretreatment process can remove alien materials from the acceptor substrate **100** before depositing the organic emission layers of the OLED.

[0042] As shown in FIG. **3**D according to further embodiments of the present invention, a hole injection layer material and a hole transport layer material are consecutively entirely deposited on the acceptor substrate **100** provided with the bank patterns **106**, by the thermal evaporation, thereby forming a hole related layer **108** including the hole injection layer and the hole transport layer.

[0043] Next, the processes S**2** of forming the donor substrates will be described further in detail with reference to FIGS. **4**A to **4**E.

[0044] As shown in FIG. **4**A according to some embodiments of the present invention, a first heat-generating material **202** is formed on an entire surface of a first donor substrate **200**R made of a transparent material(s), including, but not limited to, glass and plastic. The first heat-generating material **202** may be formed using a method, including, but not limited to, a chemical vapor deposition (CVD) process, a sputtering process, an electron beam process, an electrolysis/electroless plating. The size of the first donor substrate **200**R may be equal to or greater than the size of the acceptor substrate **100**. The first heat-generating material **202** may be made of any one, two or more alloy selected from the group consisting of Ag, Au, Al, Cu, Mo, Pt, Ti, W, and Ta, which can generate heat by application of voltage, but not limited thereto.

[0045] As shown in FIG. **4**B according to additional embodiments of the present invention, first heat-generating patterns **202**R are formed by patterning the first heat-generating material **202** entirely deposited on the first donor substrate **200**R using a process, including, but not limited to photolithography process, a wet etching and a dry etching. The first heat-generating patterns **202**R are formed corresponding to pixels of the acceptor substrate **100** to which organic emission material will be transferred. The width of each of the first heat-generating patterns **202**R formed on the first donor substrate **200**R may be equal to or smaller than a value obtained by summing the width of each pixel on the acceptor substrate **100** and the width of the bank pattern **106** which partitions adjacent pixels. The thickness of each of the first heat-generating patterns **202**R may be about 1 μm or less in consideration of a resistance component which generates joule heat. As used herein, the term "about" refers to a range of values ±10% of a specified value. For example, the phrase "about 1 μm" includes ±10% of 1 μm, or from 0.9 μm to 1.1 μm.

[0046] As shown in FIG. **4**C according to some embodiments of the present invention, a red organic emission material layer **204**R is entirely deposited, by the thermal evaporation or the like, on the first donor substrate **200**R where the first heat-generating patterns **202**R are formed. According to the processes of FIGS. **4**A to **4**C, it is possible to obtain a red donor substrate having the red R organic emission material **204**R formed on the first heat-generating patterns **202**R. The first heat-generating patterns **202**R are formed to correspond with positions of the acceptor substrate **100** on which red pixels will be formed.

[0047] In order to prevent the first heat-generating patterns **202**R generating joule heat from being oxidized or diffused to the red organic emission material **204**R, an insulating layer may be optionally formed between the first heat-generating patterns **202**R and the red organic emission material pattern **204**R. The insulating layer may be formed of a material, including, but not limited to, silicon oxide, a silicon nitride, and a silicon oxide-nitride, and entirely deposited on the first heat-generating patterns **202**R. Further, the insulating layer may employ a material used in the SOG (spin-on-glass) and may be entirely deposited on the first heat-generating patterns **202**R through the heat treatment after spin coating.

[0048] As shown in FIG. **4**D according to some embodiments of the present invention, a green organic emission material is entirely deposited, by the thermal evaporation or the like, on a second donor substrate **200**G where second heat-generating patterns **202**G are formed, thereby forming a green donor substrate. The second heat-generating patterns **202**G are formed using the same method as forming the first heat-generating patterns **202**R shown in FIGS. **4**A and **4**B.

[0049] As shown in FIG. **4**E according to some embodiments of the present invention, a blue organic emission material is entirely deposited, by the thermal evaporation or the like, on a third donor substrate **200**B where third heat-generating patterns **202**B are formed, thereby forming a blue donor substrate. The third heat-generating patterns **202**B are formed using the same method as method of forming the first heat-generating patterns **202**R shown in FIGS. **4**A and **4**B.

[0050] Subsequently, the attachment and transfer processes S**3** and S**4** will be described further in detail with reference to FIGS. **5**A to **7**B.

