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(54) ORGANIC LIGHT-EMITTING DISPLAY APPARATUS AND METHOD OF MANUFACTURING THE SAME

(71) Applicant: **SAMSUNG DISPLAY CO., LTD.**, Yongin-City (KR)

(72) Inventor: **Seung-Jun Moon**, Yongin-City (KR)

(73) Assignee: **SAMSUNG DISPLAY CO., LTD.**, Yongin-City (KR)

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(57) **ABSTRACT**

An organic light-emitting display apparatus includes a substrate, a display portion on the substrate, an organic layer extending over the display portion, an inorganic layer extending over the organic layer, and a dam surrounding an outer perimeter of the organic layer. The dam may include a groove configured to accommodate a portion of the organic layer extending beyond a perimeter of the dam surrounding the organic layer. A method of manufacturing an organic light-emitting display apparatus includes forming a display portion on a substrate, forming a dam defining a groove in a region spaced from the display portion, forming an organic layer over the display portion and extending up to the region spaced from the display portion such that the organic layer is surrounded by the dam, and forming an inorganic layer over the organic layer.

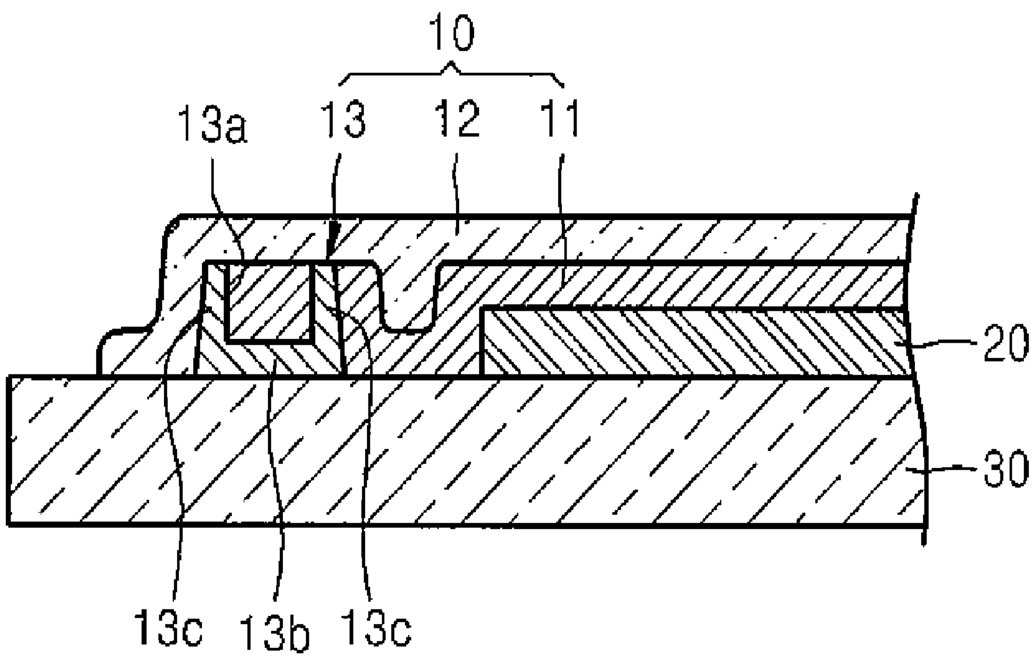


FIG. 1

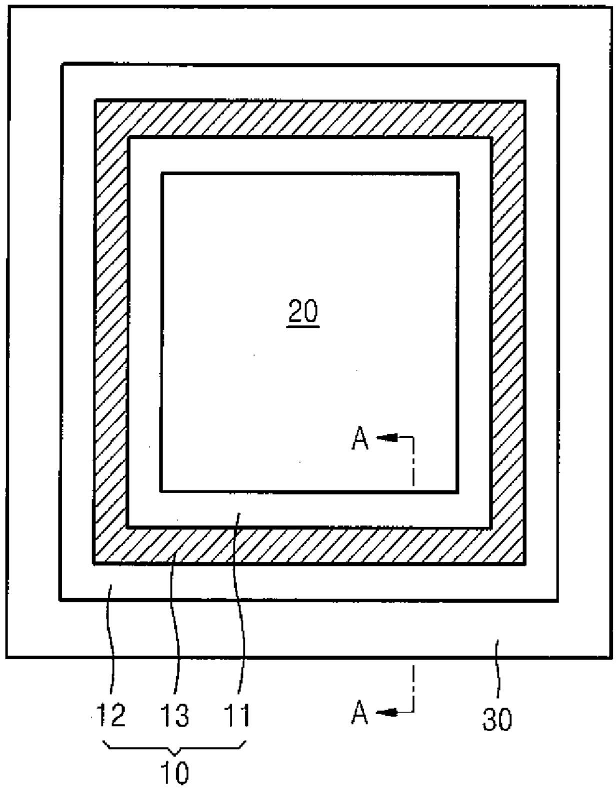


FIG. 2

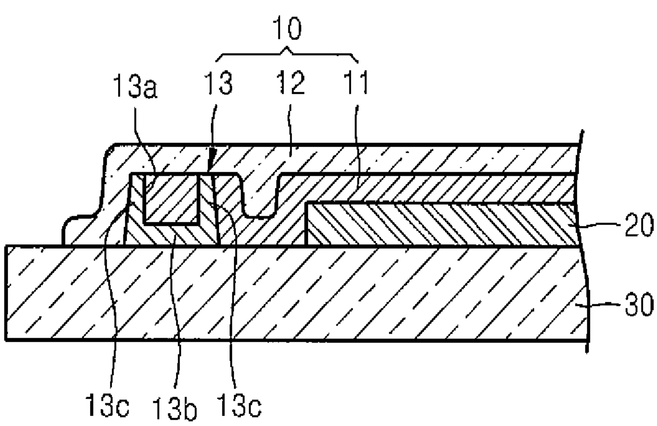


FIG. 3

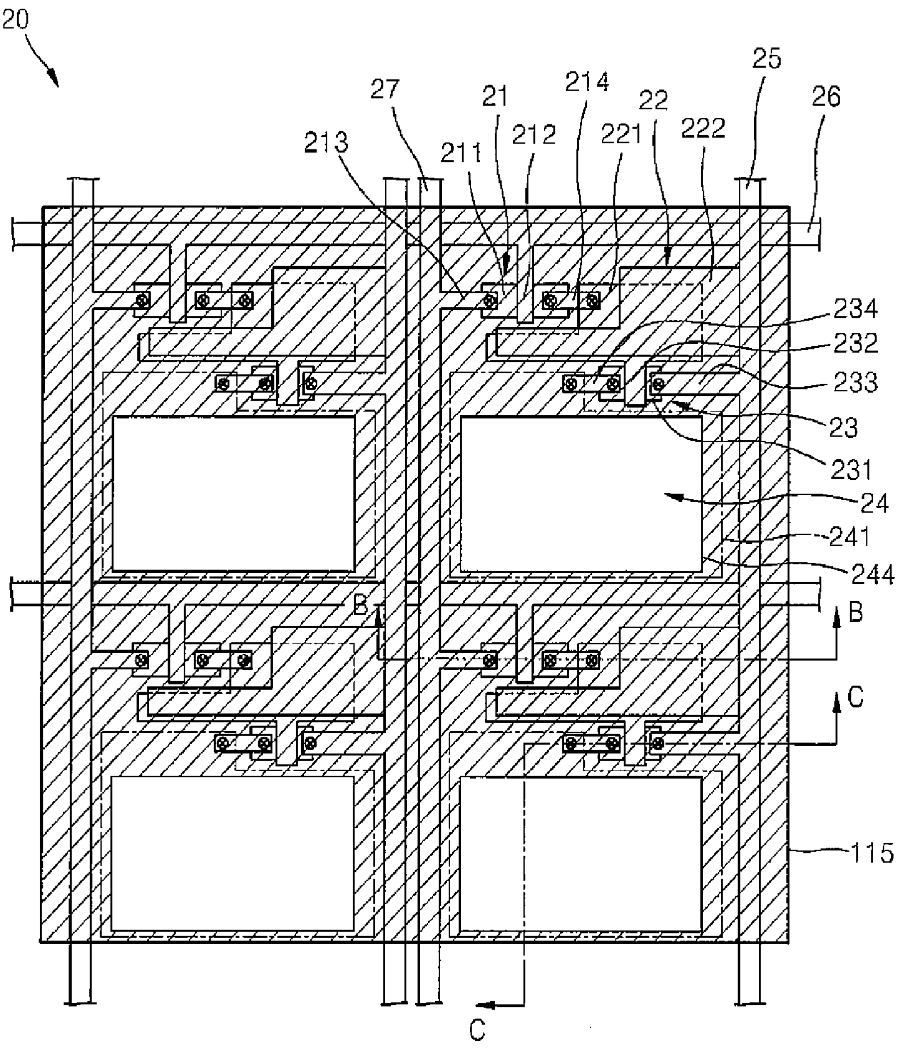
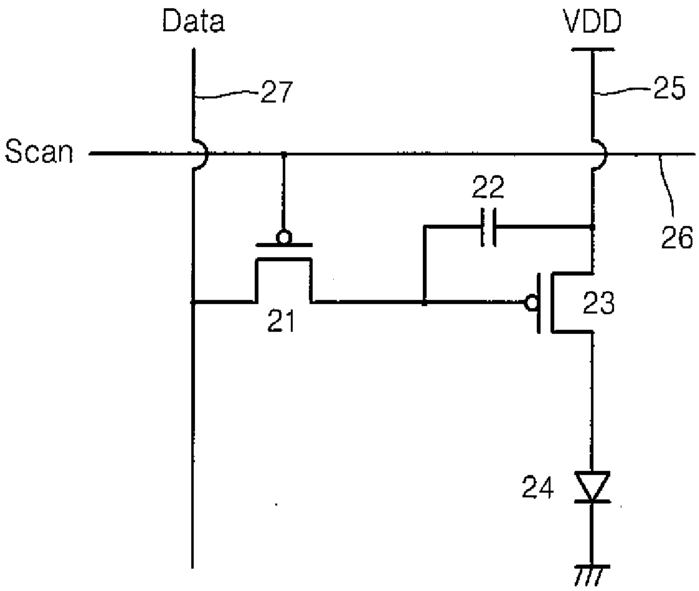
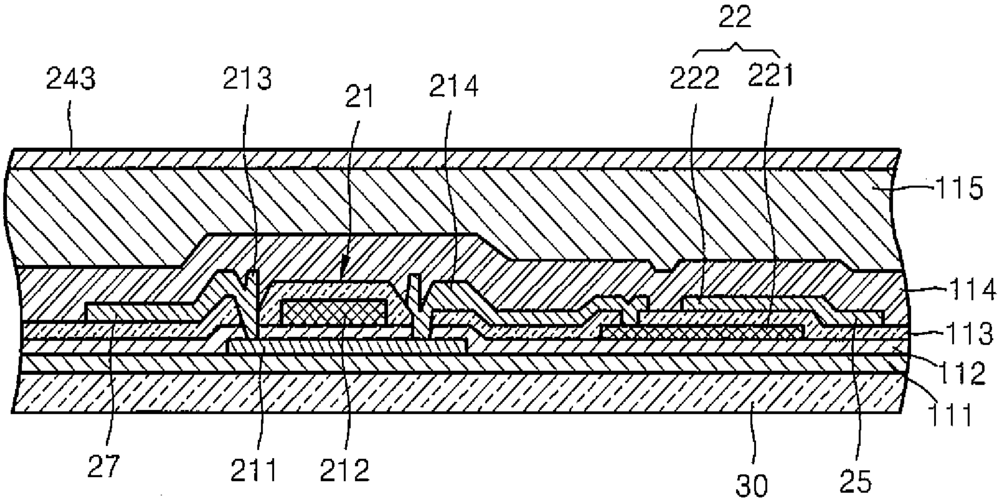

