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(54) **ORGANIC ELECTROLUMINESCENT  
DISPLAY DEVICE AND METHOD OF  
FABRICATING THE SAME**

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(57)

## ABSTRACT

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An organic electroluminescent display device includes first and second substrates facing and spaced apart from each other, gate and data lines on an inner surface of the first substrate and crossing each other to define a pixel region, a switching element at a crossing point of the gate and data lines, a driving element connected to the switching element, a first electrode on an inner surface of the second substrate, an organic light-emitting layer on the first electrode in the pixel region, a second electrode on the organic light-emitting layer in the pixel region and electrically connected to the driving element, and a coloring element on an outer surface of the second substrate in the pixel region.

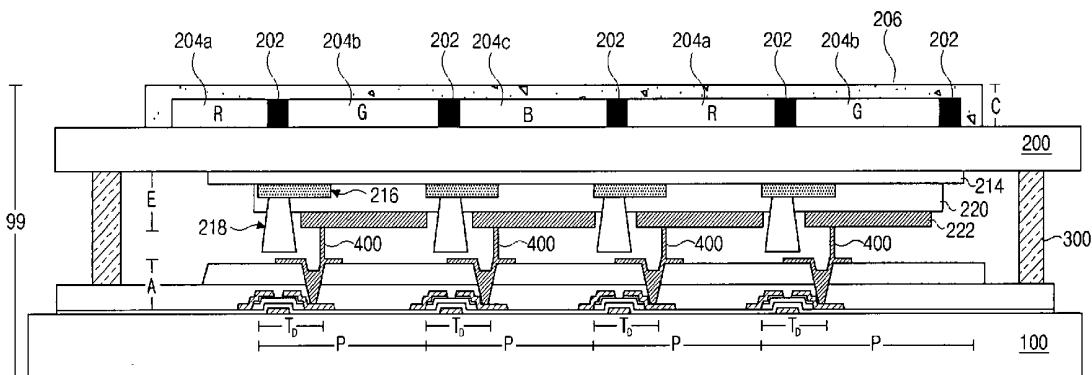
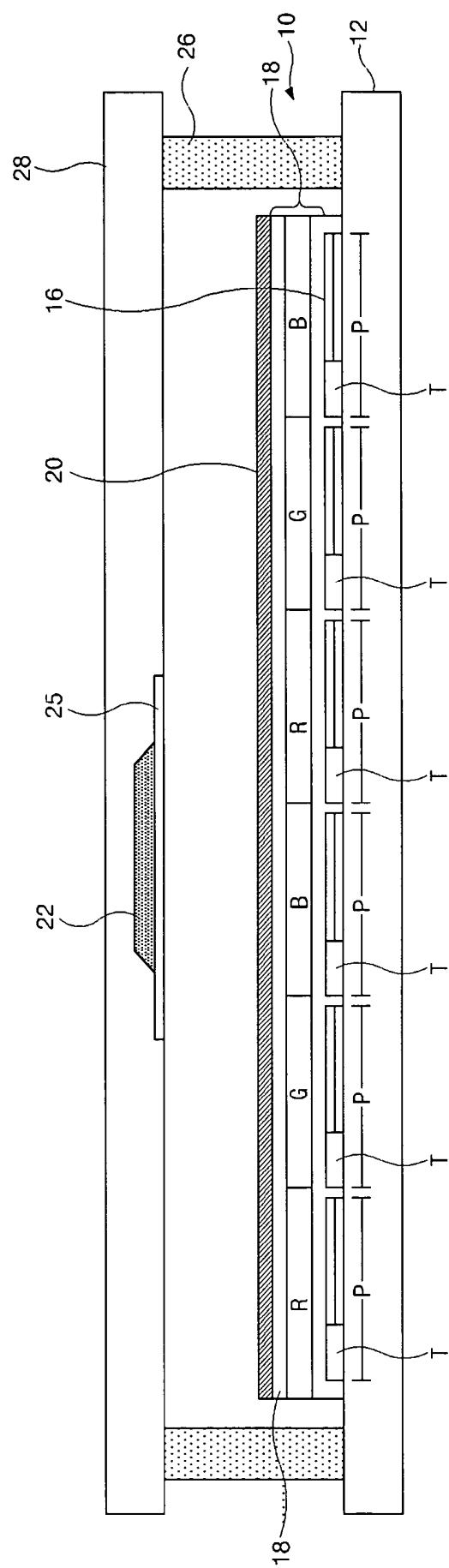