[0051] As shown in FIG. **5**A according to some embodiments of the present invention, the acceptor substrate **100** provided with the hole related layer **108** is aligned with and attached to the red donor substrate **200**R provided with the red organic emission material layer **204**R. These alignment and attachment are performed under a vacuum or inert gas (Ar, N_2, etc.) atmosphere so as to protect the red organic emission material from moisture and/or oxygen. The attachment may be performed by a process, such as mechanical pressing.

[0052] As shown in FIG. **5**B according to additional embodiments of the present invention, an external voltage V is applied to the first heat-generating patterns **202**R on the red donor substrate **200**R after the alignment and the attachment are completed. By the application of the voltage V, the first heat-generating patterns **202**R generate joule heat and in turn the red emission material **204**R sublimates. As a result, the red organic emission material **204**R on the first heat-generating patterns **202**R is transferred onto the red pixel regions on the acceptor substrate **100** to form the red organic emission layers **109**R.

[0053] As shown in FIG. **6**A according to yet additional embodiments of the present invention, the acceptor substrate **100** having the hole related layer **108** and the red organic emission layer **109**R is aligned with and attached to the green donor substrate **200**G provided with the green organic emission material **204**G. These alignment and attachment are performed under a vacuum or inert gas (Ar, N2, etc.) atmosphere so as to protect the organic material pattern from moisture and/or oxygen. The attachment may be performed by a process, such as a mechanical pressing.

[0054] As shown in FIG. **6**B according to further embodiments of the present invention, the external voltage V is applied to the second heat-generating pattern **202**G on the green donor substrate **200**G after the alignment and the attachment are completed. By the application of the voltage V, the second heat-generating patterns **202**G generate joule heat and in turn the green organic emission material **204**G sublimates. As a result, the green emission material pattern **204**G on the second heat-generating patterns **202** is transferred onto the green pixel regions on the acceptor substrate **100** to form the green organic emission layers **109**G.

[0055] As shown in FIG. **7**A according to some embodiments of the present invention, the acceptor substrate **100** having the hole related layer **108**, the red organic emission layers **109**R, and the green organic emission layer **109**G are aligned with and attached to the green donor substrate **200**B provided with the green organic emission material **204**B. These alignment and attachment are performed under a vacuum or inert gas (Ar, N2, etc.) atmosphere so as to protect the organic material pattern from moisture and/or oxygen. The attachment may be performed by a process, such as mechanical pressing.

[0056] As shown in FIG. **7**B according to additional embodiments of the present invention, the external voltage V is applied to the third heat-generating pattern **202**B on the blue donor substrate **200**B after the alignment and the attachment are completed. By the application of the voltage V, the third heat-generating patterns **202**B generate joule heat and in turn the blue organic emission material **204**B sublimates. As a result, the blue organic emission material layer **204**B on he third heat-generating patterns **202**B is transferred onto the blue pixel regions on the acceptor substrate **100** to form the blue organic emission layers **109**B.

[0057] In the above embodiments, although it has been described as the case where the red, green and blue organic emission layers are sequentially formed, but the present invention is not limited thereto. It is also possible to appropriately change order of forming the red, green and blue organic emission layers. Further, it is possible to appropriately change the colors of the emission layers.

[0058] Since the acceptor substrate **100** and each of the donor substrates are close to each other with the bank patterns **106** therein, it is possible not only to prevent a color mixing phenomenon caused by the transfer being deviated to other pixel regions or being spread, but also to accurately control positions where the organic emission layers are formed. Also, since each of the red, green and blue organic emission layers **109**R, **109**G, and **109**B is formed at a same time by the application of voltage, there is an advantage in that it is possible to save time which is wasted by the sequential scanning like the laser induced thermal imaging. Thus, the fabrication process is simple and the fabrication time is considerably shortened.

[0059] When the organic emission materials are exposed to a high temperature for a long time, they typically are denatured or their chemical bonds are destroyed. Therefore, in

order to prevent the thermal denaturalization of the organic emission materials, an application time of the voltage applied to the first to third heat-generating patterns **202**R, **202**G and **202**B may be in a range of about 0.1 μs to about 1 s, and a power density of the voltage applied to the first to third heat-generating patterns **202**R, **202**G and **202**B may be in a range of about 0.1 W/cm^2 to about 10000 W/cm^2. The voltage applied to the first to third heat-generating patterns **202**R, **202**G and **202**B may be of a direct current type or an alternating current type, and may be applied at several times intermittently.