20
27
21
214
22
25
26
213
211
212
221
222
234
232
233
23
231
24
241
244
B
B
C
115
C

FIG. 4



Data
VDD
27
25
Scan
22
26
21
23
24

FIG. 5



22
243
213
21
214
222
221
115
114
113
112
111
27
211
212
30
25

FIG. 6

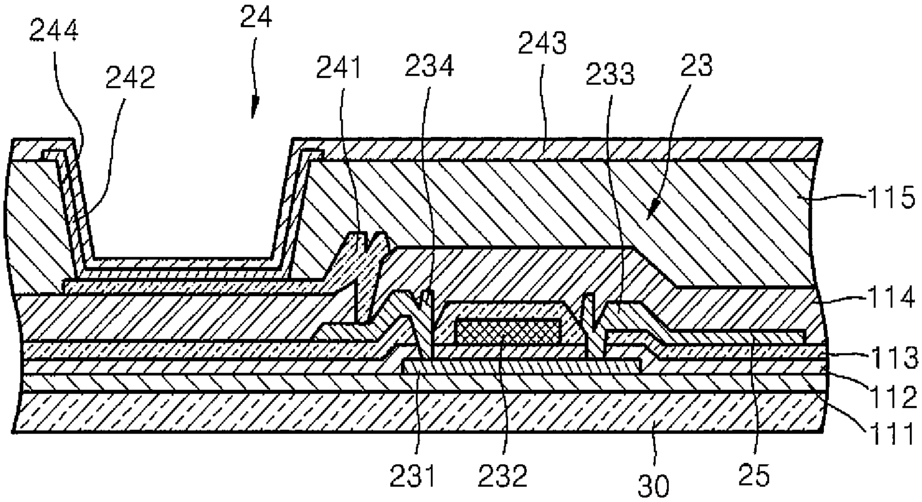


FIG. 7A

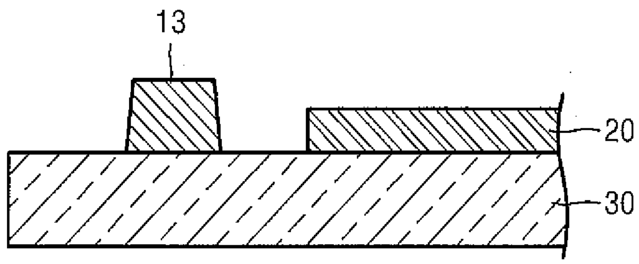


FIG. 7B

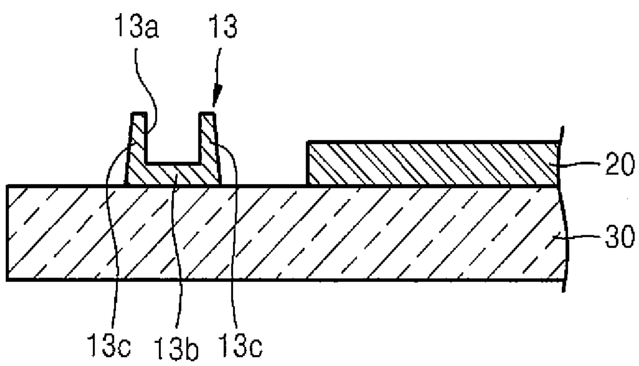


FIG. 7C

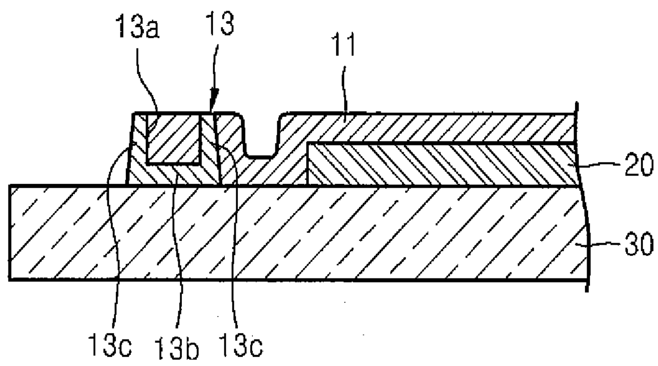


FIG. 7D

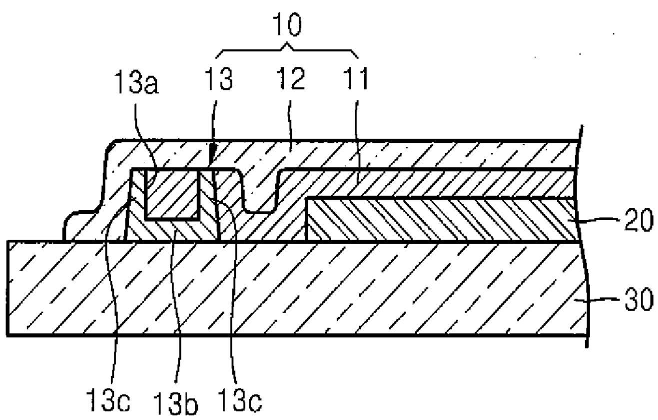
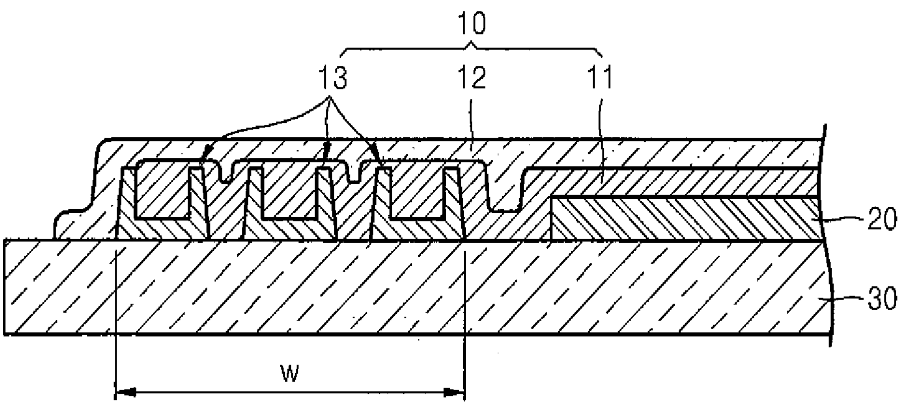


FIG. 8



ORGANIC LIGHT-EMITTING DISPLAY APPARATUS AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2013-0158682, filed on Dec. 18, 2013, in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] 1. Field

[0003] Aspects of the present invention relate to organic light-emitting display apparatuses and methods of manufacturing the organic light-emitting display apparatuses.

[0004] 2. Description of the Related Art

[0005] Organic light-emitting display apparatuses generally include a display portion having a structure in which an emission layer formed of an organic material is positioned between an anode electrode and a cathode electrode. When a voltage is applied to the anode electrode and the cathode electrode of the apparatuses, holes injected from each of the anode electrode and the cathode electrode are recombined with each other to generate an exciton. When the exciton changes from an excited state to a ground state, light is emitted forming an image on the apparatus.

[0006] If the emission layer of the display portion comes into contact with moisture, an emission characteristic of the display portion may deteriorate, thus an encapsulation member is typically used to cover the display portion to prevent such deterioration. Thin film encapsulation in which organic layers and inorganic layers are alternately stacked is one type of encapsulation member.

SUMMARY

[0007] One or more embodiments of the present invention relate to organic light-emitting display apparatuses. Embodiments of the present invention also relate to organic light-emitting display apparatuses having an improved structure of thin film encapsulation and methods of manufacturing the same.