FIG. 1  
RELATED ART



**FIG. 2**  
**RELATED ART**

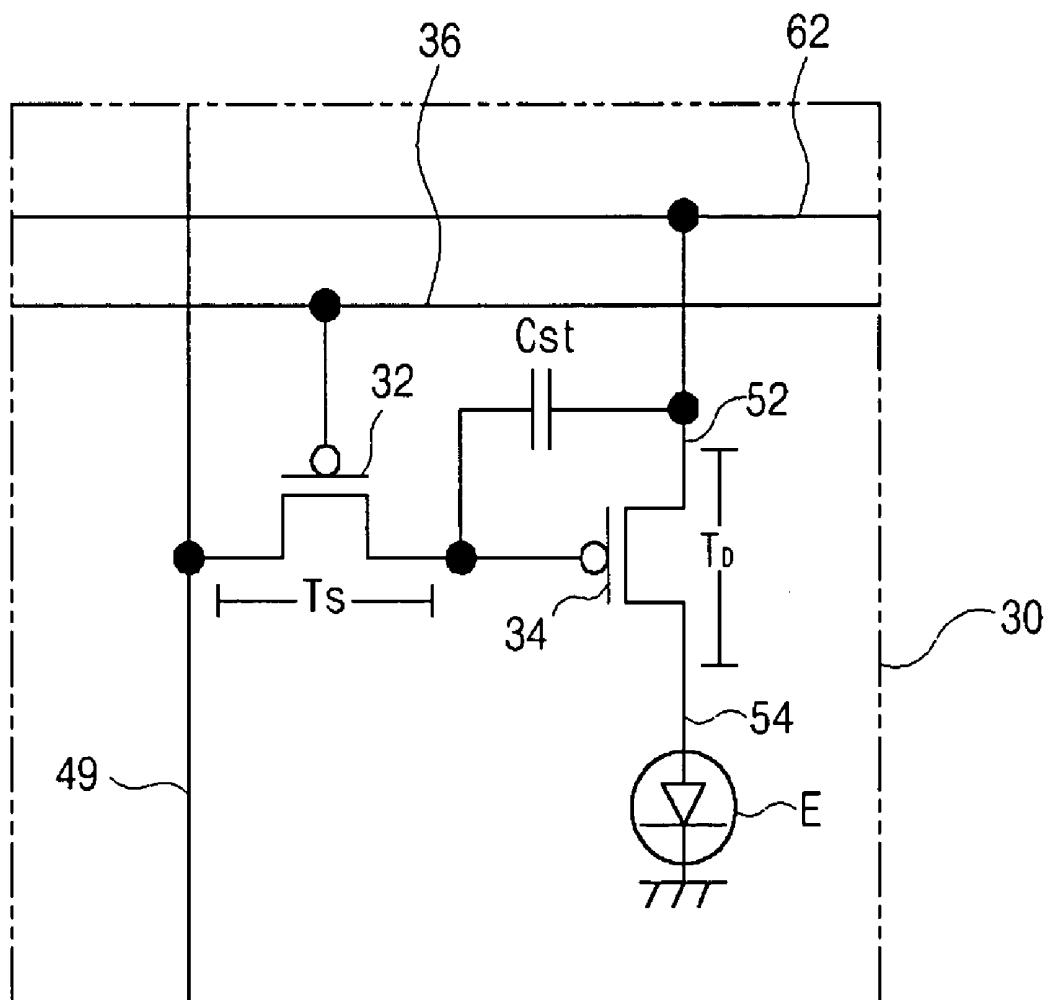


FIG. 3

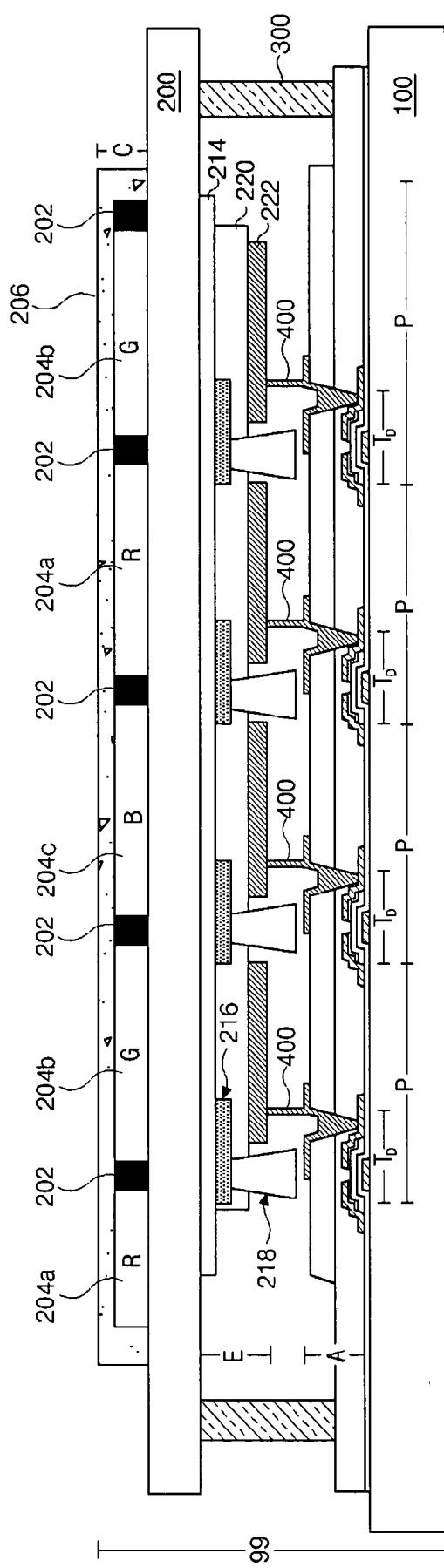


FIG. 4A

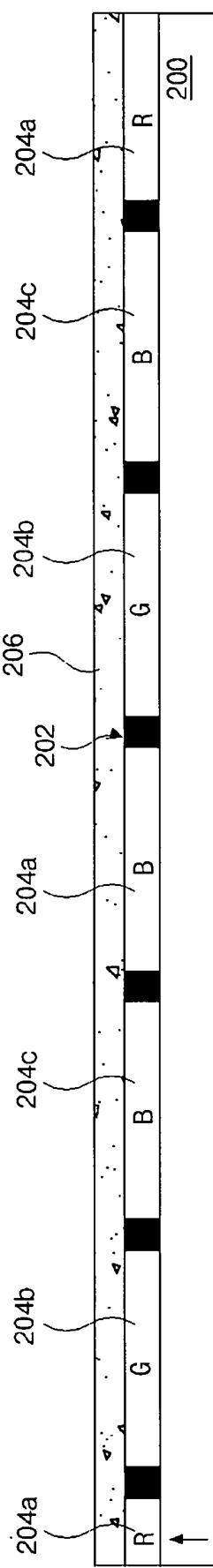


FIG. 4B

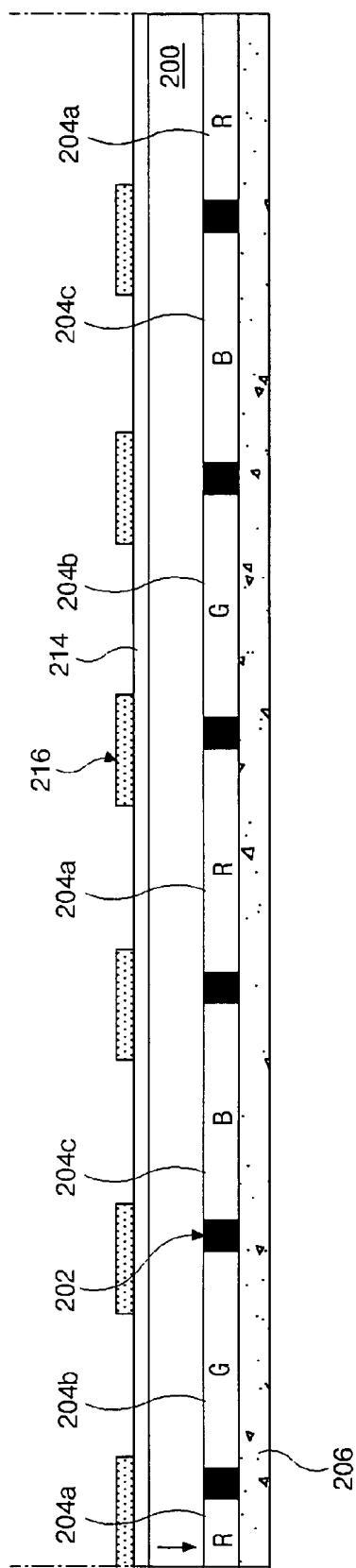


FIG. 4C

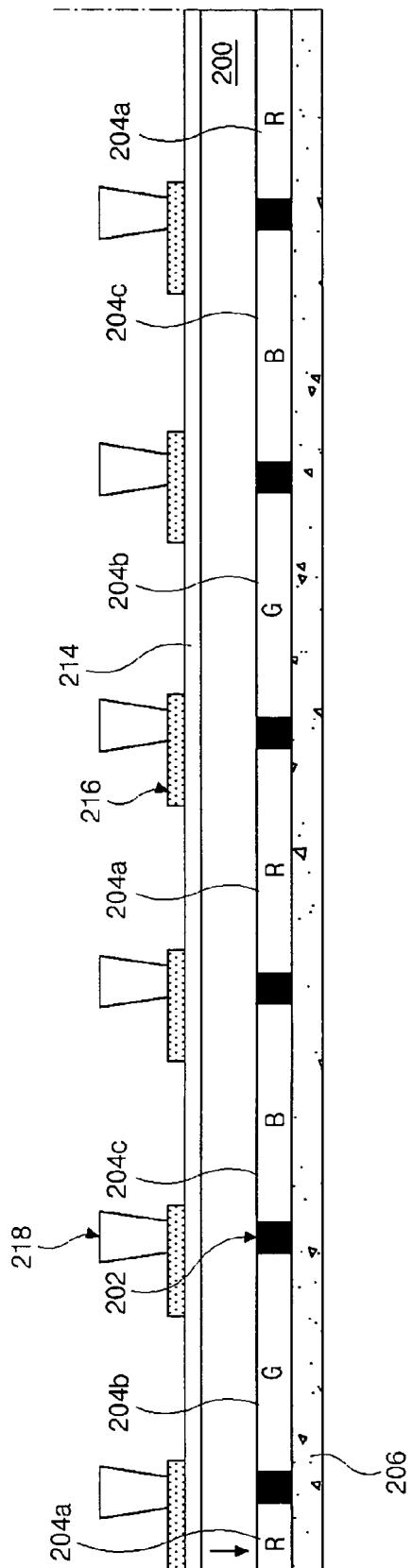


