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(54) **ORGANIC LIGHT EMITTING DIODE DISPLAY AND METHOD OF MANUFACTURING THE SAME**

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(57) **ABSTRACT**

An organic light emitting diode display with first and second substrates, and a method of manufacturing the organic light emitting diode display. The first substrate has a plurality of first organic light emitting diodes each having a first emissive area and a first non-emissive area, and a first driving circuit unit for driving the first organic light emitting diodes. The second substrate has a plurality of second organic light emitting diodes each having a second emissive area and a second non-emissive area, and a second driving circuit unit for driving the second organic light emitting diodes. The first emissive areas of the first organic light emitting diodes face the second non-emissive areas of the second organic light emitting diodes, respectively, and the second emissive areas of the second organic light emitting diodes face the first nonemissive area of the first organic light emitting diodes, respectively.

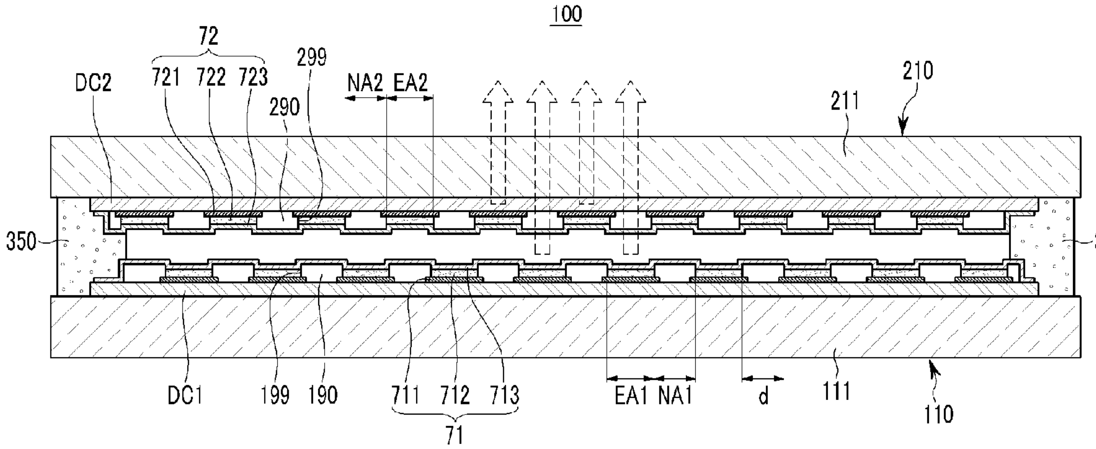


FIG. 1

100

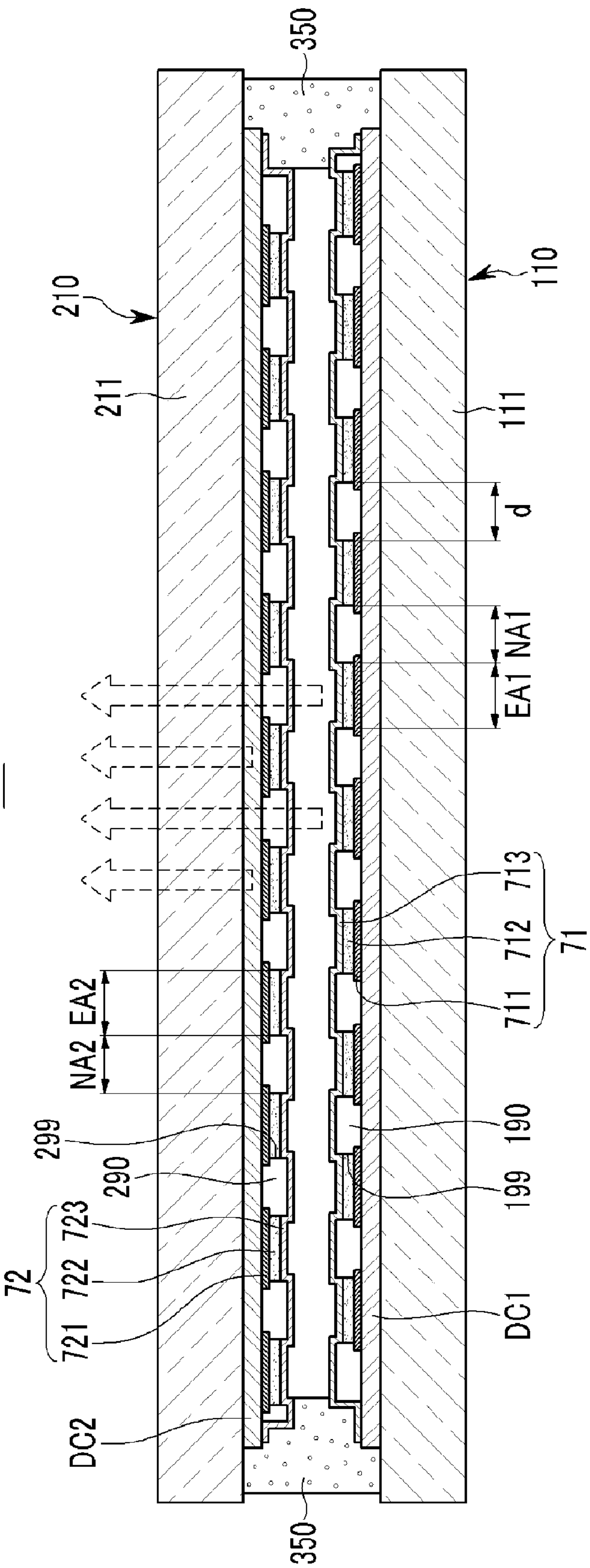

350
210
211
110
111
d
EA1 NA1
713
712
711
71
EA2
NA2
299
290
190
199
72
723
722
721
DC1
DC2
350

FIG. 2

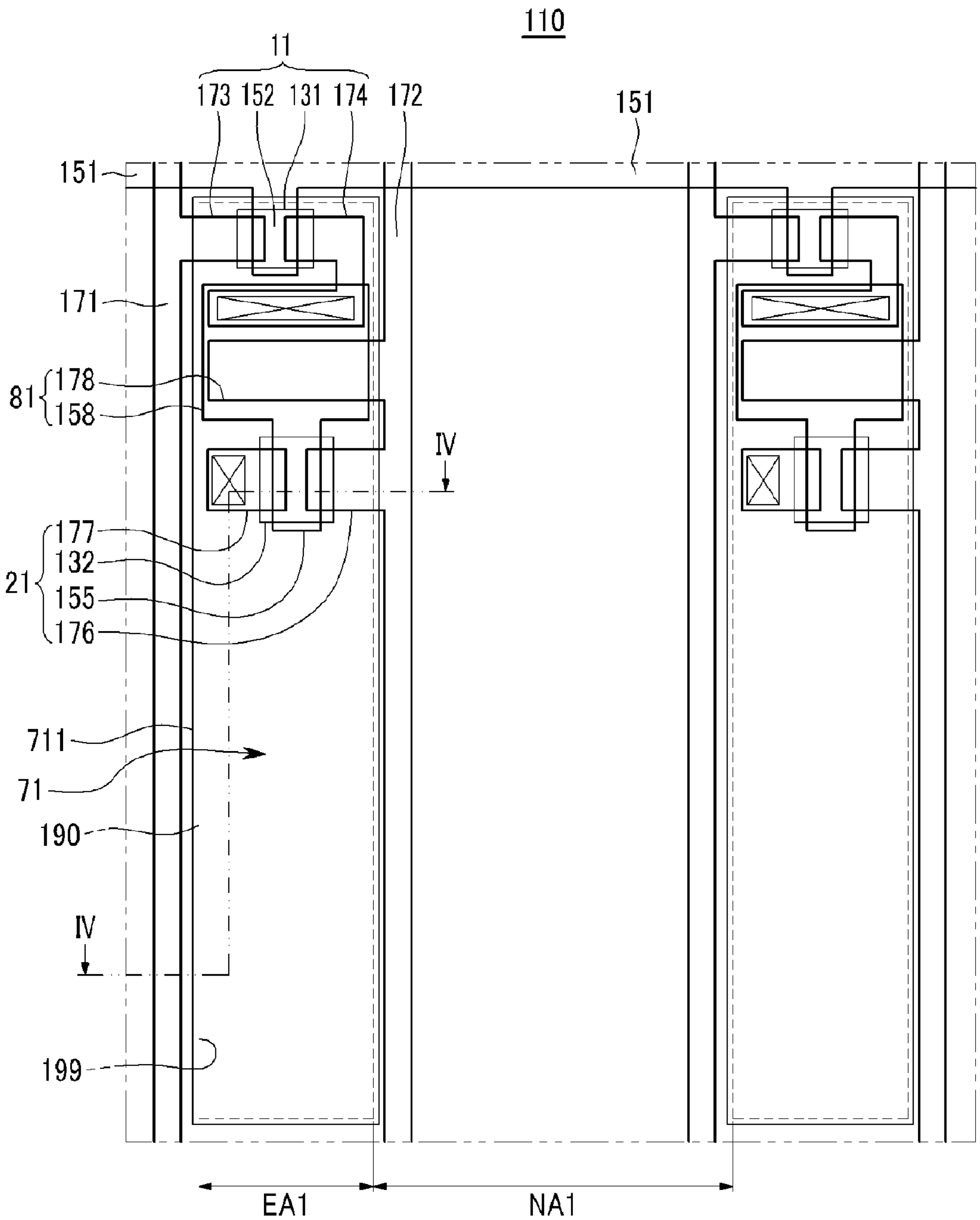

110
11
173 152 131 174 172
151
151
171
81
178
158
IV
177
132
21
155
176
711
71
190
IV
199
EA1
NA1

FIG. 3

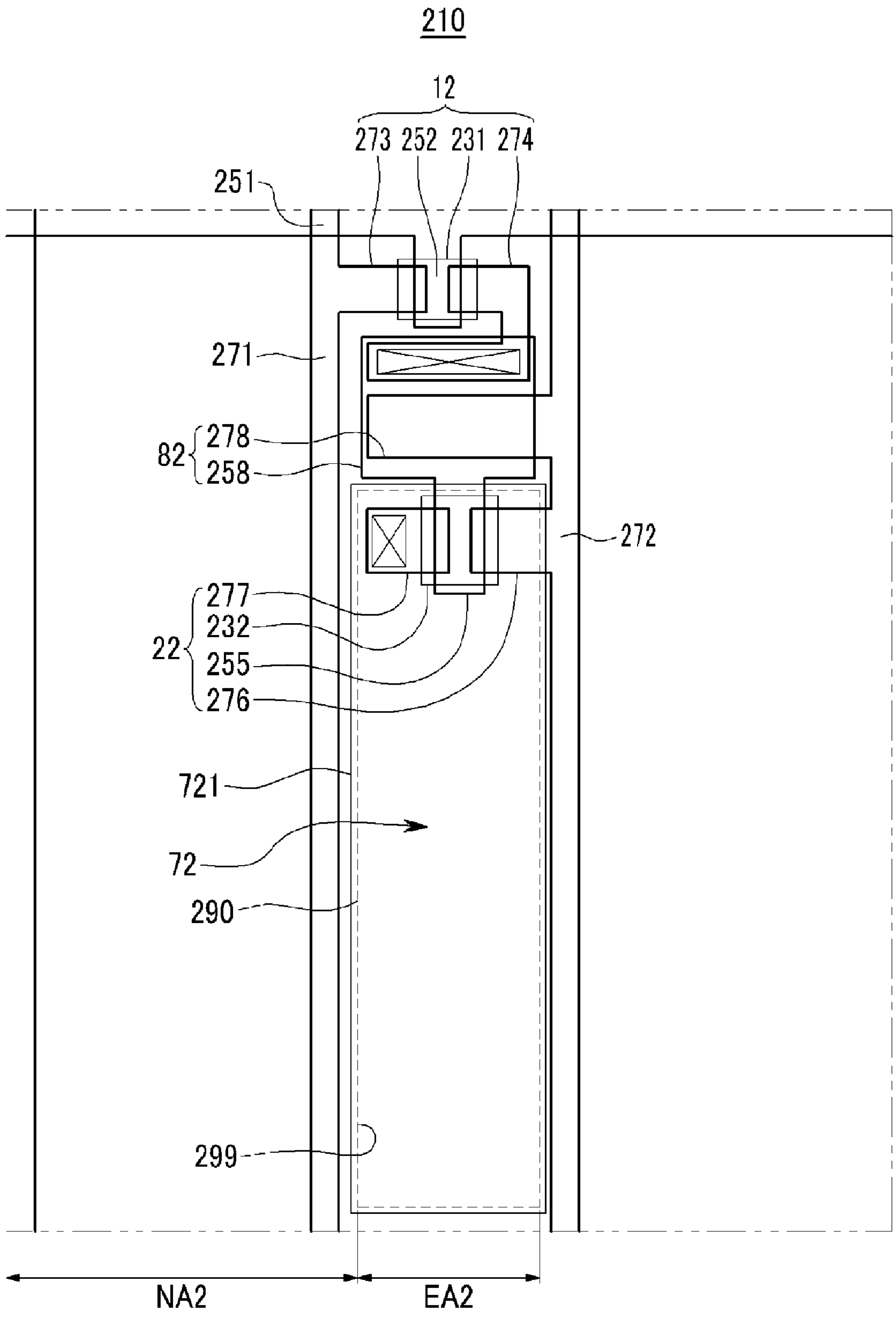

210
12
273
252
231
274
251
271
82
278
258
272
22
277
232
255
276
721
72
290
299
NA2
EA2

FIG. 4

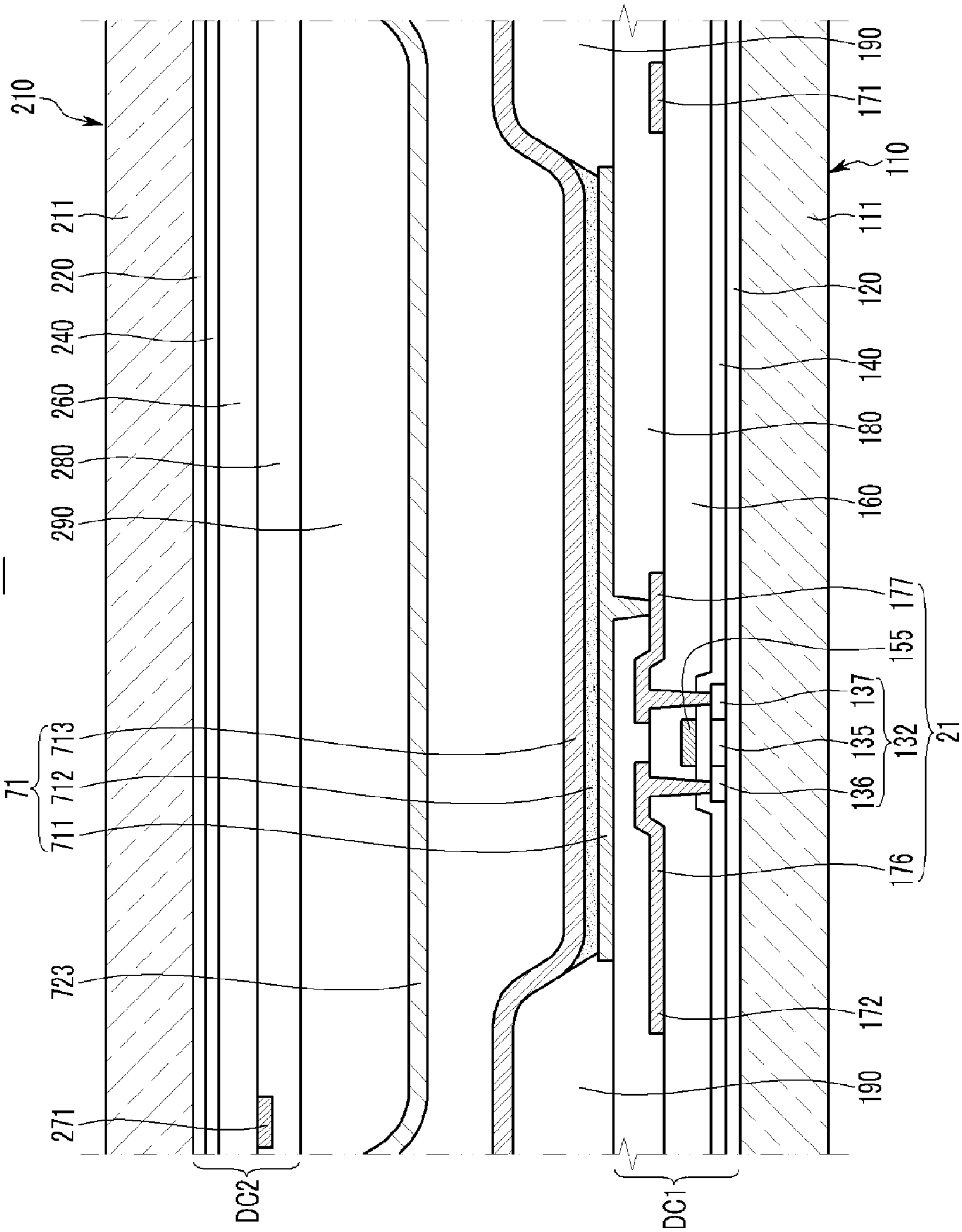
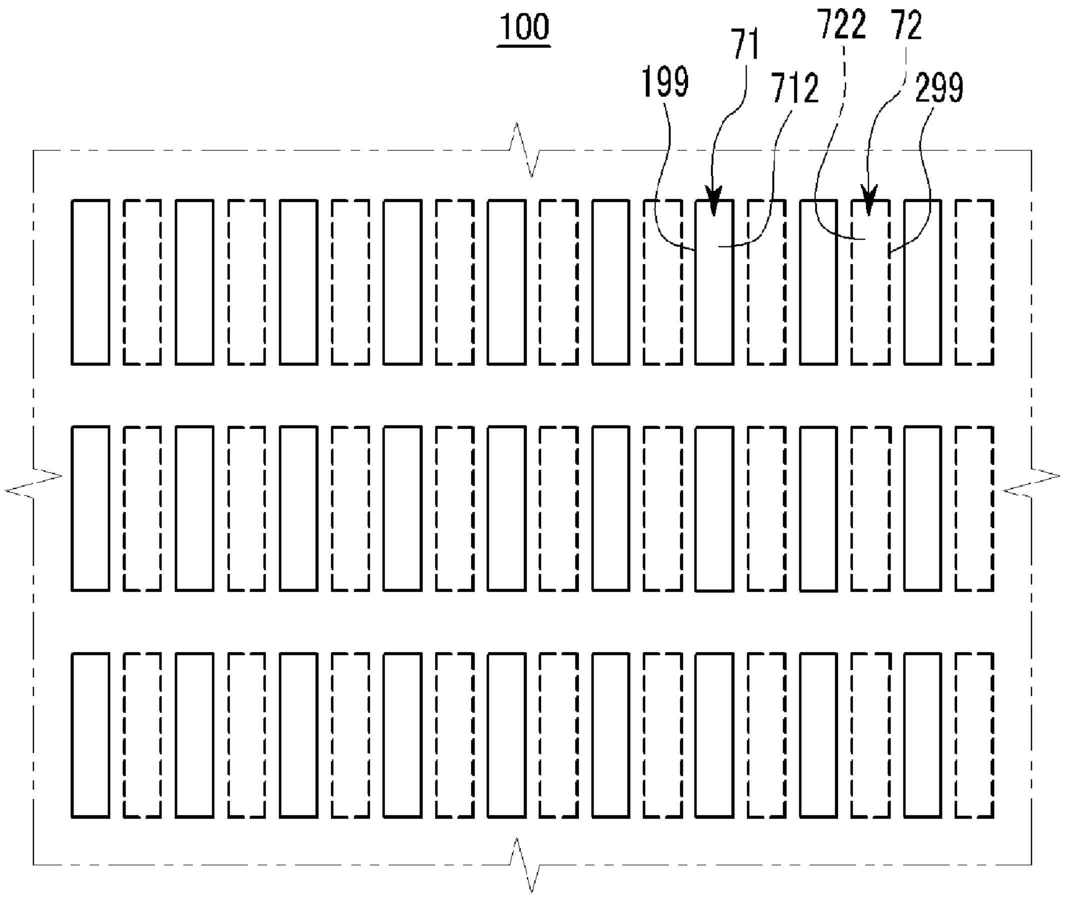