[0008] According to one or more embodiments of the present invention, an organic light-emitting display apparatus includes a substrate, a display portion on the substrate, an organic layer extending over the display portion, an inorganic layer extending over the organic layer, and a dam surrounding an outer perimeter of the organic layer, wherein the dam includes a groove configured to accommodate a portion of the organic layer extending beyond a perimeter of the dam surrounding the organic layer.

[0009] The dam may further include a single layer surrounding the outer perimeter of the organic layer. In another embodiment, the dam may further include a plurality of layers surrounding the outer perimeter of the organic layer.

[0010] The inorganic layer may extend to an outer edge of the dam.

[0011] The dam may further include a bottom surface contacting the substrate, a plurality of wall surfaces integrally formed with the bottom surface and extending upward from the bottom surface, and wherein the groove may be defined by an opening surrounded by the bottom surface and the plurality of wall surfaces of the dam.

[0012] According to one or more embodiments of the present invention, a method of manufacturing an organic light-emitting display apparatus includes forming a display portion on a substrate; forming a dam defining a groove in a region spaced from the display portion; forming an organic layer over the display portion and extending up to the region spaced from the display portion such that the organic layer is surrounded by the dam; and forming an inorganic layer over the organic layer.

[0013] The dam may be formed of a single layer. In another embodiment, the dam may be formed of a plurality of layers.

[0014] The inorganic layer may extend to and outer edge of the dam.

[0015] The groove may be defined by an opening sunken from an upper surface of the dam into the inside such that a part of an outer perimeter of the organic layer is contained in the accommodated in the groove.

[0016] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments, or as appreciated by those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings, in which:

[0018] FIG. **1** is a plan view of an organic light-emitting display apparatus, according to an embodiment of the present invention;

[0019] FIG. **2** is a cross-sectional view taken along the line A-A of FIG. **1**;

[0020] FIG. **3** is a partially expanded plan view including pixels of a display portion of the organic light-emitting display apparatus of FIGS. **1** and **2**;

[0021] FIG. **4** is an equivalent schematic circuit diagram of one of the pixels shown in FIG. **3**;

[0022] FIG. **5** is a cross-sectional view taken along the line B-B of FIG. **3**;

[0023] FIG. **6** is a cross-sectional view taken along the line C-C of FIG. **3**;

[0024] FIGS. **7**A through **7**D are diagrams sequencing a process of manufacturing the organic light-emitting display apparatus of the embodiments shown in FIGS. **1** and **2**; and

[0025] FIG. **8** is a cross-sectional view of an organic light-emitting display apparatus according to another embodiment of the present invention.

DETAILED DESCRIPTION

[0026] Reference will now be made in detail to various embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. The present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by reference to the figures, to explain aspects of the present description.

[0027] As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0028] It will be further understood that the terms "comprises" and/or "comprising" used herein specify the presence of stated features or components, but do not preclude the presence or addition of one or more other features or components.

[0029] It will be understood that when a layer, region, or component is referred to as being "formed on," or "on" another layer, region, or component, it can be directly or indirectly formed on or on the other layer, region, or component. That is, for example, intervening layers, regions, or components may also be present.

[0030] Sizes of elements in the drawings may be exaggerated for convenience of explanation. In other words, since sizes and thicknesses of components in the drawings are arbitrarily illustrated for convenience of explanation, the following embodiments are not limited thereto.

[0031] When a certain embodiment may be implemented differently, a specific process order may be performed differently from the described order. For example, two consecutively described processes may be performed substantially at the same time or performed in an order opposite to the described order.

[0032] FIG. **1** is a plan view of an organic light-emitting display apparatus, according to an embodiment of the present invention. FIG. **2** is a cross-sectional view taken along the line A-A of FIG. **1**.

[0033] The organic light-emitting display apparatus according to an embodiment has a structure in which a display portion **20** that displays an image is on a substrate **30** with a thin film encapsulation **10** covering and protecting the display portion **20**.

[0034] The thin film encapsulation **10**, according to this embodiment, includes an organic layer **11** directly covering the display portion **20** and an inorganic layer **12** on the organic layer **11**. The organic layer **11** mainly provides flexibility to the organic light-emitting display apparatus. The inorganic layer **12** firmly prevents oxygen or moisture from permeating through to the display portion **20**. Thus, the display portion **20**, according to this embodiment, is sealed between the substrate **30** and the thin film encapsulation **10**.

[0035] The organic layer **11** may be formed of a flexible organic material, for example, in some embodiments, the organic layer **11** may be formed of polyurea or polyacrylate.

[0036] The inorganic layer **12** may be formed of an inorganic material having a waterproof or water-resistant characteristic. For example, in some embodiments, the inorganic layer **12** may be formed of SiNx, Al_2O_3, SiO_2, or TiO_2.

[0037] In these embodiments, since the organic layer **11** of the thin film encapsulation **10** has minimal ability to prevent moisture movement as compared to the inorganic layer **12**, if an end portion of the organic layer **11** spreads to an outer edge of a region covered by the inorganic layer **12**, the result would be the creation of a path through which external moisture may permeate into the display portion **20**. Thus, the thin film encapsulation **10** may include a dam **13** for effectively regulating a range of the organic layer **11** to prevent the path of moisture movement from being created, according to an embodiment.