FIG. 4D

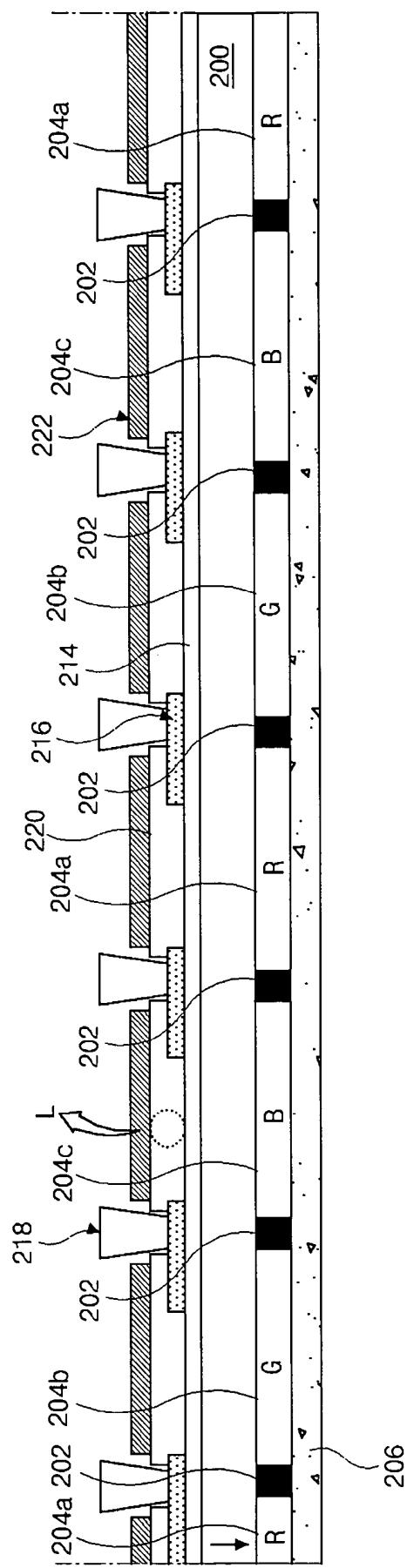


FIG. 5

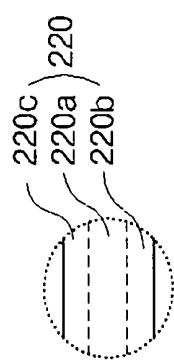


FIG. 6

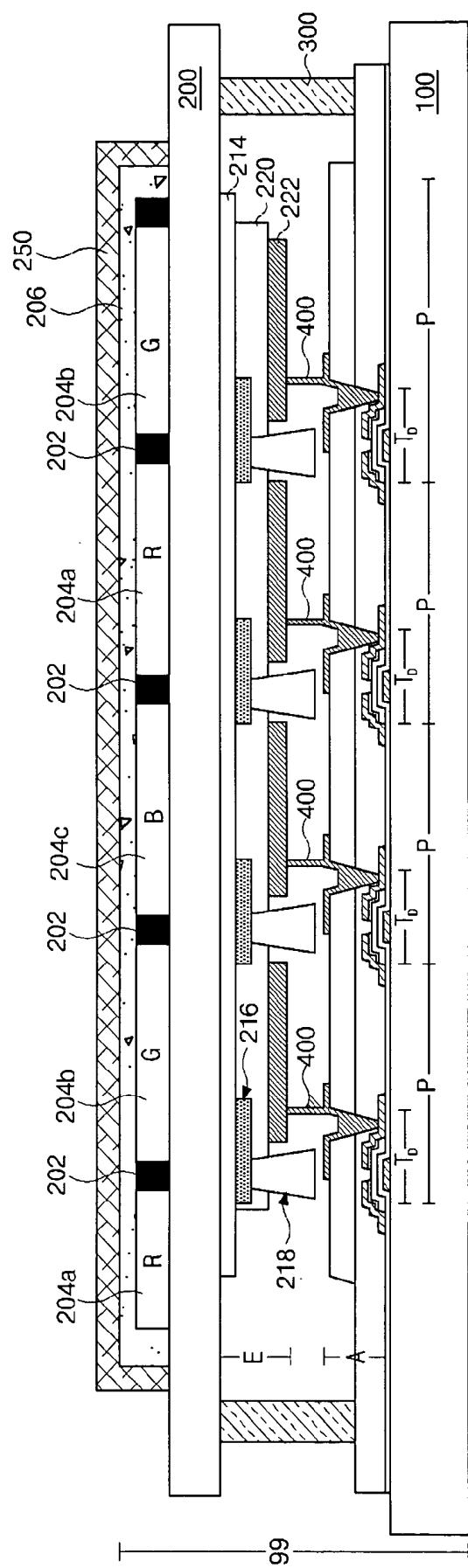


FIG. 7

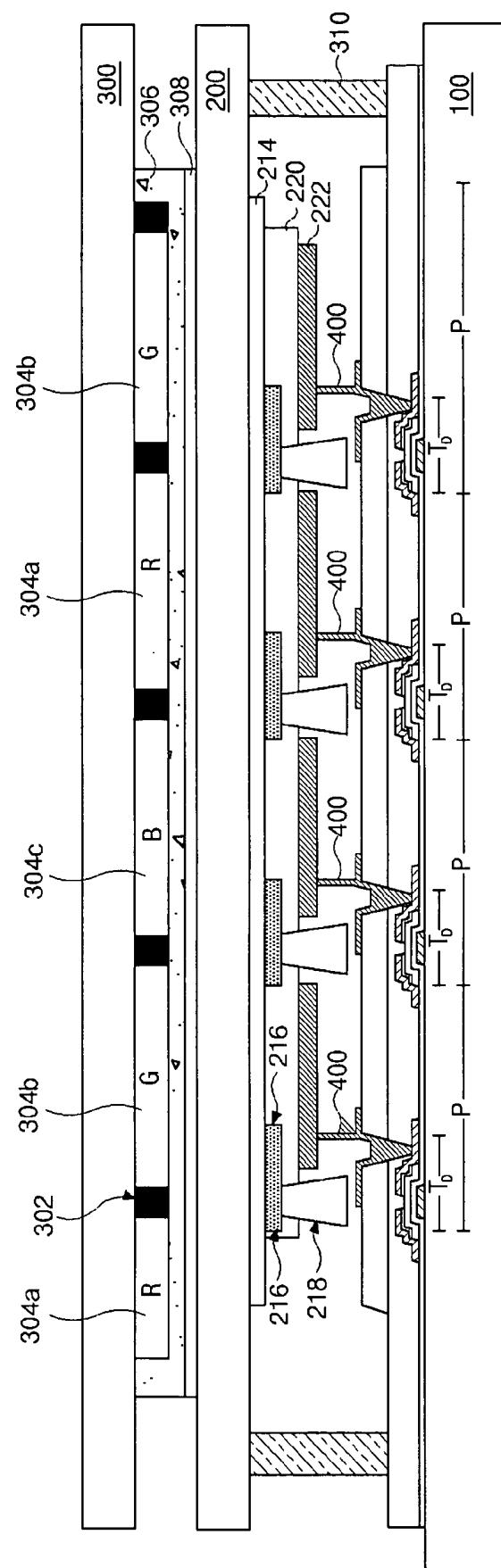


FIG. 8

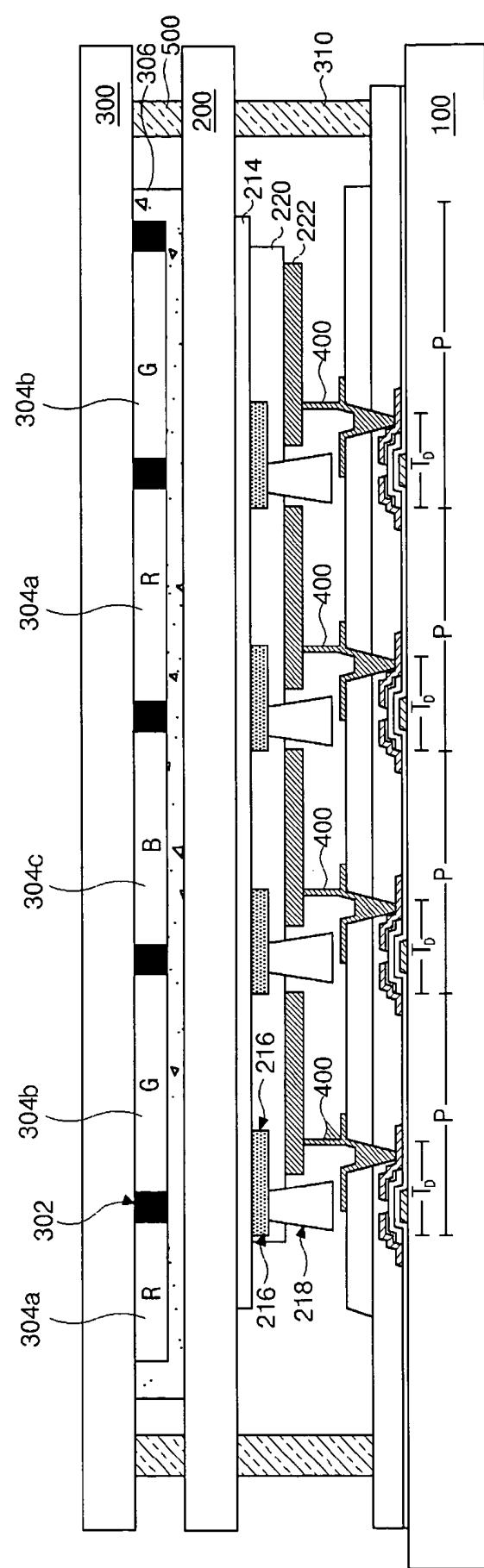
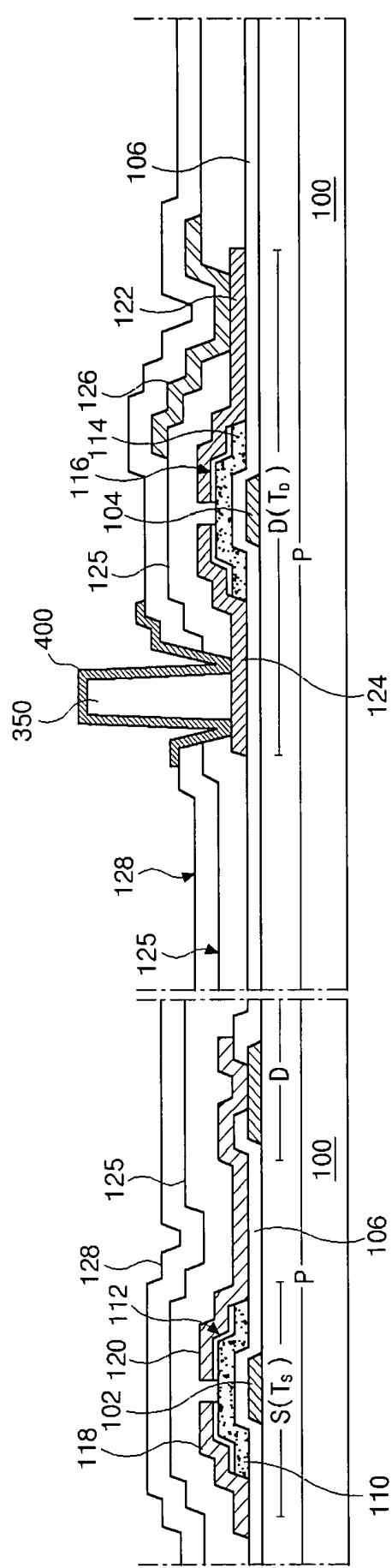