100
210
211
220
240
260
280
290
71
711
712
713
723
271
DC2
190
171
110
111
120
140
180
160
177
155
137
135
136
132
21
176
172
DC1

FIG. 5



ORGANIC LIGHT EMITTING DIODE DISPLAY AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Application No. 10-2009-0008022 filed Feb. 2, 2009, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] Aspects of the present invention relate to an organic light emitting diode display and a method of manufacturing the same, and more particularly, to an organic light emitting diode display with effectively heightened resolution and a manufacturing method thereof.

[0004] 2. Description of the Related Art

[0005] An organic light emitting diode (OLED) display has an emissive characteristic, and differs from a liquid crystal display (LCD) in that it does not require a separate light source and thereby has comparatively reduced thickness and weight. Furthermore, as the organic light emitting diode display has characteristics such as low power consumption, high luminance, and a short response time, it has been spotlighted as a next generation display device for portable electronic appliances.

[0006] The OLED displays images by using a plurality of pixels. A pixel is a minimal image display unit. An organic light emitting diode is formed at each pixel. That is, with the organic light emitting diode display, the image is displayed with light emitted from organic light emitting diodes respectively formed at the pixels. The organic light emitting diode includes a hole injection electrode, an organic emissive layer, and an electron injection electrode.

[0007] The OLED has an emissive area and a non-emissive area, and the emissive area of the organic light emitting diode is spaced apart from that of the neighboring organic light emitting diodes by interposing the non-emissive area therebetween. In this structure, the emissive areas are spaced apart from each other by interposing the corresponding non-emissive areas in order to satisfy the processing conditions and prevent possible device failures.

[0008] Accordingly, as the resolution of the organic light emitting diode display is heightened, that is, as the number of pixels per unit area increases, the emissive area is reduced. Such a reduction in emissive area deteriorates the organic emissive layer, and has a negative effect on the lifespan of the organic light emitting diode display.

SUMMARY OF THE INVENTION

[0009] Aspects of the present invention have been made in an effort to provide an organic light emitting diode display having advantages of effectively heightening the resolution and simultaneously preventing the occurrence of device failures, and a manufacturing method thereof.

[0010] An exemplary embodiment of the present invention provides an organic light emitting diode display with first and second substrates. The first substrate has a plurality of first organic light emitting diodes each having a first emissive area and a first non-emissive area, and a first driving circuit unit for driving the first organic light emitting diodes. The second substrate has a plurality of second organic light emitting diodes each having a second emissive area and a second non-emissive area, and a second driving circuit unit for driving the second organic light emitting diodes. The first emissive areas of the first organic light emitting diodes face the second non-emissive areas of the second organic light emitting diodes, respectively, and the second emissive areas of the second organic light emitting diodes face the first non-emissive areas of the first organic light emitting diodes, respectively.

[0011] The first and second organic light emitting diodes may emit light in the same direction.

[0012] The first emissive areas of each of the first organic light emitting diodes and the second emissive areas of each of the second organic light emitting diodes may be alternately arranged on respective opposing substrates, so as to not overlap in a direction parallel to the first and second substrates.

[0013] Each of the first organic light emitting diodes may include a first pixel electrode, a first common electrode, and a first organic emissive layer disposed between the first pixel electrode and the first common electrode, and each of the second organic light emitting diodes may include a second pixel electrode, a second common electrode, and a second organic emissive layer disposed between the second pixel electrode and the second common electrode.

[0014] The first and second organic emissive layers may be formed by depositing an organic material using a metal mask, an ink-jet method, or a laser induced thermal imaging (LITI) method.

[0015] The first substrate may further include a first pixel definition layer for defining the first emissive area through a first opening, and the second substrate may further include a second pixel definition layer for defining the second emissive area through a second opening, while the first and second organic emissive layers emit light within the first and second openings, respectively.

[0016] The light generated from the first organic emissive layer may be emitted to pass through the second pixel definition layer.

[0017] The distance between neighboring first emissive areas and the distance between neighboring second emissive areas may each be at least 15 microns (μm).

[0018] The first and second pixel definition layers may be formed of an organic material.

[0019] The first driving circuit unit may further include a first driving thin film transistor connected to the first pixel electrodes of the first organic light emitting diodes, and the second driving circuit unit may further include a second driving thin film transistor connected to the second pixel electrodes of the second organic light emitting diodes.

[0020] Another exemplary embodiment of the present invention provides a method of manufacturing an organic light emitting diode display. With the method, a first substrate is formed such that it has a plurality of first organic light emitting diodes each having a first emissive area and a first non-emissive area, and a first driving circuit unit for driving the first organic light emitting diodes. A second substrate is formed such that it has a plurality of second organic light emitting diodes each having a second emissive area and a second non-emissive area, and a second driving circuit unit for driving the second organic light emitting diodes. The first and second substrates are then arranged such that the first emissive areas of the first organic light emitting diodes faces the second non-emissive areas of the second organic light emitting diodes, respectively, and the second emissive areas of the second organic light emitting diodes faces the first non-emissive areas of the first organic light emitting diodes. Thereafter, the first and second substrates are attached to each other so as to seal the substrates in a vacuum-tight manner.