[0038] The dam **13**, according to this embodiment, is formed outside the display portion **20** in order to regulate a region of the organic layer **11**, and may include an accommodation groove **13*a*** surrounded by a floor surface **13*b*** and two wall surfaces **13*c***, as shown in FIG. **2**. Thus, according to this embodiment, the dam **13**, itself, may function as a dam for preventing the organic layer **11** from spreading to the outer edge of the organic light emitting display apparatus where the inorganic layer **12** is extends, as well as containing any part of the organic layer **11** that may extend over the dam **13** in the accommodation groove **13*a*** to prevent it from spreading to an outer edge. Thus, according to this embodiment, the dam **13** functions to prevent the organic layer **11** from extending to the outer edge, and the accommodation groove **13*a*** functions to prevent the organic layer **11** from extending beyond the dam **13** to the outer edge.

[0039] The dam **13** will be described in further detail, below. Further details of the structure of the display portion **20** will now be described.

[0040] In an embodiments where the display portion **20** is expanded, multiple pixels may be present as shown in the partially expanded view in FIG. **3**. A structure of one pixel of these multiple pixels is expressed as an equivalent schematic circuit diagram as shown in FIG. **4**.

[0041] As shown, each pixel according to this embodiment generally includes at least two thin film transistors (TFTs), including a first TFT **21** for switching and a second TFT **23** for driving, a capacitor **22**, and an organic light-emitting device **24** (hereinafter referred to as an "EL device").

[0042] The first TFT **21**, according to this embodiment, is driven by a scan signal (Scan) applied to a gate line **26**, and transmits a data line (Data) applied to a data line **27**.

[0043] The second TFT **23**, according to this embodiment, determines an amount of current to enter into the EL device **24** according to the data signal Data transmitted by the first TFT **21**, i.e., a voltage difference (Vgs) between a gate and a source.

[0044] The capacitor **22**, according to this embodiment, stores the data signal Data transmitted by the first TFT **21** for a frame.

[0045] To implement a circuit according to this embodiment, an organic light-emitting display apparatus has a structure as shown in the embodiments of FIGS. **3**, **5**, and **6**, which will be described in further detail below.

[0046] As shown in the embodiments of FIGS. **3**, **5**, and **6**, a buffer layer **111** is positioned on the substrate **30**, and the first TFT **21**, the second TFT **23**, the capacitor **22**, and the EL device **24** are positioned on the buffer layer **111**.

[0047] As shown in the embodiments of FIGS. **3** and **5**, the first TFT **21** includes a first active layer **211** on the buffer layer **111**, a gate insulating layer **112** on the first active layer **211**, and a gate electrode **212** on the gate insulating layer **112**.

[0048] The first active layer **211**, according to an embodiment, may be formed as an amorphous silicon thin film or a polycrystalline silicon thin film. The first active layer **211**, according to an embodiment, includes source and drain regions doped with high concentration N type or P type impurities. Alternatively, the first active layer **211**, according to another embodiment, may be formed of an oxide semiconductor. For example, the oxide semiconductor forming the first active layer **211**, according to this embodiment, may include an oxide of a material selected from Group 12, 13, or 14 metal elements, such as zinc (Zn), indium (In), gallium (Ga), tin (Sn), cadmium (Cd), germanium (Ge), or hafnium (Hf), and any combinations thereof. For example, in one embodiment, the first active layer **211** may include G-I-Z-O $[(In_2O_3)a(Ga_2O_3)b(ZnO)c]$ (where a, b, and c are real numbers satisfying a condition that $a \geq 0$, $b \geq 0$, and $c > 0$).

[0049] The gate insulating layer **112**, according to an embodiment, is on the first active layer **211**, and the gate electrode **212** is on a predetermined region of the gate insulating layer **112**. The gate electrode **212**, according to this embodiment, is connected to the gate line **26** that applies a TFT on/off signal.

[0050] In an embodiment, an inter-insulator **113** may be on the gate electrode **212**. In an embodiment, a source electrode **213** and a drain electrode **214** are respectively formed to contact the source and drain regions of the first active layer **211** through contact holes. The source electrode **213**, according to this embodiment, is connected to the data line **27** of FIG. **3** and supplies a data signal to the first active layer **211**. The drain electrode **214**, according to this embodiment, is connected to a first charging electrode **221** of the capacitor **22** and supplies power to the capacitor **22**.

[0051] According to an embodiment, a passivation layer **114**, which may be formed of an inorganic material such as SiO_2, SiNx, etc., may be positioned on the source electrode **213** and the drain electrode **214**. A planarization layer **115**, according to an embodiment, may be formed of an acryl, polyimide, BCB, etc. material, and may be positioned on the passivation layer **114**.