[0060] The processes S**5** of forming an electron related layer ETL/EIL and a second electrode on the acceptor substrate on which the red, green and blue organic emission layers **109**R, **109**G and **109**B are formed will be described further in detail with reference to FIGS. **8**A and **8**B.

[0061] As shown in FIG. **8**A according to some embodiments of the present invention, the electron related layer is formed on the acceptor substrate **100** on which the red, green and blue organic emission layer **109**R, **109**G and **109**B are formed by consecutively entirely depositing an electron injection layer EIL material and an electron transport layer ETL material on the acceptor substrate **100** using a process, such as the thermal evaporation. The hole related layer **108**, the red, green and blue organic emission layers **109**R, **109**G and **109**B constitute the organic compound layer of the OLED.

[0062] As shown in FIG. **8**B according to additional embodiments of the present invention, a second electrode **112** of the OLED is formed on an entire surface of the acceptor substrate **100** provided with the electron related layer **110**. The second electrode **112**, which is a cathode electrode, may be a single layer made of a metal material, or may be formed of multi-layers comprising first and second metal layers which are disposed between dielectric layers. The second electrode **112** applies electrons supplied via the voltage supply line Vss to the organic compound layer as shown in FIGS. **9**A to **9**C.

[0063] The red, green and blue organic emission layer **109**R, **109**G and **109**B in the OLED display according to some embodiments are formed by mixing at least two organic materials. Each of the red, green and blue organic emission layers **109**R, **109**G and **109**B may be uniformly formed on each of the R, G and B donor substrates by depositing at least two organic materials mixed in a predetermined proportion using a thermal evaporation method before the transfer process is performed. As thus, the organic materials formed on the R, G and B donor substrates are maintained at a uniform mixing state before the transfer process is performed. If thermal properties of the at least two organic materials constituting of the mixture are different from each other, however, the at least two organic materials are transferred onto the acceptor substrate in a different speed according to the thermal property of each organic material. Thus, the at least two organic materials transferred onto the acceptor substrate are in a non-uniform state.

[0064] This phenomenon is because an organic material having a lower sublimation temperature is transferred onto the acceptor substrate faster than another organic material having a higher sublimation temperature. Because efficiency, lifetime and color property of the OLED are degraded when the mixture of the organic materials transferred onto the acceptor substrate is in a non-uniform state, it is necessary for the mixture of the organic materials to be uniformly distributed on the acceptor substrate.

[0065] The inventors of the present invention have found that it is possible to prevent the mixture of the organic materials formed on the acceptor substrate from being non-uniformly formed by controlling sublimation temperature Ts of the organic materials according to equations 1 and 2 below.

$$|Ts(A)-Ts(B)|<50^\circ\ C. \qquad \text{[Equation 1]}$$

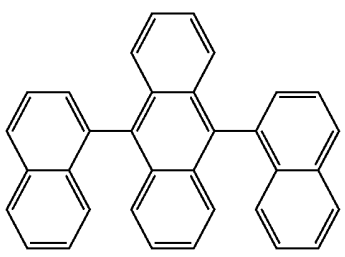
$$|Ts(A)-Ts(B)|<50^\circ\ C.,\ |Ts(A)-Ts(C)|<50^\circ\ C.,\ |Ts(B)-Ts(C)|<50^\circ\ C.$$

[0066] The equation 1 is applied in case that the organic emission layer is formed using two organic materials, and the equation 2 is applied in case that the organic emission layer is formed using three organic materials. In the equation 1 and 2, A is a host material to form the organic emission layer, and B and C are dopant materials to form the organic emission layer. The sublimation temperature Ts(A) of the host material A and sublimation temperatures Ts(B) and Ts(C) of the dopant materials B and C are temperatures measured in the thermal evaporation device when the host and dopant materials A, B and C are reached to a specific sublimation rate while the host and dopant materials A, B and C received in a crucible of the thermal evaporation device are heated. From the equations 1 and 2, it is possible to know that at least two organic materials can be uniformly formed on the acceptor substrate before and after the transfer is completed when a difference of sublimation temperature between the at least two organic materials used as the organic emission layer of this invention is set to less than about 50° C.