[0021] The plurality of first and second organic light emitting diodes may emit light in the same direction.

[0022] The first and second substrates may be arranged such that the first emissive areas of each of the first organic light emitting diodes and the second emissive areas of each of the second organic light emitting diodes are alternately disposed on respective opposing substrates, so as to not overlap in a direction parallel to the first and second substrates.

[0023] With the method of manufacturing an organic light emitting diode display, the first organic light emitting diodes may each include a first pixel electrode, a first common electrode, and a first organic emissive layer disposed between the first pixel electrode and the first common electrode, and the second organic light emitting diodes may each include a second pixel electrode, a second common electrode, and a second organic emissive layer disposed between the second pixel electrode and the second common electrode.

[0024] The first and second organic emissive layers may be formed by depositing an organic material using a metal mask, an ink-jet method, or a laser induced thermal imaging (LITI) method.

[0025] The first substrate may further include a first pixel definition layer for defining the first emissive area with a first opening, and the second substrate may further include a second pixel definition layer for defining the second emissive area with a second opening, while the first and second organic emissive layers emit light within the first and second openings, respectively.

[0026] The light generated from the first organic emissive layer may be emitted to the outside while passing through the second pixel definition layer.

[0027] The distance between neighboring first emissive areas and the distance between neighboring second emissive areas may be at least 15 microns (μm).

[0028] The first and second pixel definition layers may be formed of an organic material.

[0029] The first driving circuit unit may further include a first driving thin film transistor connected to the first pixel electrodes of the first organic light emitting diodes, and the second driving circuit unit may further include a second driving thin film transistor connected to the second pixel electrodes of the second organic light emitting diodes.

[0030] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

[0032] FIG. **1** is a cross-sectional view of an organic light emitting diode (OLED) display with first and second substrates according to an exemplary embodiment of the present invention.

[0033] FIG. **2** is a layout view illustrating the inner structure of the first substrate shown in FIG. **1**.

[0034] FIG. **3** is a layout view illustrating the inner structure of the second substrate shown in FIG. **1**. FIG. **4** is a partial sectional view of the organic light emitting diode display taken along the IV-IV line of FIG. **2**.

[0035] FIG. **5** is a partial plan view illustrating the arrangement of first and second organic light emitting diodes shown in FIG. **1**.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0036] Reference will now be made in detail to the present embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain aspects of the present invention by referring to the figures.

[0037] Structural parts that are irrelevant to the description are omitted in order to clearly describe aspects of the present invention, and like reference numerals designate like elements throughout the specification.

[0038] Furthermore, as the size and thickness of the respective structural components shown in the drawings are arbitrarily illustrated for explanatory convenience, aspects of the present invention are not necessarily limited to as illustrated.

[0039] In the drawings, the thickness of layers, films, panels, regions, etc., are exaggerated for clarity, better understanding, and convenience in description. It will be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements present.

[0040] Furthermore, even though an active matrix (AM) organic light emitting diode (OLED) display having a 2Tr-1 Cap structure with two thin film transistors (TFT) and one capacitor at each pixel is illustrated in the appended drawings, aspects of the present invention are not limited thereto. The organic light emitting diode display may have three or more thin film transistors and two or more capacitors at each pixel, and various structures with separate wires. A pixel is a minimal image display unit, and the organic light emitting diode display makes the image display by way of a plurality of pixels.

[0041] An exemplary embodiment of the present invention will now be described with reference to FIG. **1**.

[0042] As shown in FIG. **1**, an organic light emitting diode display **100** according to an exemplary embodiment of the present invention includes a first substrate **110**, a second substrate **210**, and a sealant **350**.

[0043] The first substrate **110** includes a first substrate member **111**, and a first organic light emitting diode **71** and a first driving circuit unit DC**1** formed on the first substrate member **111**.

[0044] As shown in FIG. **2**, the first driving circuit unit DC**1** has two or more thin film transistors (TFT) **11** and **21** and one or more capacitors **81** at each pixel. The first driving circuit unit DC**1** is electrically connected to the first organic light emitting diode **71** to drive it.

[0045] The first organic light emitting diode **71** includes a first pixel electrode **711**, a first organic emissive layer **712**, and a first common electrode **713**. The first organic emissive layer **712** is disposed between the first pixel electrode **711** and the first common electrode **713**, and emits light when voltages are applied to the first pixel electrode **711** and the first common electrode **713** in accordance with the driving signals from the first driving circuit unit DC**1**. The light generated from the first organic emissive layer **712** is emitted in the direction of the second substrate **210**.

[0046] Furthermore, the first organic light emitting diode **71** is demarcated into a first emissive area EA**1** and a first non-emissive area NA**1**. The first organic emissive layer **712** emits light at the first emissive area EA**1** thereof.

[0047] As is illustrated in FIG. **1**, the first driving circuit unit DC**1** is formed on the first substrate member **111** while the first organic light emitting diode **71** is formed on the first driving circuit unit DC**1**, but an exemplary embodiment of the present invention is not limited thereto. The structure and disposition of the first driving circuit unit DC**1** and the first organic light emitting diode **71** may be variously altered as is well known to those skilled in the art.

[0048] The second substrate **210** includes a second substrate member **211**, and a second organic light emitting diode **72** and a second driving circuit unit DC**2** formed on the second substrate member **211**.

[0049] As shown in FIG. **3**, the second driving circuit unit DC**2** has two or more thin film transistors (TFT) **12** and **22** and one or more capacitors **82**, similar to the first driving circuit unit DC**1**. The second driving circuit unit DC**2** is electrically connected to the second organic light emitting diode **72** to drive it.

[0050] The second organic light emitting diode **72** includes a second pixel electrode **721**, a second organic emissive layer **722**, and a second common electrode **723**. The second organic emissive layer **722** is disposed between the second pixel electrode **721** and the second common electrode **723**, and emits light when voltages are applied to the second pixel electrode **721** and the second common electrode **723** in accordance with the driving signals from the second driving circuit unit DC**2**. The light generated from the second organic emissive layer **722** is emitted in a direction away from the first substrate **110**. Accordingly, the first and second organic light emitting diodes **71** and **72** are formed such that they emit light in the same direction. Consequently, the light components emitted from the first and second organic light emitting diodes **71** and **72** are merged to thereby display an image.

[0051] The second organic light emitting diode **72** is demarcated into a second emissive area EA**2** and a second non-emissive area NA**2**. The second organic emissive layer **722** emits light at the second emissive area EA**2** thereof.

[0052] As is illustrated in FIG. **1**, the second driving circuit unit DC**2** is formed under the second substrate member **211** while the second organic light emitting diode **72** is formed under the second driving circuit unit DC**2**, but an exemplary embodiment of the present invention is not limited thereto. The structure and disposition of the second driving circuit unit DC**2** and the second organic light emitting diode **72** may be variously altered as is well known to those skilled in the art.

[0053] Particularly, as illustrated in FIG. **1**, the first and second organic light emitting diodes **71** and **72** are similar to each other in structure, however an exemplary embodiment of the present invention is not limited thereto. The first and second organic light emitting diodes **71** and **72** should be formed at different places, but they emit light in the same direction so as to display an image. The first and second organic light emitting diodes **71** and **72** may be altered in structure within the available range as is well known to those skilled in the art. Furthermore, the first and second driving circuit units DC**1** and DC**2**, respectively connected to the first and second organic light emitting diodes **71** and **72**, may be different in structure from each other.

[0054] Although not shown in the drawings, the organic light emitting diode display **100** may further include a driving circuit board connected to the first and second driving circuit units DC**1** and DC**2** to supply driving signals and power thereto. The driving circuit board may be electrically connected to the edge of the first substrate **110** or the second substrate **210**. For example, if the driving circuit board is connected to the edge of the first substrate **110**, the first driving circuit unit DC**1** may be connected with the driving circuit board via a wire on the first substrate **110**. The second driving circuit unit DC**2** may be connected with the driving circuit board via the first substrate **110** by way of an electrical connector (not shown). The electrical connector (not shown) may be formed at the edges of the first and second substrates **110** and **210** within the sealant **350** or separately from the sealant **350**.

[0055] Meanwhile, the first and second substrates **110** and **210** are arranged such that the first emissive area EA**1** of the first organic light emitting diode **71** faces the second non-emissive area NA**2** of the second organic light emitting diode **72**, while the second emissive area EA**2** of the second organic light emitting diode **72** faces the first non-emissive area NA**1** of the first organic light emitting diode **71**.

[0056] Furthermore, the first emissive areas EA**1** of the first organic light emitting diodes **71** and the second emissive areas EA**2** of the second organic light emitting diodes **72** are alternately disposed in a direction parallel to the first and second substrates **110** and **210**.