[0052] The capacitor **22** for charging, according to an embodiment, is between the first TFT **21** and the second TFT **23** and stores a driving voltage necessary for driving the second TFT **23** for one frame. As shown in the embodiments of FIGS. **5** and **7**, the capacitor **22** may include a first charging electrode **221** connected to the drain electrode **214** of the first TFT **21**, a second charging electrode **222** overlapping with an upper portion of the first charging electrode **221** and electrically connected to a driving power line **25** that applies driving power, and the inter-insulator **113** between the first charging electrode **221** and the second charging electrode **222** and used as a dielectric substance.

[0053] A second active layer **231**, according to an embodiment, may be on the buffer layer **111** in the second TFT **23**, as shown in FIGS. **3** and **6**. The second active layer **231**, according to this embodiment, includes source and drain regions doped with high concentration N type or P type impurities. The second active layer **231**, according to an embodiment, may also be formed of an oxide semiconductor. For example, the second active layer **231**, according to this embodiment, may be formed of an oxide semiconductor including an oxide of a material selected from Group 12, 13, or 14 metal elements, such as zinc (Zn), indium (In), gallium (Ga), tin (Sn), cadmium (Cd), germanium (Ge), or hafnium (Hf), and any combinations thereof. For example, in one embodiment, the second active layer **231** may include G-I-Z-O $[(In_2O_3)a(Ga_2O_3)b(ZnO)c]$ (where a, b, and c are real numbers satisfying a condition that $a \geq 0$, $b \geq 0$, and $c > 0$). In an embodiment, a second gate electrode **232** that is connected to the first charging electrode **221** of the capacitor **22** and supplies a TFT on/off signal may be on the second active layer **231** with the gate insulating layer **112** between the second active layer **231** and the second gate electrode **232**. A second source electrode **233**, according to an embodiment, may be connected to the driving power line **25** supplying a reference voltage to the second active layer **231** for driving, and a second drain electrode **234** connecting the second TFT **23** and the EL device **24** and applying driving power to the EL device **24** may be on the second gate electrode **232**, according to the embodiment. The inter-insulator **113** in this embodiment is between the second gate electrode **232**, the second source electrode **233**, and the second drain electrode **234**. The passivation layer **114**, according to this embodiment, is between the second source electrode **233** and the second drain electrode **234**, and between the first electrode **241** that is an anode electrode of the EL device **24**.

[0054] The insulating planarization layer **115**, according to an embodiment, may be formed of a material such as acryl, etc, and positioned on the first electrode **241**. An opening **244** may be defined in the planarization layer **115**, and then the EL device **24** may be formed.

[0055] The EL device **24**, according to an embodiment, emits red, green, and blue light according to a flow of current, and displays predetermined image information. The EL device **24**, according to this embodiment, may include the first electrode **241** that is the anode electrode connected to the second drain electrode **234** of the second TFT **23** and receives a positive power supply from the second drain electrode **234**, a second electrode **243** that is a cathode electrode configured to cover whole pixels and supplies negative power, and an emission layer **242** between the first electrode **241** and the second electrode **243** that emits light.

[0056] A hole injection layer (HIL), a hole transport layer (HTL), an emission layer (EML), an electron transport layer (ETL), and an electron injection layer (EIL) may be stacked adjacent to the emission layer **242**, according to embodiments of the present invention.

[0057] According an embodiment, the emission layer **242** may be separately formed for each pixel such that pixels that emit red, green, and blue light form a single unit pixel as shown in the embodiment of FIG. **6**. Alternatively, the emission layer **242**, according to another embodiment, may be commonly formed on a whole pixel region regardless of the positions of the pixels. In this embodiment, the emission layer **242** may be formed by vertically stacking or mixing, for example, layers including an emission material that emits the red, green, and blue lights. A combination of other colors may be possible in other embodiments where the emission layer **242** may be able to emit white light. A color conversion layer that converts the emitted white light into a predetermined color or a color filter may be further included, in other embodiments.

[0058] The emission layer **242**, according to these embodiments, is highly vulnerable to moisture, and thus if moisture permeates into the display portion **20**, an image forming characteristic of the organic light-emitting display apparatus may rapidly deteriorate.

[0059] A structure of the organic light-emitting display apparatus according to an embodiment of the present invention will now be described with reference back to FIGS. **1** and **2**.

[0060] The display portion **20**, according to an embodiment, may be formed by using the above-described pixels as shown in FIG. **3**. An image may be formed on the display portion **20**. In this embodiment, the TFTs **21** and **23**, the capacitors **22**, and the EL devices **24** shown in FIGS. **3**, **5**, and **6** may be installed in the display portion **20**.

[0061] The thin film encapsulation **10** is placed over the display portion **20**, according to an embodiment, to protect the display portion **20** from external moisture and air. The thin film encapsulation **10** in this embodiment has the organic layer **11** and the inorganic layer **12** sequentially stacked. More specifically, the organic layer **11**, according to an embodiment, directly covers the display portion **20**, and the inorganic layer **12** covers the organic layer **11**. Thus, the thin film encapsulation **10** according to this embodiment in which the organic layer **11** and the inorganic layer **12** are sequentially stacked, may have both a moisture movement prevention function and flexibility function.