FIG. 9



## ORGANIC ELECTROLUMINESCENT DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME

[0001] The present invention claims the benefit of Korean Patent Application No. 2003-0100603 filed in Korea on Dec. 30, 2003, which is hereby incorporated by reference.

### BACKGROUND OF THE INVENTION

#### [0002] 1. Field of the Invention

[0003] The present invention relates to an electroluminescent display device, and more particularly, to an organic electroluminescent display device and a method of fabricating the same.

#### [0004] 2. Discussion of the Related Art

[0005] In general, an organic electroluminescent display device emits light by injecting electrons from a cathode electrode and holes from an anode electrode into an emissive layer, combining the electrons and the holes to generate an exciton, and by transiting the exciton from an excited state to a ground state. Since the organic electroluminescent display device does not require an additional light source due to its self-luminescence property, the organic electroluminescent display device has a small size and is light weight, as compared to a liquid crystal display device. The organic electroluminescent display device also has a low power consumption, high brightness, and a short response time. Thus, the organic electroluminescent display device is used in many consumer electronic applications, such as cellular phones, car navigation systems (CNSs), personal digital assistants (PDAs), camcorders, and palm PCs. In addition, the organic electroluminescent display device can have reduced manufacturing costs because of its simple manufacturing processes.

[0006] Organic electroluminescent display devices may be categorized into passive matrix-type and active matrix-type depending upon the method used to drive the device. Passive matrix-type organic electroluminescent display devices have a simple structure and are fabricated through a simple manufacturing process. However, the passive matrix-type organic electroluminescent display devices have a high power consumption, thereby preventing use in large area displays. Furthermore, in passive matrix organic electroluminescent display devices, the aperture ratio decreases due to the increased number of electrical lines. Thus, the passive matrix-type organic electroluminescent display devices are commonly used as small-sized display devices. Active matrix-type organic electroluminescent display (AMOELD) devices are commonly used as large-sized display devices since they have a high luminous efficacy, and provide high definition images.

[0007] FIG. 1 is a cross sectional view of an active matrix-type organic electro-luminescent display (AMOELD) device according to the related art. In FIG. 1, the AMOELD device 10 includes a first substrate 12 and a second substrate 28, which are spaced apart and face each other. The first substrate 12 is transparent and flexible. A plurality of thin film transistors T and a plurality of first electrodes 16 are formed on an inner surface of the first substrate 12, in which each of first electrodes 16 are connected to the respective thin film transistor T. Organic layers 18 are formed on the first electrodes 16 and the thin film

transistors T, and a second electrode 20 is formed on the organic layers 18. The organic layers 18 emit light of three colors: red (R), green (G), and blue (B) within a pixel region P, and are generally formed by patterning an organic material that emits one of red, green and blue.

[0008] A desiccant 22 is formed on an inner surface of the second substrate 28 to remove any external moisture and air that may permeate into a space between the first and second substrates 12 and 28. The inner surface of the second substrate 28 is patterned to form a groove, and the desiccant 22 is disposed within the groove and is fastened with a tape 25.

[0009] A sealant 26 is formed between the first and second substrates 12 and 28 to attach the first and second substrates 12 and 28, and surrounds elements, such as the thin film transistors T, the first electrodes 16, the organic layers 18, and the second electrodes 20. The sealant 26 forms an airtight space to protect the elements from the external moisture and air.

[0010] In the above OELD device, the first electrode 16 functions as an anode electrode and is transparent. Thus, this AMOELD device has a bottom emission type, in which light is emitted through the first electrode 16.

[0011] FIG. 2 is an equivalent circuit for a pixel of an organic electroluminescent display (OELD) device according to the related art.

[0012] As shown in FIG. 2, a gate line 36 is formed along one direction of a substrate 30 and a data line 49 perpendicularly crosses the gate line 36. A switching element T<sub>S</sub> is formed at a crossing point of the gate line 36 and the data line 49, and a driving element T<sub>D</sub> is electrically connected to the switching element T<sub>S</sub>.

[0013] Since the driving element T<sub>D</sub> is a p-type thin film transistor, a storage capacitor C<sub>ST</sub> is disposed between a source electrode 52 of the driving element T<sub>D</sub> and a gate electrode 34 of the driving element T<sub>D</sub>, and a drain electrode 54 of the driving element T<sub>D</sub> is connected to an anode electrode of an organic electroluminescent diode E, which corresponds to a first electrode 16 of FIG. 1. The source electrode 52 of the driving element T<sub>D</sub> is also connected to a power line 62.

[0014] The OELD device having the above structure can be driven as follows.

[0015] First, when a gate signal is applied to a gate electrode 32 of the switching element T<sub>S</sub>, a current signal flowing through the data line 49 is changed into a voltage signal through the switching element T<sub>S</sub> and is applied to the gate electrode 34 of the driving element T<sub>D</sub>. Then, the driving element T<sub>D</sub> turns on, and thus the gray scale is realized by determining levels of the current flowing through the organic electroluminescent diode E.

[0016] At this time, because signals stored in the storage capacitor C<sub>ST</sub> maintain the signal of the gate electrode 34 of the driving element T<sub>D</sub>, the level of the currents flowing through the organic electroluminescent diode E is kept constant until a next signal is applied even if the switching element T<sub>S</sub> turns off. The switching element T<sub>S</sub> and the driving element T<sub>D</sub> may be an amorphous silicon thin film transistor or a polycrystalline silicon thin film transistor. The

amorphous silicon thin film transistor is more simply manufactured as compared with the polycrystalline silicon thin film transistor.

[0017] The above OELD device is manufactured by attaching a substrate having array elements and organic luminescent diodes with another substrate for encapsulation. Since the yield of the OELD device depends on the yields of the thin film transistor and the organic light-emitting layer, the whole processing yield is largely affected by processes for forming the organic light-emitting layer that occur at a later stage. Thus, even if the array elements are properly well formed, if the organic light-emitting layer to be formed to a thickness of about 1,000 Å is improperly formed due to impurities or other factors, the resulting OELD device is rejected as bad. Accordingly, the yield of the OELD device is reduced because of the impurities and other factors in the organic light-emitting forming processes, thereby resulting in a loss of manufacturing costs and source materials for the thin film transistor.

[0018] The bottom emission mode OELD device has a good stability and a certain degree of freedom in its manufacturing processes. However, the bottom emission mode OELD device has a reduced aperture ratio. Thus, the bottom emission mode OELD device is not suited for a high aperture device.

[0019] On the other hand, a top emission mode OELD device has a high aperture ratio, and is easy to manufacture. Additionally, the top emission mode OELD device has a long lifetime. However, in the top emission mode OELD device, since a cathode electrode is generally disposed over the organic light-emitting layer, a choice of material with which to make the cathode electrode is limited. Accordingly, the transmittance of light is limited, and a light-emitting efficacy is reduced. Furthermore, in order to improve the light transmittance, the passivation layer should be formed as a thin film, whereby the exterior moisture and air are not fully blocked.

#### SUMMARY OF THE INVENTION

[0020] Accordingly, the present invention is directed to an organic electroluminescent display device and a method of fabricating the same that substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

[0021] An object of the present invention is to provide an organic electroluminescent display device and a method of fabricating the same having a high aperture ratio and displaying high definition images.

[0022] Another object of the present invention is to provide an organic electroluminescent display device and a method of fabricating the same having an improved yield and productivity.

[0023] Another object of the present invention is to provide an organic electroluminescent display device and a method of fabricating the same that are reliable.