[0057] The first substrate **110** further includes a first pixel definition layer **190**, and the second substrate **210** further includes a second pixel definition layer **290**. The first pixel definition layer **190** defines the first emissive area EA**1** with a first opening **199**. The second pixel definition layer **290** defines the second emissive area EA**2** with a second opening **299**. That is, the first and second organic emissive layers **712** and **722** emit light within the first opening **199** of the first pixel definition layer **190** and the second opening **299** of the second pixel definition layer **290**, respectively.

[0058] The first opening **199** of the first pixel definition layer **190** faces the second pixel definition layer **290**, and the second opening **299** of the second pixel definition layer **290** faces the first pixel definition layer **190**. The light generated from the first organic emissive layer **712** is emitted to the outside while passing through the second pixel definition layer **290**.

[0059] The distance d between the neighboring first emissive areas EA**1**, that is, the length of the first non-emissive area NA**1** disposed between two neighboring first emissive areas EA**1**, is preferably established to be 15 microns (μm) or more. If the distance d between the first emissive area neighbors EA**1** is less than 15 microns (μm), the first organic emissive layer **712** intrudes into the neighboring organic emissive layer **712** during the processing so that they may be needlessly mixed with each other. Furthermore, it is necessary in forming the first openings **199** at the first pixel definition layer **190** through a photolithography process that the distance between the first opening neighbors **199** should be established to be minimally 15 microns or more. Similarly, the distance between the second emissive area neighbors EA**2**, that is, the length of the second non-emissive area NA**2**

disposed between the second emissive area neighbors EA**2**, is preferably established to be 15 microns or more.

[0060] The first emissive areas EA**1** of the first organic light emitting diodes **71** and the second emissive areas EA**2** of the second organic light emitting diodes **72** are alternately arranged on opposing substrates in a direction parallel to the first and second substrates **110** and **210**.

[0061] The sealant **350** is disposed along the edges of the first and second substrates **110** and **210** so as to attach the first and second substrates **110** and **210** to each other and seal them in a vacuum-tight manner.

[0062] With the above-structured organic light emitting diode display **100**, the resolution can be enhanced effectively while preventing possible device failures.

[0063] That is, with the organic light emitting diode display **100**, the first and second organic light emitting diodes **71** and **72** separately formed on the first and second substrates **110** and **210** facing each other emit light in the same direction to thereby display an image. Consequently, it is possible with the organic light emitting diode display **100** to solve such a problem that as the resolution is increased, the emissive area is reduced due to the non-emissive area, and the luminous efficiency is deteriorated. Furthermore, the organic light emitting diode display **100** is prevented from being reduced in lifespan.

[0064] Meanwhile, as the improvement in luminous efficiency is not based on a reduction in the non-emissive area, the possible processing failures induced by the reduction of the non-emissive area can be prevented.

[0065] The internal structure of an organic light emitting diode display **100** according to an exemplary embodiment of the present invention will now be described in detail with reference to FIG. **2** through FIG. **4**. FIG. **2** is a layout view illustrating a pixel structure centered on the first substrate **110**, and FIG. **3** is a layout view illustrating a pixel structure centered on the second substrate **210**. FIG. **4** is a cross-sectional view of the first and second substrates **110** and **210** taken along the III-III line of FIG. **2**.

[0066] The first substrate **110** includes a first switching thin film transistor **11**, a first driving thin film transistor **21**, a first capacitor **81**, and a first organic light emitting diode (OLED) **71**, which are formed at each pixel. The first substrate **110** further includes first gate lines **151** arranged in a direction, and first data lines **171** and first common power lines **172** that cross the first gate lines **151** in an insulated manner. Here, a pixel is defined by taking the first gate line **151**, the first data line **171**, and the first common power line **172** as a boundary, but is not limited thereto.

[0067] The first organic light emitting diode **71** includes a first pixel electrode **711**, a first organic emissive layer **712** formed on the first pixel electrode **711**, and a first common electrode **713** formed on the first organic emissive layer **712**. The first pixel electrode **711** functions as a positive (+) electrode or anode being a hole injection electrode, and the first common electrode **713** functions as a negative (−) electrode or cathode being an electron injection electrode. However, an exemplary embodiment of the present invention is not necessarily limited thereto, and depending upon the ways of driving the organic light emitting diode display **100**, it is possible that the first pixel electrode **711** functions as the cathode and the first common electrode **713** functions as the anode. Holes and electrons from the first pixel electrode **711** and the first common electrode **713** are injected into the organic emissive layer **712**. When excitons, which are combinations of the electrons and the holes, shift from the excited state to the ground state, the light emission occurs.

[0068] Furthermore, with the organic light emitting diode display **100** according to an exemplary embodiment of the present invention, the first organic light emitting diode **71** emits light in the direction of the second substrate **210**. That is, the first organic light emitting diode **71** is a front emission type. In order for the first organic light emitting diode **71** to emit light in the direction of the second substrate **210**, the first pixel electrode **711** is formed as a reflective electrode, and the first common electrode **713** is formed as a transparent or semi-transparent electrode.

[0069] The first capacitor **81** has a pair of capacitor electrode plates **158** and **178**, and an interlayer insulating layer **160** interposed between the two capacitor electrode plates **158** and **178**. The interlayer insulating layer **160** functions as a dielectric. The capacitance is determined depending upon electric charges charged at the first capacitor **81** and the voltages applied to the two capacitor electrode plates **158** and **178**.

[0070] The first switching thin film transistor **11** includes a first switching semiconductor layer **131**, a first switching gate electrode **152**, a first switching source electrode **173**, and a first switching drain electrode **174**. The first driving thin film transistor **21** includes a first driving semiconductor layer **132**, a first driving gate electrode **155**, a first driving source electrode **176**, and a first driving drain electrode **177**.

[0071] The first switching thin film transistor **11** is used as a switch for selecting the pixels to emit light. The first switching gate electrode **152** is connected to the first gate line **151**. The first switching source electrode **173** is connected to the first data line **171**.

[0072] The first switching drain electrode **174** is spaced apart from the first switching source electrode **173** by a distance, and is connected to any one of the capacitor electrode plates **158**.

[0073] The first driving thin film transistor **21** applies a driving voltage to the first pixel electrode **711** to excite the first organic emissive layer **712** of the first organic light emitting diode **71** in the selected pixel. The first driving gate electrode **155** is connected to the capacitor electrode plate **158** connected with the first switching drain electrode **174**. The first driving source electrode **176** and the other capacitor electrode plate **178** are each connected to the first common power line **172**. The first driving drain electrode **177** is connected to the first pixel electrode **711** of the first organic light emitting diode **71** through a contact hole.

[0074] With the above structure, the first switching thin film transistor **11** is operated by the gate voltage applied to the first gate line **151**, and transmits the data voltage applied to the first data line **171** to the first driving thin film transistor **21**. The voltage with a value corresponding to a difference between the common voltage applied to the first driving thin film transistor **21** from the first common power line **172** and the data voltage transmitted from the first switching thin film transistor **11** is stored at the first capacitor **81**, and the current corresponding to the voltage stored at the first capacitor **81** flows to the first organic light emitting diode **71** through the first driving thin film transistor **21** to thereby excite the first organic light emitting diode **71**.

[0075] A first pixel definition layer **190** defines a first emissive area EA**1** with a first opening **199**. The first opening **199** exposes the first pixel electrode **711**, and the first organic emissive layer **712** emits light within the first opening **199**.

That is, the area of the first opening **199** becomes a first emissive area EA**1**, and the area of the first pixel definition layer **190** becomes a first non-emissive area NA**1**.

[0076] Furthermore, the first organic light emitting diode **71** emits light in the direction of the second substrate **210**. Accordingly, the first opening **199** and the first organic emissive layer **712** may also be formed on the first switching thin film transistor **11** and the first driving thin film transistor **21** so as to enlarge the first emissive area EA**1**.

[0077] The second substrate **210** is similar in structure to the first substrate **110**. That is, as with the first substrate **110**, the second substrate **210** includes a second switching thin film transistor **12**, a second driving thin film transistor **22**, a second capacitor **82** and a second organic light emitting diode **72**, which are formed at each pixel. The second substrate **210** further includes second gate lines **251**, arranged in a direction parallel to a direction along which the OLEDs are sequentially disposed, and second data lines **271** and second common power lines **272** that cross the second gate lines **251** in an insulated manner. Here, a pixel is defined by taking the second gate line **251**, the second data line **271**, and the second common power line **272** as a boundary, but is not limited thereto.