[0067] FIG. **10**A is a conceptual view illustrating mixing states of two organic materials before and after the two organic materials (host material and dopant material) are transferred onto the acceptor substrate when a difference of sublimation temperature between the two organic materials is equal to or larger than about 50° C. FIG. **10**A shows that the two organic materials can be non-uniformly formed on the acceptor substrate after the transfer is completed although the two organic materials formed on the donor substrate are uniformly mixed before the transfer is completed. FIG. **10**B is a conceptual view illustrating mixing states before and after a mixture of two organic materials (host material and dopant material) are transferred onto an acceptor substrate when a difference of sublimation temperature between the two organic materials is less than about 50° C. FIG. **10**B shows that two organic materials can be uniformly formed on the acceptor substrate before and after the transfer is completed.

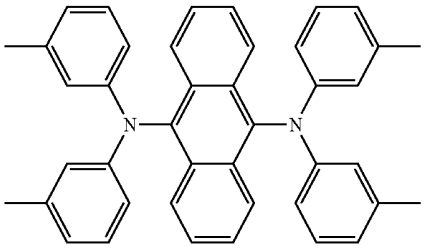
[0068] Subsequently, technical effects of this invention in some embodiments in which the green organic emission layer is formed by mixing the host material A expressed as a chemical formula 1, the dopant material B expressed as a chemical formula 2, and the dopant material C expressed as a chemical formula 3 is described below.

[chemical formula 1]

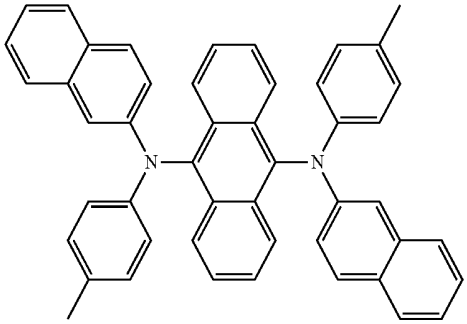


-continued

[chemical formula 2]



[chemical formula 3]



[0069] In chemical formulas 1 and 2, the sublimation temperature Ts(A) of the host material A is about 170° C., the sublimation temperature Ts(B) of the dopant material B is about 170° C., and the sublimation temperature Ts(C) of the dopant material C is about 250° C. The sublimation temperatures Ts(A), Ts(B) and Ts(C) of the host and dopant materials A, B and C are temperatures measured when the sublimation rates of the host and dopant materials A, B and C are reached at 0.1 Å/sec while a boron nitride crucible having a capacity of 5 cc in a vacuum chamber maintained at about 5×10^{-6} torr is heated in 10° C./min. In the boron nitride crucible, each 1 gram of the host and dopant materials A, B and C is filled.

[0070] In order to examine uniformity of the green organic emission layer formed on the acceptor substrate, green organic emission layers (examples 1 and 2) are formed using joule heat, and green organic emission layers (comparative examples 1 and 2) are formed using a conventional thermal evaporation. Hereafter, methods of manufacturing Examples 1 and 2, and comparative examples 1 and 2 are will be described.

[0071] Firstly, the host material A and the dopant material B are mixed each other for forming the green organic emission layer. Subsequently, the green organic emission layer is formed on the acceptor substrate according to the method shown in FIGS. **6**A and **6**B. Such green organic emission layer is referred to as example 1. The green organic emission layer of the example 1 is formed by transferring the mixture of the host material A (sublimation temperature 170° C.) and the dopant material B (sublimation temperature 170° C.) to the acceptor substrate using joule heat. The green organic emission layer of example 2 is formed using the same method as example 1. In the example 2, the sublimation temperature of the host material A is about 170° C. and the sublimation temperature of the dopant material C is about 250° C.

[0072] In order to compare with the examples 1 and 2 of the green organic emission layer according to this invention, the green organic emission layers of comparative examples 1 and 2 formed using the conventional thermal evaporation method are prepared. The green organic emission layer of comparative examples 1 is formed with the host material A and the dopant material B, and the green organic emission layer of comparative examples 2 is formed with the host material A and the dopant material C.

[0073] Table 1 shows a relationship of light emission efficiency between example 1 and comparative example 1, and a relationship of light emission efficiency between example 2 and comparative example 2.