[0024] Additional features and advantages of the invention will be set forth in the description which follows and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by

the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0025] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, an organic electroluminescent display device includes first and second substrates facing and spaced apart from each other, gate and data lines on an inner surface of the first substrate and crossing each other to define a pixel region, a switching element at a crossing point of the gate and data lines, a driving element connected to the switching element, a first electrode on an inner surface of the second substrate, an organic light-emitting layer on the first electrode in the pixel region, a second electrode on the organic light-emitting layer in the pixel region and electrically connected to the driving element, and a coloring element on an outer surface of the second substrate in the pixel region.

[0026] In another aspect, a method of fabricating an organic electroluminescent display device includes forming gate and data lines on a first substrate, the gate and data lines crossing each other to define a pixel region, forming a switching element at a crossing point of the gate and data lines, forming a driving element connected to the switching element, forming a first electrode on a first surface of a second substrate, forming an organic light-emitting layer on the first electrode, forming a second electrode on the organic light-emitting layer, forming a coloring element on a second surface of the second substrate, attaching the first substrate and the second substrate including the coloring element such that the second electrode faces and is electrically connected to the driving element.

[0027] In another aspect, an organic electroluminescent display device includes first and second substrates facing and spaced apart from each other, gate and data lines on an inner surface of the first substrate and crossing each other to define a pixel region, a switching element at a crossing point of the gate and data lines, a driving element connected to the switching element, a first electrode on an inner surface of the second substrate, an organic light-emitting layer on the first electrode in the pixel region, a second electrode on the organic light-emitting layer in the pixel region and electrically connected to the driving element, a third substrate attached to an outer surface of the second substrate, and a coloring element on an inner surface of the third substrate.

[0028] In another aspect, a method of fabricating an organic electroluminescent display device includes forming gate and data lines on a first substrate, the gate and data lines crossing each other to define a pixel region, forming a switching element at a crossing point of the gate and data lines, forming a driving element connected to the switching element, forming a first electrode on a first surface of a second substrate, forming an organic light-emitting layer on the first electrode in the pixel region, forming a second electrode on the organic light-emitting layer in the pixel region, the second electrode being electrically connected to the driving element, forming a coloring element on a third substrate, attaching the first substrate and the second substrate such that the second electrode faces and is electrically connected to the driving element, and attaching the third substrate to a second surface of the second substrate such that the coloring element is disposed between the third substrate and the second substrate.

[0029] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention. In the drawings:

[0031] FIG. 1 is a cross sectional view of an active matrix-type organic electro-luminescent display device according to the related art;

[0032] FIG. 2 is an equivalent circuit for a pixel of an organic electroluminescent display device according to the related art;

[0033] FIG. 3 is a schematic cross-sectional view of an organic electroluminescent display device according to a first embodiment of the present invention;

[0034] FIGS. 4A to 4D are cross-sectional views illustrating a manufacturing method of an organic electroluminescent display device according to an embodiment of the present invention;

[0035] FIG. 5 is a view enlarging the portion L of FIG. 4D;

[0036] FIG. 6 is a schematic cross-sectional view of an organic electroluminescent display device according to a second embodiment of the present invention;

[0037] FIG. 7 is a schematic cross-sectional view of an organic electroluminescent display device according to a third embodiment of the present invention;

[0038] FIG. 8 is a schematic cross-sectional view of an organic electroluminescent display device according to a fourth embodiment of the present invention; and FIG. 9 is a cross-sectional view of an array substrate for an organic electroluminescent display device according to an embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0039] Reference will now be made in detail to the illustrated embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

[0040] FIG. 3 is a schematic cross-sectional view of an organic electroluminescent display (OELD) device according to a first embodiment of the present invention. The OELD device of the first embodiment has a dual plate structure, in which a first substrate including a switching element and a second substrate including an electroluminescent diode are attached. The OELD device of the first embodiment also includes an additional color displaying element on the outside of the second substrate.

[0041] As shown in FIG. 3, the OELD device 99 of the first embodiment includes a first substrate 100 and a second substrate 200 that are spaced apart and face each other. A sealant 300 is formed between the first and second

substrates 100 and 200 to bond the first and second substrates 100 and 200 together. An array part A including a plurality of thin film transistors  $T_D$  is formed on an inner surface of the first substrate 100. An emission part E is formed on an inner surface of the second substrate 200 (i.e., a surface facing the first substrate 100), and a color part C is formed on an outer surface of the second substrate 200 (i.e., a surface opposite to the inner surface of the second substrate 200).

[0042] In FIG. 3, the thin film transistor  $T_D$  functions as a driving element of the OELD device. Although not shown, a switching element, a gate line, a data line, and a power line are typically formed on the inner surface of the first substrate 100. The switching element (not shown) and the driving element  $T_D$  are formed in each pixel region P.

[0043] A first electrode 214 is formed on the inner surface of the second substrate 200 facing the first substrate 100. The first electrode 214 may include transparent conductive material or materials, and may function as an anode electrode for injecting holes into an organic light-emitting layer to be formed thereon. A plurality of organic light-emitting layers 220 is formed on the first electrode 214, and a plurality of second electrodes 222 is formed on the organic light-emitting layer 220. The second electrodes 222 may function as a cathode electrode for injecting electrons into the organic light-emitting layer 220.

[0044] A partition wall 218 is formed over the first electrode 214 in each border portion between adjacent pixel regions P. The organic light-emitting layers 220 may be patterned due to the partition wall 218 at the moment the organic light-emitting layers 220 are deposited.

[0045] An isolation pattern 216 may be formed between the partition wall 218 and the first electrode 214 to ensure that the second electrode 222 does not contact the first electrode 214.

[0046] The second electrodes 222 are independently patterned in each pixel region P, and the second electrode 222 is electrically connected to the corresponding driving element  $T_D$  through a connection electrode 400.

[0047] The color part C, which is formed on the outer surface of the second substrate 200, includes coloring elements 204a, 204b and 204c and a passivation layer 206, which may be referred to as an overcoat layer, protecting the coloring elements 204a, 204b and 204c.

[0048] More particularly, a black matrix 202 is formed on the outer surface of the second substrate 200 to correspond to the border portion between the adjacent pixel regions P, and the coloring elements 204a, 204b and 204c are formed such that each coloring element 204a, 204b and 204c corresponds to one pixel region P. The passivation layer 206 is formed on an entire surface of the second substrate 200 including the black matrix 202 and the coloring elements 204a, 204b and 204c.

[0049] The coloring elements 204a, 204b and 204c may be a single layer of a color filter layer or a color-changing medium layer, or a double layer of the color filter layer and the color-changing medium layer.

[0050] In the case that the coloring elements 204a, 204b and 204c include the color-changing medium layer, the organic light-emitting layers 220 may emit blue light, for

example. Thus, the blue light emitted from the organic light-emitting layer 220 is absorbed into the color-changing medium layer, and then the color-changing medium layer emits one of red, green and blue lights, depending upon the property of the color-changing medium layer. The color-changing medium layer is patterned to correspond to one pixel region because the color-changing medium layer is formed of different materials for emitting the red, green and blue lights, respectively.

[0051] The connection electrode 400 between the second electrode 222 and the driving element  $T_D$  has a predetermined thickness in accordance with a gap between the first and second substrates 100 and 200.

[0052] FIGS. 4A to 4D are cross-sectional views illustrating a manufacturing method of an OELD device according to an embodiment of the present invention. FIGS. 4A to 4D show a substrate including an organic electroluminescent diode for the OELD device.

[0053] In FIG. 4A, a black matrix 202 is formed on a first surface of a substrate 200 using a black resin or a metal material such as chromium (Cr) to define a plurality of pixel regions. The black matrix 202 corresponds to each border portion between adjacent pixel regions.

[0054] Next, coloring elements 204a, 204b and 204c are formed on the first surface of the substrate 200 corresponding to the pixel regions. The coloring elements 204a, 204b and 204c are disposed within the black matrix 202. The coloring elements 204a, 204b and 204c may be a single layer of a color filter layer or a color-changing medium layer, or a double layer of the color filter layer and the color-changing medium layer. Each coloring element 204a, 204b and 204c corresponds to one pixel region. Red, green and blue lights are transmitted through the coloring elements 204a, 204b and 204c, respectively.

[0055] A passivation layer 206 is formed on an entire first surface of the substrate 200 including the coloring elements 204a, 204b and 204c. The passivation layer 206 is formed of, for example, a transparent organic material such as benzocyclobutene (BCB), polyacrylate, polyimide, or polyamide.