[0078] The second capacitor **82** includes a pair of capacitor electrode plates **258** and **278**, and a second gate insulating layer **240** interposed between the capacitor electrode plates **258** and **278**. The second gate insulating layer **240** functions as a dielectric. The capacitance is determined depending upon the electric charges charged at the second capacitor **82**, and the voltages applied to the two capacitor electrode plates **258** and **278**.

[0079] The second switching thin film transistor **12** includes a second switching semiconductor layer **231**, a second switching gate electrode **252**, a second switching source electrode **273**, and a second switching drain electrode **274**. The second driving thin film transistor **22** includes a second driving semiconductor layer **232**, a second driving gate electrode **255**, a second driving source electrode **276**, and a second driving drain electrode **277**.

[0080] With this structure, the second organic light emitting diode **72** emits light in the same way as in the first organic light emitting diode **71**.

[0081] The second organic light emitting diode **72**, however, is placed opposite to the first substrate **110**, and emits light in a direction opposite to the first substrate **110**. Accordingly, the second opening **299** of the second pixel definition layer **290** and the second organic emissive layer **722** are formed such that they do not overlap with the second switching thin film transistor **12** and the second driving thin film transistor **22**. That is, the second organic light emitting diode **72** is formed as a rear side emission type. The second emissive area EA**2** of the second organic light emitting diode **72** is smaller than the first emissive area EA**1** of the first organic light emitting diode **71**. In order for the second organic light emitting diode **72** to pass the light emitted from the first organic light emitting diode, the second pixel electrode **721** and the second common electrode **723** are formed with a transparent or semi-transparent electrode. However, an exemplary embodiment of the present invention is not limited thereto. The second pixel electrode **721** and the second common electrode **723** may be switched in position with each other.

[0082] The second pixel definition layer **290** defines the second emissive area EA**2** with the second opening **299**. The second opening **299** exposes the second pixel electrode **721**, and the second organic emissive layer **722** emits light within the second opening **299**. That is, the area of the second opening **299** becomes a second emissive area EA**2**, and the area of second pixel definition layer **290** becomes a second non-emissive area NA**2**.

[0083] Meanwhile, the first and second substrates **110** and **210** are arranged such that the first emissive area EA**1** of the first organic light emitting diode **71** faces the second non-emissive area NA**2** of the second organic light emitting diode **72**, and the second emissive area EA**2** of the second organic light emitting diode **72** faces the first non-emissive area NA**1** of the first organic light emitting diode **71**. That is, the first opening **199** of the first pixel definition layer **190** faces the second pixel definition layer **290**, and the second opening **299** of the second pixel definition layer **290** faces the first pixel definition layer **190**.

[0084] It is illustrated in FIG. **3** that the second switching thin film transistor **12** and the second driving thin film transistor **22** of the second substrate **210** have the same structure as that of the first switching thin film transistor **11** and the first driving thin film transistor **21** of the first substrate **110**, however an exemplary embodiment of the present invention is not limited thereto. The second switching thin film transistor **12** and the second driving thin film transistor **22** may be different in structure from the first switching thin film transistor **11** and the first driving thin film transistor **21** within an available that is range well known to those skilled in the art.

[0085] The specific structure of an organic light emitting diode display **100** according to an exemplary embodiment of the present invention will now be described in detail in accordance with the sequence of deposition. The structure of a thin film transistor will be described on the basis of the first driving thin film transistor **21**.

[0086] The first substrate member **111** of the first substrate **110** is formed with an insulating material such as glass, quartz, ceramic, and plastic. However, aspects of the present invention are not limited thereto. The first substrate member **111** may be formed with a metallic material such as stainless steel.

[0087] A first buffer layer **120** is formed on the first substrate member **111**. The first buffer layer **120** prevents the intrusion of impurity elements while flattening the surface, and may be formed with various materials that are capable of filling such a role. For example, the first buffer layer **120** may be formed with any one of silicon nitride (SiNx), silicon oxide (SiOx), and silicon oxynitride (SiOxNy). However, the first buffer layer **120** is not necessarily required, and may be omitted depending upon the kind of the first substrate member **111** and the processing conditions.

[0088] A first driving semiconductor layer **132** is formed on the first buffer layer **120**. The first driving semiconductor layer **132** may be formed with polycrystalline silicon. The first driving semiconductor layer **132** has a non-doped channel region **135**, and p+ doped source and drain regions **136** and **137** formed at respective sides of the non-doped channel region **135**. The dopant ion material is a P-type impurity such as boron (B), and B_2H_6 is primarily used as such a material. The impurity is differentiated depending upon the kinds of thin film transistors.

[0089] With an exemplary embodiment of the present invention, a thin film transistor with a PMOS structure using a P-type impurity is used as the first driving thin film transistor **21**, but the first driving thin film transistor **21** is not limited thereto. A thin film transistor with an NMOS structure or a CMOS structure may also be used as the first driving thin film transistor **21**.

[0090] A gate insulating layer **140** is formed on the first driving semiconductor layer **132** with silicon nitride (SiNx) or silicon oxide (SiOx). A first gate wire including first driving gate electrodes **155** is formed on the first gate insulating layer **140**. The first gate wire further includes first gate lines **151**, and other wiring lines. The first driving gate electrode **155** is overlapped with at least a part of the first driving semiconductor layer **132**, and particularly with the channel region **135** thereof.

[0091] A first interlayer insulating layer **160** is formed on the first gate insulating layer **140** such that it covers the first driving gate electrodes **155**. The first gate insulating layer **140** and the first interlayer insulating layer **160** commonly have through-holes exposing the source and drain regions **136** and **137** of the first driving semiconductor layer **132**. The first interlayer insulating layer **160** as well as the first gate insulating layer **140** are formed with silicon nitride (SiNx) or silicon oxide (SiOx).

[0092] A first data wire including first driving source and drain electrodes **176** and **177** is formed on the first interlayer insulating layer **160**. The first data wire further includes first data lines **171**, first common power lines **172**, and other wiring lines. The first driving source and drain electrodes **176** and **177** are connected to the source and drain regions **136** and **137** of the first driving semiconductor layer **132** via the through-holes formed at the first interlayer insulating layer **160** and the first gate insulating layer **140**, respectively.

[0093] In this way, the first driving thin film transistor **21** is formed with the first driving semiconductor layer **132**, the first driving gate electrode **155**, and the first driving source and drain electrodes **176** and **177**. The structure of the first driving thin film transistor **21** is not limited to the above, but may be altered in various manners with an available structure that is well known to those skilled in the art.

[0094] A first planarization layer **180** is formed on the first interlayer insulating layer **160** such that it covers the first data wires **172**, **176**, **177**, and **178**. The first planarization layer **180** eliminates a stepped difference and flattens the surface in order to heighten the luminous efficiency of a first organic light emitting diode **71** to be formed thereon. Furthermore, the first planarization layer **180** has a contact hole partially exposing the first drain electrode **177**.

[0095] The first planarization layer **180** may be formed with at least one material selected from acrylic resin, epoxy resin, phenolic resin, polyamide resin, polyimide resin, unsaturated polyester resin, polyphenylene ether resin, polyphenylene sulfide resin, and benzocyclobutene (BCB).

[0096] Furthermore, an exemplary embodiment of the present invention is not limited to the above-described structure, and either one of the first planarization layer **180** and the first interlayer insulating layer **160** may be occasionally omitted.

[0097] A first pixel electrode **711** of the first organic light emitting diode **71** is formed on the first planarization layer **180**. That is, the organic light emitting diode display **100** has a plurality of first pixel electrodes **711** disposed at a plurality of pixels, respectively. The plurality of first pixel electrodes **711** are spaced apart from each other by a distance. The first pixel electrode **711** is connected to the first drain electrode **177** through the contact hole of the first planarization layer **180**.

[0098] A first pixel definition layer **190** having a plurality of first openings **199** each exposing the first pixel electrode **711** is formed on the first planarization layer **180**. That is, the first openings **199** of the first pixel definition layer **190** are formed at the respective pixels one by one. The first pixel electrode **711** is disposed corresponding to the first opening **199** of the first pixel definition layer **190**. However, the first pixel electrode **711** is not necessarily disposed only at the first opening **199** of the first pixel definition layer **190**, but may be disposed under the first pixel definition layer **190** such that it is partially overlapped with the first pixel definition layer **190**. The area of the first pixel definition layer **190** becomes substantially a first non-emissive area NA**1**, and the area of the first opening **199** of the first pixel definition layer **190** becomes substantially a first emissive area EA**1**.

[0099] The first pixel definition layer **190** may be formed with a resin such as polyacrylate resin and polyimide resin, or a silica-based inorganic material.