TABLE 1

light emission efficiency of example 1 to light emission efficiency of comparative example 1	light emission efficiency of example 1 is about 74% of light emission efficiency of comparative example 1
light emission efficiency of example 2 to light emission efficiency of comparative example 2	light emission efficiency of example 2 is about 21% of light emission efficiency of comparative example 2

[0074] As shown in the table 1, the light emission efficiency of example 1 at 0° C. when the difference of the sublimation temperatures between the host material A and the dopant material B is less than about 50° C. is much higher than the light emission efficiency of example 2 at 80° C. when the difference of the sublimation temperature between the host material A and the dopant material C is equal to or larger than 50° C.

[0075] FIG. **11**A is a graph illustrating spectra of the green organic emission layers according to the example 1 and the comparative example 1, and FIG. **11**B is a graph illustrating spectra of the green organic emission layers according to example 2 and comparative example 2. In graphs of FIGS. **11**A and **11**B, x axis represents a wave length mm, and y axis represents a light intensity.

[0076] As shown in FIG. **11**A, the distribution of spectrum of example 1 at 0° C. when the difference of the sublimation temperature between the host material A and the dopant material B is less than 50° C. is similar to comparative example 1 since the green organic emission layer formed on the acceptor is maintained in an uniform state. As shown in FIG. **11**B, however, the distribution of spectrum of example 2 at 80° C. when the difference of the sublimation temperature between the host material A and the dopant material C is larger than 50° C. is different from comparative example 2 since the organic emission layer formed on the acceptor are maintained in a non-uniform state.

[0077] In above-mentioned embodiments, the green organic emission layers are described as examples, but this invention is not limited thereto. For example, the method of forming an organic layer by applying a mixture of at least two organic materials onto a donor substrate, and then transferring the mixture to an acceptor substrate using joule heat can be applied to this invention. Accordingly, if an electron related layer including an electron injection layer and an electron transport layer, and a hole related layer including a hole injection layer and a hole transport layer are formed by mixing at least two organic materials, it is possible to apply this invention in order to make the electron and hole related layers.

[0078] As described herein, according to one aspect of the present invention, it is possible to obtain an effect capable of quickly forming the organic emission layer having a high pattern precision on a large substrate because the organic emission layer of the OLED is formed by using joule heat.

Accordingly, the organic emission layer according to the present invention is suitable for a large screen OLED display.

[0079] As described herein, according to another aspect of the presentinvention, it is possible for the mixture constituting the organic emission layer to be uniformly formed by appropriately setting the difference of sublimation temperatures between the at least two organic materials. Therefore, it is possible to obtain an OLED display with improved efficiency, color property, and lifetime.

[0080] One skilled in the art will readily recognize from the disclosures herein, the accompanying drawings and the claims that various modifications can be made without departing from the spirit and scope of the invention. For example, although some embodiments where the first and second electrodes are an anode electrode and a cathode electrode, respectively, has been described herein, the present invention is also applicable to a case where the first and second electrodes are a cathode electrode and an anode electrode, respectively. In this case, the hole related layer described in the embodiment may be replaced with an electron related layer, and the electron related layer described in the embodiment may be replaced with a hole related layer. Therefore, the scope of the invention is indicated by the appended claims rather than the foregoing description, and all changes that come within the meaning and range and equivalence thereof are intended to be embraced therein.

What is claimed is:

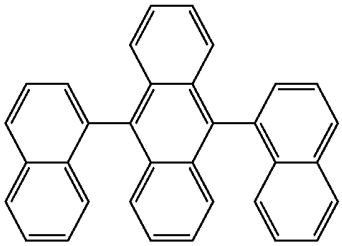
1. An organic light emitting diode (OLED) display comprising a plurality of pixels in each of the OLEDs, each of the OLEDs comprising a first electrode, an organic emission layer, and a second electrode sequentially formed on a substrate,

wherein the organic emission layer comprises a mixture of at least two organic materials, and

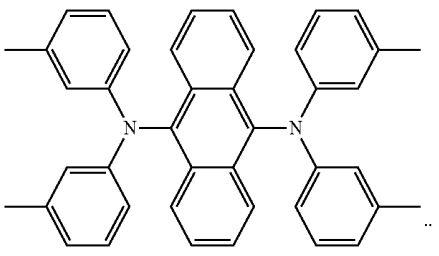
wherein a difference of sublimation temperatures between the at least two organic materials is set to be less than about 50° C.

2. The OLED display of claim **1**, wherein the at least two organic materials are chemical formulas 1 and 2:

[chemical formula 1]



[chemical formula 2]



3. The OLED display of claim **1**, further comprising a first layer and a second layer, wherein the first layer is a hole injection layer and/or a hole transport layer, and the second layer is an electron injection layer and/or an electron transport layer.