[0056] In FIG. 4B, a first electrode 214 is formed on a second surface of the substrate 200 opposite to the surface having the coloring elements 204a, 204b and 204c. The first electrode 214 functions as an anode for injecting holes into an organic light-emitting layer to be formed later. The first electrode 214 may be formed of indium tin oxide (ITO) that is transparent and has a high work function.

[0057] Next, isolation patterns 216 are formed on the first electrode 214 in the border portions between the adjacent pixel regions by depositing, for example, an inorganic insulating material, such as silicon nitride ( $SiN_x$ ) or silicon oxide ( $SiO_2$ ), and then patterning the inorganic insulating material. The isolation patterns 216 prevent the first electrode 214 from electrically shorting with second electrodes to be formed later.

[0058] In FIG. 4C, partition walls 218 are formed on the isolation patterns 216 by coating a photosensitive organic material on an entire surface of the substrate 200 including the isolation patterns 216 and then patterning the photosen-

sitive organic material. The partition walls 218 are disposed in the border portions between the adjacent pixel regions.

[0059] In FIG. 4D, organic light-emitting layers 220 are formed on the first electrode 214 between adjacent partition walls 218. Each organic light-emitting layer 220 corresponds to one pixel region. The organic light-emitting layer 220 in different pixel regions emits red, green and blue lights, respectively. Next, second electrodes 222 are formed on the organic light-emitting layers 220 by depositing a conductive material that has relatively a low work function on an entire surface of the substrate 200 including the organic light-emitting layers 220 and then patterning the conductive material. The second electrodes 222 may be a single layer including one of aluminum (Al), calcium (Ca) and magnesium (Mg) or may be a double layer including lithium-fluorine/aluminum(LiF/Al), for example.

[0060] The organic light-emitting layer 220 may be formed in a single layer or in a multiple layer. In the multiple layer, as shown in FIG. 5, the organic light-emitting layer 220 may include an emissive layer 220a, a hole transporting layer 220b and an electron transporting layer 220c. FIG. 5 is a view enlarging the portion L of FIG. 4D. Here, the emissive layer 220a is disposed between the hole transporting layer 220b and the electron transporting layer 220c. The hole transporting layer 220b contacts the first electrode 214 and the electron transporting layer 220c contacts the second electrode 222.

[0061] The second electrodes 222 may be patterned in each pixel region due to the partition walls 218, each of which has reversely tapered sides, at the moment the second electrodes 222 are deposited. On the other hand, the second electrodes 222 may be patterned in each pixel region using a shadow mask without use of the partition walls 218.

[0062] In the present embodiment, if the passivation layer 206 is not durable against scratch, the passivation layer 206 may be damaged when the substrate 200 including the passivation layer 206 is turned upside down and the organic electroluminescent diode is formed. Thus, to protect the passivation layer 206, an additional insulating layer may be formed on the passivation layer 206, as described below.

[0063] FIG. 6 is a schematic cross-sectional view of an organic electroluminescent display (OELD) device according to a second embodiment of the present invention. The OELD device of the second embodiment further includes an insulating layer on a passivation layer.

[0064] As shown in FIG. 6, the OELD device 99 of the second embodiment may include a first substrate 100 and a second substrate 200 that are spaced apart from and face each other. A sealant 300 is formed between the first and second substrates 100 and 200 to bond the first and second substrates 100 and 200 together. An array part A including a plurality of thin film transistors  $T_D$  is formed on an inner surface of the first substrate 100. An emission part E is formed on an inner surface of the second substrate 200 (i.e., a surface facing the first substrate 100), and a color displaying element is formed on an outer surface of the second substrate 200 (i.e., a surface opposite to the inner surface of the second substrate 200).

[0065] In FIG. 6, the thin film transistor  $T_D$  functions as a driving element of the OELD device. Although not shown, a switching element, a gate line, a data line, and a power line

are typically formed on the inner surface of the first substrate **100**. The switching element (not shown) and the driving element  $T_D$  are formed in each pixel region P.

[0066] A first electrode **214** is formed on the inner surface of the second substrate **200** facing the first substrate **100**. The first electrode **214** may include transparent conductive material or materials, and may function as an anode electrode for injecting holes into an organic light-emitting layer to be formed thereon. A plurality of organic light-emitting layers **220** is formed on the first electrode **214**, and a plurality of second electrodes **222** is formed on the organic light-emitting layer **220**. The second electrodes **222** may function as a cathode electrode for injecting electrons into the organic light-emitting layer **220**.

[0067] A partition wall **218** is formed over the first electrode **214** in each border portion between adjacent pixel regions P. The organic light-emitting layers **220** may be patterned due to the partition wall **218** at the moment the organic light-emitting layers **220** are deposited. An isolation pattern **216** may be formed between the partition wall **218** and the first electrode **214** to ensure that the second electrode **222** does not contact the first electrode **214**. The second electrodes **222** are independently patterned in each pixel region P, and the second electrode **222** is electrically connected to the corresponding driving element  $T_D$  through a connection electrode **400**.

[0068] Coloring elements **204a**, **204b** and **204c** and a passivation layer **206**, which may be referred to as an overcoat layer, for protecting the coloring elements **204a**, **204b** and **204c** are formed on the outer surface of the second substrate **200**. More particularly, a black matrix **202** is formed on the outer surface of the second substrate **200** to correspond to the border portion between the adjacent pixel regions P, and the coloring elements **204a**, **204b** and **204c** are formed such that each coloring element **204a**, **204b** and **204c** corresponds to one pixel region P. The passivation layer **206** is formed on an entire surface of the second substrate **200** including the black matrix **202** and the coloring elements **204a**, **204b** and **204c**.

[0069] A transparent insulating layer **250** is formed on the passivation layer **206**. The insulating layer **250** may be removed after completion of processes that may likely damage the outer surface of the second substrate. If the insulating layer **250** is removed at a subsequent process, the insulating layer **250** may be formed of an opaque material. In addition, a surface of the insulating layer **250** may be scratched or damaged. However, if the insulating layer **250** is to remain in the final product, the insulating layer **250** should be transparent and must not be scratched or damaged.

[0070] The coloring elements **204a**, **204b** and **204c** may be a single layer of a color filter layer or a color-changing medium layer, or a double layer of the color filter layer and the color-changing medium layer.

[0071] In the case that the coloring elements **204a**, **204b** and **204c** include the color-changing medium layer, the organic light-emitting layers **220** may emit blue light, for example. Thus, the blue light emitted from the organic light-emitting layer **220** is absorbed into the color-changing medium layer, and then the color-changing medium layer emits one of red, green and blue lights, depending upon the property of the color-changing medium layer. The color-

changing medium layer is patterned to correspond to one pixel region because the color-changing medium layer is formed of different materials for emitting the red, green and blue lights, respectively.

[0072] The connection electrode **400** between the second electrode **222** and the driving element  $T_D$  has a predetermined thickness in accordance with a gap between the first and second substrates **100** and **200**.

[0073] FIG. 7 is a schematic cross-sectional view of an organic electroluminescent display device according to a third embodiment of the present invention. In the OELD device of the third embodiment, a substrate having a color displaying element thereon is attached to a dual plate structure OELD device.

[0074] As shown in FIG. 7, the OELD device of the third embodiment includes a first substrate **100** having an array part that includes a plurality of thin film transistors  $T_D$  thereon, a second substrate **200** having an emission part on a surface facing the first substrate **100**, and a third substrate **300** having a color displaying element.

[0075] A sealant **310** is formed between the first and second substrates **100** and **200** to bond the first and second substrates **100** and **200** together. The third substrate **300** including coloring elements **304a**, **304b** and **304c** is attached to an outer surface of the second substrate **200** using an adhesion layer **308**, which is formed on an entire surface of the third substrate **300**.

[0076] In FIG. 7, the thin film transistor  $T_D$  functions as a driving element of the OELD device. Although not shown, a switching element, a gate line, a data line, and a power line are also typically formed on the inner surface of the first substrate **100**. The switching element (not shown) and the driving element  $T_D$  are formed in each pixel region P.

[0077] A first electrode **214** is formed on an inner surface of the second substrate **200** facing the first substrate **100**. The first electrode **214** may include transparent conductive material or materials, and may function as an anode electrode for injecting holes into an organic light-emitting layer to be formed thereon. A plurality of organic light-emitting layers **220** are formed on the first electrode **214**, and a plurality of second electrodes **222** are formed on the organic light-emitting layer **220**. The second electrodes **222** may function as a cathode electrode for injecting electrons into the organic light-emitting layer **220**.