[0100] The first pixel definition layer **190** defines the first emissive area EA**1**, and furthermore, makes it easy to form a first organic emissive layer **712** while preventing electric current from concentrating on the edge of the first pixel electrode **711**.

[0101] A first organic emissive layer **712** is formed on the first pixel electrode **711**, and a first common electrode **713** is formed on the first organic emissive layer **712**. In this way, the first organic light emitting diode **71** is formed with the first pixel electrode **711**, the first organic emissive layer **712**, and the first common electrode **713**. The first organic emissive layer **712** is disposed between the first pixel electrode **711** and the first common electrode **713** within the first opening **199** of the first pixel definition layer **190** close thereto so as to emit light. The first common electrode **713** is formed on the first organic emissive layer **712** and the first pixel definition layer **190**.

[0102] The first organic emissive layer **712** is formed with a low molecular organic material or a high molecular organic material. The first organic emissive layer **712** may have a multi-layered structure with some or all of an emission layer, a hole injection layer (HIL), a hole transport layer (HTL), an electron transport layer (ETL), and an electron injection layer (EIL). If the first organic emissive layer **712** is formed with all of the layers, the hole injection layer (HIL) is disposed on the first pixel electrode **711** being the anode, and is sequentially overlaid with the hole transport layer (HTL), the emission layer, the electron transport layer (ETL), and the electron injection layer (EIL).

[0103] Furthermore, as shown in FIG. **4**, the first organic emissive layer **712** is disposed only within the first opening **199** of the first pixel definition layer **190**, but an exemplary embodiment of the present invention is not limited thereto. The first organic emissive layer **712** may be formed on the first pixel electrode **711** within the first opening **199** of the first pixel definition layer **190**, or may be disposed between the first pixel definition layer **190** and the first common electrode **713**. Specifically, the hole injection layer (HIL), the hole transport layer (HTL), the electron transport layer (ETL), and the electron injection layer (EIL) belonging to the first organic emissive layer **712** in addition to the emission layer may be formed on the first pixel definition layer **190** as well as on the first pixel electrode **711**, as with the first common electrode **713**, using an open mask. By contrast, the emission layer is formed at the respective first openings **199** through a fine metal mask (FMM) process. That is, one or more layer components of the first organic emissive layer **712** may be interposed between the first pixel definition layer **190** and the first common electrode **713**.

[0104] The first pixel electrode **711** and the first common electrode **713** may be formed with a transparent conductive material, or a semi-transparent or reflective conductive material, respectively. In an exemplary embodiment of the present invention, as the first organic light emitting diode **71** emits light in the direction of the second substrate **210**, the first pixel electrode **711** is formed with a reflective or semi-transparent material, and the first common electrode **713** is formed with a transparent or semi-transparent material.

[0105] The transparent conductive material may be indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), or indium oxide (In_2O_3). The reflective material and the semi-transparent material may be selected from lithium (Li), calcium (Ca), lithium fluoride/calcium (LiF/Ca), lithium fluoride/aluminum (LiF/Al), aluminum (Al), silver (Ag), magnesium (Mg), and gold (Au).

[0106] The second substrate **210** faces the first common electrode **713** from the top side. Specifically, a second common electrode **723** is formed on the first common electrode **713**. A second pixel definition layer **290** is disposed on the second common electrode **723**. That is, the second pixel definition layer **290** is placed over the first opening **199** of the first pixel definition layer **190** corresponding thereto.

[0107] Furthermore, the second pixel definition layer **290** is sequentially overlaid with a second planarization layer **280**, a second interlayer insulating layer **260**, a second gate insulating layer **240**, a second buffer layer **220**, and a second substrate member **211**, corresponding in position to the first opening **199** of the first pixel definition layer **190**. As the overlaid layers are all formed with a transparent material, the light generated from the first organic emissive layer **712** of the first organic light emitting diode **71** sequentially passes through them, and flows to the outside.

[0108] With an organic light emitting diode display **100** according to an exemplary embodiment of the present invention, as shown in FIG. **5**, the first organic emissive layers **712** of the first organic light emitting diodes **71** and the second organic emissive layers **722** of the second organic light emitting diodes **72** are alternately arranged in a direction parallel to the first and second substrates **110** and **210**. That is, the first and second openings **199** and **299** are arranged in an alternating manner.

[0109] In this structure, the organic light emitting diode display **100** can effectively enhance the resolution, and simultaneously prevent the occurrence of device failures.

[0110] In the organic light emitting diode display **100**, the first and second organic light emitting diodes **71** and **72** separately formed on the first and second substrates **110** and **210** facing each other emit light in the same direction so as to display an image. Accordingly, it is possible with the organic light emitting diode display **100** to solve such a problem that as the resolution is heightened, the emissive area is reduced due to the non-emissive area, and the luminous efficiency is deteriorated. Consequently, a lifespan of the organic light emitting diode display **100** is prevented from being reduced.

[0111] Furthermore, as the improvement in luminous efficiency is not based on the reduction in the non-emissive area, the possible processing failures induced by a reduction of the non-emissive area can also be prevented.

[0112] A method of manufacturing an organic light emitting diode display **100** according to an exemplary embodiment of the present invention will be described with reference to FIG. **1** through FIG. **4**, based on the arrangement procedures of the first and second substrates **110** and **210**.

[0113] A first substrate **110** having a plurality of first organic light emitting diodes **71** each with a first emissive area EA**1** and a first non-emissive area NA**1**, and a second substrate **210** having a plurality of second organic light emitting diodes **72** each with a second emissive area EA**2** and a second non-emissive area NA**2**, are first formed in a separate manner. The first emissive area EA**1** is defined by the first opening **199** of the first pixel definition layer **190**, and the second emissive area EA**2** is defined by the second opening **299** of the second pixel definition layer **290**. A first organic emissive layer **712** is disposed within the first opening **199**, and a second organic emissive layer **722** is disposed within the second opening **299**. The first and second organic emissive layers **712** and **722** are formed by depositing an organic material using a metal mask, an ink-jet method, or a laser induced thermal imaging (LITI) method.

[0114] The specific structure of the first and second substrates **110** and **210** are as previously described. A sealant **350** is applied onto the edge of at least one of the first and second substrates **110** and **210**.

[0115] Thereafter, the first and second substrates **110** and **210** are arranged such that the first emissive area EA**1** of the first organic light emitting diode **71** faces the second non-emissive area NA**2** of the second organic light emitting diode **72**, and the second emissive area EA**2** of the second organic light emitting diode **72** faces the first non-emissive area NA**1** of the first organic light emitting diode **71**. Specifically, the first and second substrates **110** and **210** are arranged such that the first and second organic light emitting diodes **71** and **72** are disposed as illustrated in FIG. **5**.

[0116] The first and second substrates **110** and **210** are attached to each other in a vacuum-tight manner by interposing the sealant **350**, which is then hardened. However, an exemplary embodiment of the present invention is not limited thereto. In addition to the vacuum sealing, the first and second substrates **110** and **210** may be attached to each other and sealed in various manners, which are well known to those skilled in the art.

[0117] With the manufacturing method, an organic light emitting diode display **100** with high resolution is fabricated effectively.

[0118] Furthermore, as the improvement in luminous efficiency is not based on the reduction in the non-emissive area, possible processing failures induced by reduction of the non-emissive area can be prevented.

[0119] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. An organic light emitting diode display comprising:

a first substrate having a plurality of first organic light emitting diodes each having a first emissive area and a first non-emissive area, and a first driving circuit unit for driving the first organic light emitting diodes; and

a second substrate having a plurality of second organic light emitting diodes each having a second emissive area and a second non-emissive area, and a second driving circuit unit for driving the second organic light emitting diodes,

wherein the first emissive areas of the first organic light emitting diodes face the second non-emissive areas of the second organic light emitting diodes, respectively, and the second emissive areas of the second organic light emitting diodes face the first non-emissive area of the first organic light emitting diodes, respectively.

2. The organic light emitting diode display of claim **1**, wherein the first and second organic light emitting diodes emit light in the same direction.

3. The organic light emitting diode display of claim **1**, wherein the first emissive areas of the first organic light emitting diodes and the second emissive areas of the second organic light emitting diodes are alternately arranged on respective opposing substrates, so as to not overlap, in a direction parallel to the first and second substrates.

4. The organic light emitting diode display of claim **1**, wherein the first organic light emitting diodes each includes a first pixel electrode, a first common electrode and a first organic emissive layer disposed between the first pixel electrode and the first common electrode, and the second organic light emitting diodes each includes a second pixel electrode, a second common electrode and a second organic emissive layer disposed between the second pixel electrode and the second common electrode.