4. A method of fabricating an OLED display comprising a plurality of pixels according to claim **1**, comprising the steps of:

forming a substrate comprising a first electrode,

forming a color donor substrate comprising an organic emission material and a heat-generating pattern,

attaching the substrate and the color donor substrate,

transferring the organic emission material from the color donor substrate to the substrate, forming a color organic emission layer on the substrate, and

forming a second electrode on the color organic emission layer.

5. The method of claim **4**, further comprising forming a hole related layer prior to forming the second electrode or prior to attaching the substrate and the color donor substrate.

6. The method of claim **4**, further comprising forming an electron related layer prior to forming the second electrode or prior to attaching the substrate and the color donor substrate.

7. The method of claim **4**, wherein the heat-generating pattern is formed corresponding to the pixels of the substrate to which organic emission material is transferred.

8. The method of claim **4**, further comprising forming a bank pattern partitioning adjacent pixels, wherein the width of the heat-generating pattern is equal to or smaller than a value obtained by summing the width of each pixel on the substrate and the width of the bank pattern.

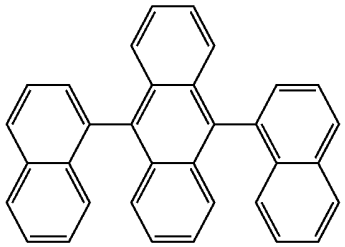
9. The method of claim **4**, wherein the thickness of the heat-generating patters is about 1 μm or less.

10. The method of claim **4**, further comprising forming an insulating layer between the heat-generating pattern and the organic emission material.

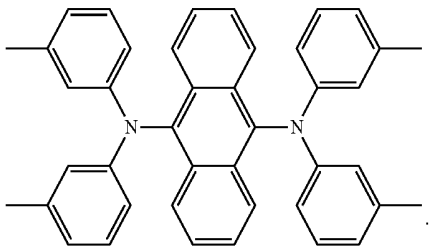
11. The method of claim **9**, wherein the insulating layer comprises silicon oxide, silicon nitride, silicon oxide-nitride, or the mixture thereof.

12. The method of claim **4**, wherein the organic emission layer comprises a mixture of at least two organic materials, and the at least two organic materials are chemical formulas 1 and 2:

[chemical formula 1]



[chemical formula 2]



13. The method of claim **4**, wherein the application time of the voltage applied is in a range of about 0.1 μs to about 1 s, and a power density of the voltage applied is in a range of about 0.1 W/cm^2 to about 10000 W/cm^2.

14. The method of claim **4**, wherein the attaching step is performed under a vacuum or inert gas atmosphere.

15. The method of claim **4**, wherein the transferring step comprises applying voltage to the heat-generating pattern.

16. The method of claim **4**, wherein the color donor substrate is red, green, or blue donor substrate, comprising red, green, or blue organic emission material, respectively.

17. The method of claim **5**, wherein the step of forming the electron related layer comprises consecutively depositing an electron injection layer material and an electron transport layer material.

* * * * *

专利名称(译)	OLED显示器及其制造方法		
公开(公告)号	US20120097926A1	公开(公告)日	2012-04-26
申请号	US13/154929	申请日	2011-06-07
[标]申请(专利权)人(译)	PARK洪基 PARK YONGPAL BAE KYONGJI		
申请(专利权)人(译)	PARK洪基 PARK YONGPAL BAE KYONGJI		
当前申请(专利权)人(译)	PARK洪基 PARK YONGPAL BAE KYONGJI		
[标]发明人	PARK HONGKI PARK YONGPAL BAE KYONGJI		
发明人	PARK, HONGKI PARK, YONGPAL BAE, KYONGJI		
IPC分类号	H01L51/54 H01L51/56		
CPC分类号	H01L51/0013 H01L51/5012 H01L51/006		
优先权	1020100103081 2010-10-21 KR		
其他公开文献	US9093647		
外部链接	Espacenet USPTO		

摘要(译)

OLED（OLED）显示器在每个OLED中设置有多个像素，每个OLED包括顺序形成在基板上的第一电极，有机发光层和第二电极，其中有机发光层包括：所述至少两种有机材料的混合物，其中所述至少两种有机材料之间的升华温度差设定为小于约50℃。