[0078] A partition wall **218** is formed over the first electrode **214** in each border portion between adjacent pixel regions P. The organic light-emitting layers **220** may be independently patterned due to the partition wall **218** at the moment the organic light-emitting layers **220** are deposited. An isolation pattern **216** may be formed between the partition wall **218** and the first electrode **214** to ensure that the second electrode **222** does not contact the first electrode **214**. The second electrodes **222** are independently patterned in each pixel region P, and the second electrode **222** is electrically connected to the corresponding driving element  $T_D$  through a connection electrode **400**.

[0079] A black matrix **302** is formed on a surface of the third substrate **300**, which faces the outer surface of the second substrate **200**, to correspond to the border portion between the adjacent pixel regions P. The coloring elements

**304a, 204b and 204c** are formed on the surface of the third substrate **300** such that each coloring element **304a, 304b** and **340c** corresponds to one pixel region P. A passivation layer **306** is formed on an entire surface of the third substrate **300** including the black matrix **302** and the coloring elements **304a, 304b** and **304c**.

[0080] The coloring elements **304a, 304b** and **304c** may be a single layer of a color filter layer or a color-changing medium layer, or a double layer of the color filter layer and the color-changing medium layer.

[0081] In the case that the coloring elements **304a, 304b** and **304c** include the color-changing medium layer, the organic light-emitting layers **220** may emit blue light, for example. Thus, the blue light emitted from the organic light-emitting layer **220** is absorbed into the color-changing medium layer, and then the color-changing medium layer emits one of red, green and blue lights, depending upon the property of the color-changing medium layer. The color-changing medium layer is patterned to correspond to one pixel region because the color-changing medium layer is formed of different materials for emitting the red, green and blue lights, respectively.

[0082] The connection electrode **400** between the second electrode **222** and the driving element  $T_D$  has a predetermined thickness in accordance with a gap between the first and second substrates **100** and **200**.

[0083] A process of forming the coloring elements **304a, 304b** and **304c** is the same as the process illustrated in FIG. 4A.

[0084] FIG. 8 is a schematic cross-sectional view of an organic electroluminescent display device according to a fourth embodiment of the present invention. In the OELD device of the fourth embodiment, a substrate having a color displaying element thereon is attached to a dual plate structure OELD device using a seal pattern.

[0085] As shown in FIG. 8, the OELD device of the fourth embodiment includes a first substrate **100** having an array part that includes a plurality of thin film transistors  $T_D$  thereon, a second substrate **200** having an emission part on a surface facing the first substrate **100**, and a third substrate **300** having a color displaying element.

[0086] A first seal pattern **310** is formed between the first and second substrates **100** and **200** in a peripheral portion to bond the first and second substrates **100** and **200** together. A second seal pattern **500** having a line shape is formed between the second substrate **200** and the third substrate **300** in the peripheral portion to bond the second and third substrates **200** and **300**.

[0087] In FIG. 8, the thin film transistor  $T_D$  functions as a driving element of the OELD device. Although not shown, a switching element, a gate line, a data line, and a power line are also typically formed on the inner surface of the first substrate **100**. The switching element (not shown) and the driving element  $T_D$  are formed in each pixel region P.

[0088] A first electrode **214** is formed on an inner surface of the second substrate **200**, which faces the first substrate **100**. The first electrode **214** may include transparent conductive material or materials, and may function as an anode electrode for injecting holes into an organic light-emitting layer to be formed thereon. A plurality of organic light-

emitting layers **220** are formed on the first electrode **214**, and a plurality of second electrodes **222** are formed on the organic light-emitting layer **220**. The second electrodes **222** may function as a cathode electrode for injecting electrons into the organic light-emitting layer **220**.

[0089] A partition wall **218** is formed over the first electrode **214** in each border portion between adjacent pixel regions P. The organic light-emitting layers **220** may be independently patterned due to the partition wall **218** at the moment the organic light-emitting layers **220** are deposited. An isolation pattern **216** may be formed between the partition wall **218** and the first electrode **214** to ensure that the second electrode **222** does not contact the first electrode **214**. The second electrodes **222** are independently patterned in each pixel region P, and the second electrode **222** is electrically connected to the corresponding driving element  $T_D$  through a connection electrode **400**.

[0090] A black matrix **302** is formed on a surface of the third substrate **300**, which faces an outer surface of the second substrate **200**, to correspond to the border portion between the adjacent pixel regions P, and the coloring elements **304a, 204b** and **204c** are formed on the surface of the third substrate **300** such that each coloring element **304a, 304b** and **340c** corresponds to one pixel region P. A passivation layer **306** is formed on an entire surface of the third substrate **300** including the black matrix **302** and the coloring elements **304a, 304b** and **304c**.

[0091] The coloring elements **304a, 304b** and **304c** may be a single layer of a color filter layer or a color-changing medium layer, or a double layer of the color filter layer and the color-changing medium layer.

[0092] In the case that the coloring elements **304a, 304b** and **304c** include the color-changing medium layer, the organic light-emitting layers **220** may emit blue light, for example. Thus, the blue light emitted from the organic light-emitting layer **220** is absorbed into the color-changing medium layer, and then the color-changing medium layer emits one of red, green and blue lights, depending on the property of the color-changing medium layer. The color-changing medium layer is patterned to correspond to one pixel region because the color-changing medium layer is formed of different materials for emitting the red, green and blue lights, respectively.

[0093] The connection electrode **400** between the second electrode **222** and the driving element  $T_D$  has a predetermined thickness in accordance with a gap between the first and second substrates **100** and **200**.

[0094] FIG. 9 is a cross-sectional view of an array substrate for an organic electroluminescent display device according to an embodiment of the present invention, and shows one pixel. The array substrate of FIG. 9 may be used as the lower substrate of the OELD device in the first to fourth embodiments.

[0095] In FIG. 9, a pixel region P is defined on a substrate **100**, and the pixel region P includes a switching area S and a driving area D.

[0096] First and second gate electrodes **102** and **104** are formed in the switching area S and the driving area D, respectively, on a substrate **100**, and a gate insulating layer

**106** is formed on an entire surface of the substrate **100** including the first and second gate electrodes **102** and **104**.

**[0097]** First and second active layers **110** and **114** and first and second ohmic contact layers **112** and **116** are sequentially formed on the gate insulating layer **106**. The first active layer **110** and the first ohmic contact layer **112** are disposed over the first gate electrode **102**, and the second active layer **114** and the second ohmic contact layer **116** are disposed over the second gate electrode **104**.

**[0098]** First source and drain electrodes **118** and **120** and second source and drain electrodes **122** and **124** are formed on the first ohmic contact layer **112** and the second ohmic contact layer **116**, respectively, by depositing a metal material on an entire surface of the substrate **100** including the first and second ohmic contact layers **112** and **116** and then patterning the metal material. The first source and drain electrodes **118** and **120** are spaced apart from each other over the first ohmic contact layer **112** in the switching area **S**, and the second source and drain electrodes **120** and **124** are spaced apart from each other over the second ohmic contact layer **116** in the driving area **D**.

**[0099]** The first drain electrode **120** of the switching area **S** is connected to the second electrode **104** of the driving area **D**. Thus, a switching element **T<sub>S</sub>** and a driving element **T<sub>D</sub>** are formed in the switching area **S** and the driving area **D**, respectively. The switching element **T<sub>S</sub>** includes the first gate electrode **102**, the first active layer **110**, the first ohmic contact layer **112**, the first source electrode **118** and the first drain electrode **120**. The driving element **T<sub>D</sub>** includes the second gate electrode **104**, the second active layer **114**, the second ohmic contact layer **116**, the second source electrode **122** and the second drain electrode **124**.

**[0100]** A first passivation layer **125** is formed on an entire surface of the substrate **100** including the switching element **T<sub>S</sub>** and the driving element **T<sub>D</sub>**. The first passivation layer **125** is patterned to expose the second source electrode **122**. The first passivation layer **125** may be formed of an inorganic insulating material.

**[0101]** A power line **126** is formed on the first passivation layer **125**. The power line **126** is connected to the second source electrode **122** of the driving element **T<sub>D</sub>** exposed by the first passivation layer **125**.

**[0102]** A second passivation layer **128** is formed on an entire surface of the substrate **100** including the power line **126**. The second passivation layer **128** is patterned to expose the second drain electrode **124** of the driving element **T<sub>D</sub>**.

**[0103]** Next, a connection electrode **400** is formed on the second passivation layer **128**. The connection electrode **400** will be connected to a second electrode formed on another substrate. The connection electrode **400** is connected to the second drain electrode **124** of the driving element **T<sub>D</sub>**. The connection electrode **400** should have an appropriate height in accordance with a gap between two substrates for the OELD device. Thus, for example, an organic pattern **350** having a predetermined thickness is formed under the connection electrode **400**.