5. The organic light emitting diode display of claim **4**, wherein the first and second organic emissive layers are formed by depositing an organic material using a metal mask, an ink-jet method, or a laser induced thermal imaging (LITI) method.

6. The organic light emitting diode display of claim **4**, wherein the first substrate further comprises a first pixel definition layer for defining the first emissive area through a first opening, and the second substrate further comprises a second pixel definition layer for defining the second emissive area through a second opening, while the first and second organic emissive layers emit light within the first and second openings, respectively.

7. The organic light emitting diode display of claim **6**, wherein the light generated from the first organic emissive layer is emitted to pass through the second pixel definition layer.

8. The organic light emitting diode display of claim **6**, wherein the distance between neighboring first emissive areas and the distance between neighboring second emissive areas are at least 15 microns (μm).

9. The organic light emitting diode display of claim **8**, wherein the first and second pixel definition layers are formed of an organic material.

10. The organic light emitting diode display of claim **4**, wherein the first driving circuit unit further comprises a first driving thin film transistor connected to the first pixel electrodes of the first organic light emitting diodes, and the second driving circuit unit further comprises a second driving thin film transistor connected to the second pixel electrodes of the second organic light emitting diodes.

11. A method of manufacturing an organic light emitting diode display, the method comprising:

forming a first substrate having a plurality of first organic light emitting diodes each having a first emissive area and a first non-emissive area, and a first driving circuit unit for driving the first organic light emitting diodes;

forming a second substrate having a plurality of second organic light emitting diodes each having a second emissive area and a second non-emissive area, and a second driving circuit unit for driving the second organic light emitting diodes;

arranging the first and second substrates such that the first emissive areas of the first organic light emitting diodes face the second non-emissive areas of the second organic light emitting diodes, respectively, and the second emissive areas of the second organic light emitting diodes face the first non-emissive areas of the first organic light emitting diodes, respectively; and

attaching the first and second substrates to each other to seal the substrates in a vacuum-tight manner.

12. The method of claim **11**, wherein the plurality of the first and second organic light emitting diodes emit light in the same direction.

13. The method of claim **11**, wherein the first and second substrates are arranged such that the first emissive areas of the first organic light emitting diodes and the second emissive areas of the second organic light emitting diodes are alternately disposed on respective opposing substrates, so as to not overlap in a direction parallel to the first and second substrates.

14. The method of claim **11**, wherein the first organic light emitting diodes each comprises a first pixel electrode, a first common electrode, and a first organic emissive layer disposed between the first pixel electrode and the first common electrode, and the second organic light emitting diodes each comprises a second pixel electrode, a second common electrode, and a second organic emissive layer disposed between the second pixel electrode and the second common electrode.

15. The method of claim **14**, wherein the first and second organic emissive layers are formed by depositing an organic material using a metal mask.

16. The method of claim **14**, wherein the first substrate further comprises a first pixel definition layer for defining the first emissive area with a first opening, and the second substrate further comprises a second pixel definition layer for defining the second emissive area with a second opening, while the first and second organic emissive layers emit light within the first and second openings, respectively.

17. The method of claim **16**, wherein the light generated from the first organic emissive layer is emitted to pass through the second pixel definition layer.

18. The method of claim **16**, wherein the distance between neighboring first emissive areas and the distance between neighboring second emissive areas are each at least 15 microns (μm).

19. The method of claim **18**, wherein the first and second pixel definition layers are formed of an organic material.

20. The method of claim **14**, wherein the first driving circuit unit further comprises a first driving thin film transistor connected to the first pixel electrodes of the first organic light emitting diodes, and the second driving circuit unit further comprises a second driving thin film transistor connected to the second pixel electrodes of the second organic light emitting diodes.

21. The organic light emitting diode display of claim **2**, wherein light emitted from the first and second organic light emitting diodes is merged to display an image.

22. The organic light emitting diode display of claim **2**, wherein the first organic light emitting diodes are a front emission type diode and the second organic light emitting diodes are a rear side emission type.

23. The organic light emitting diode display of claim **4**, wherein the first pixel electrode is formed as a reflective electrode.

24. The organic light emitting diode display of claim **4**, wherein the first common electrode, the second common electrode, and the second pixel electrode are formed as transparent or semi-transparent electrodes.

25. The organic light emitting diode display of claim **23**, wherein the reflective electrodes are formed of one of lithium, calcium, lithium fluoride/calcium, lithium fluoride/aluminum, aluminum, silver, magnesium and gold.

26. The organic light emitting diode display of claim **24**, wherein the transparent or semi-transparent electrodes are formed of one of indium tin oxide, indium zinc oxide, zinc oxide and indium oxide.

27. The organic light emitting diode display of claim **1**, wherein the second emissive areas of the second organic light emitting diodes are smaller than the first emissive areas of the first organic light emitting diodes.

28. An organic light emitting diode (OLED) display comprising:

a plurality of substrates; and

a plurality of OLEDs disposed on one face of each of the plurality of substrates,

wherein the plurality of substrates are parallel to each other such that the faces having the OLEDs face each other, and

wherein emissive areas of the OLEDs of a bottom substrate emit light through the at least one substrate above the bottom substrate.

29. The OLED display of claim **28**, wherein the plurality of OLEDs emit light in the same direction.

30. The OLED display of claim **29**, further comprising:

non-emissive areas of the plurality of OLEDs,

wherein the emissive areas of the plurality of OLEDs disposed on one of the substrates emit light through the non-emissive areas of the plurality of OLEDs disposed on another one of the substrates.

31. The OLED display of claim **30** wherein the emissive areas of the one of the substrates and the emissive areas of the other of the substrates are disposed in an alternating pattern on their respective substrates so as to not overlap with each other in the direction of light emission.

32. The OLED display of claim **28**, wherein each of the OLEDs includes a pixel electrode, a common electrode and an organic emissive layer disposed between the pixel electrode and the common electrode.

33. The OLED display of claim **31**, wherein the organic emissive layers are formed by depositing an organic material using a metal mask, an ink-jet method, or a laser induced thermal imaging (LITI) method.

34. The OLED display of claim **31**, wherein each of the substrates further comprises a pixel definition layer for defining the emissive area through an opening, while the organic emissive layers emit light through the openings.

35. The organic light emitting diode display of claim **28**, wherein the distance between neighboring emissive areas is at least 15 microns (μm).

36. The organic light emitting diode display of claim **34**, wherein the pixel definition layers are formed of an organic material.

37. The organic light emitting diode display of claim **29**, wherein each OLED further comprises a driving circuit unit having a driving thin film transistor connected to the pixel electrode of each of the OLEDs.

38. A method of increasing a display resolution of an organic light emitting diode (OLED) display, comprising:

arranging a plurality of OLEDs disposed on a plurality of substrates in a staggered pattern on respective substrates of the plurality of substrates; and

emitting light from emissive areas of the plurality of OLEDs disposed on one of the substrates,

wherein the emitted light passes between emissive areas of the plurality of OLEDs disposed on another of the substrates.

39. The method of claim **38**, wherein the plurality of OLEDs emit light in the same direction.

40. The method of claim **39**, wherein the emitting of the light comprises emissive areas of OLEDs disposed on the one of the substrates emitting light through non-emissive areas of the plurality of OLEDs disposed on the other of the substrates.

41. The method of claim **40** wherein emissive areas of the one of the substrates and the emissive areas of the other of the substrates are disposed in an alternating pattern on their respective substrates so as to not overlap with each other in the direction of light emission.

42. The OLED display of claim **41**, wherein each of the substrates further comprises a pixel definition layer for defining the emissive area through a opening, while the organic emissive layers emit light through the openings.

43. The organic light emitting diode display of claim **38**, wherein the distance between neighboring emissive areas is at least 15 microns (μm).

44. The method of claim **38**, further comprising driving the plurality of OLEDs with a driving circuit unit having a driving thin film transistor connected to a pixel electrode of each of the OLEDs.

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摘要(译)

一种具有第一和第二基板的有机发光二极管显示器，以及制造该有机发光二极管显示器的方法。第一基板具有多个第一有机发光二极管，每个第一有机发光二极管具有第一发光区域和第一非发光区域，以及第一驱动电路单元，用于驱动第一有机发光二极管。第二基板具有多个第二有机发光二极管，每个第二有机发光二极管具有第二发光区域和第二非发光区域，以及第二驱动电路单元，用于驱动第二有机发光二极管。第一有机发光二极管的第一发光区域分别面对第二有机发光二极管的第二非发光区域，第二有机发光二极管的第二发光区域面对第一有机发光二极管的第一非发光区域发光二极管。