**[0104]** In the embodiments of the present invention, the thin film transistor is formed on the first substrate and the organic layer is formed on the second substrate. Furthermore, since the first electrode is disposed over the second

electrode and is transparent, the OELD is a top emission mode. In addition, coloring elements including a color filter layer or a color-changing medium layer are formed on or over the outer surface of the second substrate. Therefore, the present invention can provide an OELD and a method of fabricating the same having a high aperture ratio and can improve the yield and productivity. Additionally, the OELD and a method of fabricating the same are reliable, and the lifetime of the OELD device is increased.

**[0105]** It will be apparent to those skilled in the art that various modifications and variations can be made in the organic electroluminescent display device and the method of fabricating the same of the present invention without departing from the spirit or scope of the inventions. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. An organic electroluminescent display device, comprising:

first and second substrates facing and spaced apart from each other;

gate and data lines on an inner surface of the first substrate and crossing each other to define a pixel region;

a switching element at a crossing point of the gate and data lines;

a driving element connected to the switching element;

a first electrode on an inner surface of the second substrate;

an organic light-emitting layer on the first electrode in the pixel region;

a second electrode on the organic light-emitting layer in the pixel region and electrically connected to the driving element; and

a coloring element on an outer surface of the second substrate in the pixel region.

2. The device according to claim 1, further comprising a power line connected to the driving element.

3. The device according to claim 1, wherein the first electrode functions as an anode electrode and the second electrode acts as a cathode electrode.

4. The device according to claim 1, wherein the coloring element includes a color filter layer.

5. The device according to claim 1, wherein the coloring element includes a color-changing medium layer.

6. The device according to claim 5, wherein the coloring element further includes a color filter layer.

7. The device according to claim 5, wherein the organic light-emitting layer emits blue light.

8. The device according to claim 1, further comprising a black matrix on the outer surface of the second substrate, wherein the black matrix corresponds to a border portion between adjacent pixel regions.

9. The device according to claim 8, further comprising a passivation layer covering the coloring element and the black matrix over the outer surface of the second substrate.

10. The device according to claim 9, further comprising a transparent layer covering the passivation layer over the outer surface of the second substrate.

**11.** A method of fabricating an organic electroluminescent display device, comprising:

- forming gate and data lines on a first substrate, the gate and data lines crossing each other to define a pixel region;
- forming a switching element at a crossing point of the gate and data lines;
- forming a driving element connected to the switching element;
- forming a first electrode on a first surface of a second substrate;
- forming an organic light-emitting layer on the first electrode;
- forming a second electrode on the organic light-emitting layer;
- forming a coloring element on a second surface of the second substrate;
- attaching the first substrate and the second substrate including the coloring element such that the second electrode faces and is electrically connected to the driving element.

**12.** The method according to claim 11, wherein the first electrode functions as an anode electrode and the second electrode acts as a cathode electrode.

**13.** The method according to claim 12, wherein the first electrode has a higher work function than the second electrode.

**14.** The method according to claim 13, wherein the first electrode includes indium tin oxide, and the second electrode includes one of aluminum (Al), calcium (Ca), magnesium (Mg) and lithium-fluorine/aluminum(LiF/Al).

**15.** The method according to claim 11, wherein the coloring element includes a color filter layer.

**16.** The method according to claim 11, wherein the coloring element includes a color-changing medium layer.

**17.** The method according to claim 16, wherein the coloring element further includes a color filter layer.

**18.** The method according to claim 16, wherein the organic light-emitting layer emits blue light.

**19.** The method according to claim 11, further comprising forming a power line connected to the driving element.

**20.** The method according to claim 11, further comprising forming a black matrix on the second surface of the second substrate, wherein the black matrix corresponds to a border portion between adjacent pixel regions.

**21.** The method according to claim 20, further comprising forming a passivation layer covering the coloring element and the black matrix over the second surface of the second substrate.

**22.** The method according to claim 21, further comprising forming a transparent layer covering the passivation layer over the second surface of the second substrate.

**23.** The method according to claim 22, further comprising removing the transparent layer.

**24.** An organic electroluminescent display device, comprising:

- first and second substrates facing and spaced apart from each other;
- gate and data lines on an inner surface of the first substrate and crossing each other to define a pixel region;
- a switching element at a crossing point of the gate and data lines;
- a driving element connected to the switching element;
- a first electrode on an inner surface of the second substrate;
- an organic light-emitting layer on the first electrode in the pixel region;
- a second electrode on the organic light-emitting layer in the pixel region and electrically connected to the driving element;
- a third substrate attached to an outer surface of the second substrate; and
- a coloring element on an inner surface of the third substrate.

**25.** The device according to claim 24, further comprising a power line connected to the driving element.

**26.** The device according to claim 24, wherein the first electrode functions as an anode electrode and the second electrode acts as a cathode electrode.

**27.** The device according to claim 24, wherein the coloring element includes a color filter layer.

**28.** The device according to claim 24, wherein the coloring element includes a color-changing medium layer.

**29.** The device according to claim 28, wherein the coloring element further includes a color filter layer.

**30.** The device according to claim 28, wherein the organic light-emitting layer emits blue light.

**31.** The device according to claim 24, further comprising a black matrix on the inner surface of the third substrate, wherein the black matrix corresponds to a border portion between adjacent pixel regions.

**32.** The device according to claim 31, further comprising a passivation layer covering the coloring element and the black matrix at the inner surface of the third substrate.

**33.** The device according to claim 24, wherein the first and second substrates are attached by a seal pattern, and the second and third substrates are attached by an adhesion layer that is applied to an entire inner surface of the third substrate.

**34.** The device according to claim 24, wherein the first and second substrates are attached by a first seal pattern in a peripheral portion and the second and third substrates are attached by a second seal pattern in a peripheral portion.

**35.** A method of fabricating an organic electroluminescent display device, comprising:

- forming gate and data lines on a first substrate, the gate and data lines crossing each other to define a pixel region;
- forming a switching element at a crossing point of the gate and data lines;
- forming a driving element connected to the switching element;
- forming a first electrode on a first surface of a second substrate;
- forming an organic light-emitting layer on the first electrode in the pixel region;

forming a second electrode on the organic light-emitting layer in the pixel region, the second electrode being electrically connected to the driving element;

forming a coloring element on a third substrate;

attaching the first substrate and the second substrate such that the second electrode faces and is electrically connected to the driving element; and

attaching the third substrate to a second surface of the second substrate such that the coloring element is disposed between the third substrate and the second substrate.

**36.** The method according to claim 35, wherein the first electrode functions as an anode electrode and the second electrode acts as a cathode electrode.

**37.** The method according to claim 36, wherein the first electrode has a higher work function than the second electrode.

**38.** The method according to claim 37, wherein the first electrode includes indium tin oxide, and the second electrode includes one of aluminum (Al), calcium (Ca), magnesium (Mg) and lithium-fluorine/aluminum(LiF/Al).

**39.** The method according to claim 35, wherein the coloring element includes a color filter layer.

**40.** The method according to claim 35, wherein the coloring element includes a color-changing medium layer.

**41.** The method according to claim 40, wherein the coloring element further includes a color filter layer.

**42.** The method according to claim 40, wherein the organic light-emitting layer emits blue light.

**43.** The method according to claim 35, further comprising forming a power line connected to the driving element.

**44.** The method according to claim 35, further comprising forming a black matrix on a surface of the third substrate that has the color element thereon, wherein the black matrix corresponds to a border portion between adjacent pixel regions.

**45.** The method according to claim 44, further comprising forming a passivation layer covering the coloring element and the black matrix over the third substrate.

**46.** The method according to claim 35, wherein attaching the first substrate and the second substrate includes forming a seal pattern at a periphery portion, and

wherein attaching third substrate to the second surface of the second substrate includes forming an adhesion layer between substantially the entire second surface of the second substrate and substantially an entire surface of the third substrate that has the coloring element thereon.

**47.** The method according to claim 35, wherein attaching the first substrate and the second substrate includes forming a first seal pattern in a peripheral portion, and

wherein attaching the third substrate to the second surface of the second substrate includes forming a second seal pattern in a peripheral portion.

\* \* \* \* \*

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## 摘要(译)

一种有机电致发光显示装置，包括彼此面对且间隔开的第一和第二基板，在第一基板的内表面上的栅极线和数据线，并且彼此交叉以限定像素区域，在栅极的交叉点处的开关元件数据线，连接到开关元件的驱动元件，第二基板内表面上的第一电极，像素区域中第一电极上的有机发光层，有机发光层上的第二电极在像素区域中并且电连接到驱动元件，以及在像素区域中的第二基板的外表面上的着色元件。