[0062] As described above, the dam **13**, according to embodiments, may regulate a region of the organic layer **11** to prevent creation of a moisture movement path through the organic layer **11**. In these embodiments, the wall surface **13***c* of the dam **13** of the display portion **20** may prevent the organic layer **11** from extending to the outer edge, and, if a part of the organic layer **11** does extend beyond the dam **13**, allows that extension to be contained in the accommodation groove **13***a* to prevent its further extension to the outer edge. Thus, the dam **13** according to an embodiment having the above-described structure, may prevent the organic layer **11** from extending to the outer edge beyond a region covered by the inorganic layer **12**, thus, reducing the possibility of moisture movement to the display portion **20** from the outer edge through the organic layer **11**.

[0063] The organic light-emitting display apparatus according to embodiments having the above-described structure may be manufactured through a process as sequenced in FIGS. **7**A through **7**D.

[0064] According to an embodiment, a body of the dam **13** may be formed in a region outside the display portion **20** on the substrate **30**, as shown in FIG. **7**A. In an embodiment, the dam **13** may be formed, for example, by using a deposition process using a mask, and may be formed of a material capable of patterning by exposure and etching.

[0065] Next, the accommodation groove **13***a* sunken from an upper surface of the dam **13** into the inside thereof may be defined, according to an embodiment, as shown in FIG. **7**B. The accommodation groove **13***a* may be defined in the upper surface of the dam **13** after exposing and etching, for example, a corresponding region of the dam **13**.

[0066] The organic layer **11** covering the display portion **20** may be formed as shown in the embodiment of FIG. **7**C. In this embodiment, a region of the organic layer **11** may be regulated by the dam **13**. If a portion of the organic layer **11** extends beyond the dam **13**, since the portion is contained in the accommodation groove **13***a*, according to this embodiment, there possibility of continuously spreading the organic layer **11** to the outside edges is reduced.

[0067] Next, placement of the inorganic layer **12** over the organic layer **11** and the dam **13**, as shown in the embodiment of FIG. **7**D, may complete the thin film encapsulation **10** process according to these embodiments.

[0068] Therefore, the dam **13**, according to these embodiments, may effectively prevent the organic layer **11** from extending to the outer edge, such that the organic layer **11** remains entirely covered by the inorganic layer **12** having outstanding waterproof properties, and thus implement a highly stable anti-moisture movement property in the thin film encapsulation **10**.

[0069] In these embodiments, an outer boundary of the organic layer **11** is strictly regulated by the dam **13** and is wholly covered by the inorganic layer **12**, thereby limiting a possibility of permeating external moisture into the display portion **20** through the organic layer **11**. Thus, a performance deterioration problem of the display portion **20** due to permeation of oxygen or moisture may be greatly avoided.

[0070] Although the dam **13** may be formed in a single layer in a region outside the display portion **20**, as described in the previous embodiments, the dam **13** may also be formed in several layers, as shown in the embodiment of FIG. **8**. In this embodiment, a possibility of the organic layer **11** extending to the outer edge may be more strictly prevented. However, in this embodiment, a dead space outside the display portion **20** may increase, and thus a width W of an overall region of the dam **13** on the substrate **30** may be large, for example up to 5 millimeters (mm) in width.

[0071] It should be understood that the exemplary embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

[0072] While one or more embodiments of the present invention have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention, and as further defined by the following claims.

What is claimed is:

1. An organic light-emitting display apparatus comprising:

a substrate, a display portion on the substrate, an organic layer extending over the display portion, an inorganic layer extending over the organic layer, and a dam surrounding an outer perimeter of the organic layer,

wherein the dam comprises a groove configured to accommodate a portion of the organic layer extending beyond a perimeter of the dam surrounding the organic layer.

2. The organic light-emitting display apparatus of claim **1**, wherein the dam further comprises a single layer surrounding the outer perimeter of the organic layer.

3. The organic light-emitting display apparatus of claim **1**, wherein the dam further comprises a plurality of layers surrounding the outer perimeter of the organic layer.

4. The organic light-emitting display apparatus of claim **1**, wherein the inorganic layer extends to an outer edge of the dam.

5. The organic light-emitting display apparatus of claim **1**, wherein the dam further comprises a bottom surface contacting the substrate, a plurality of wall surfaces integrally formed with the bottom surface and extending upward from the bottom surface, and wherein the groove is defined by an opening surrounded by the bottom surface and the plurality of wall surfaces of the dam.

6. A method of manufacturing an organic light-emitting display apparatus, the method comprising:

forming a display portion on a substrate;

forming a dam defining a groove in a region spaced from the display portion;

forming an organic layer over the display portion and extending up to the region spaced from the display portion such that the organic layer is surrounded by the dam; and

forming an inorganic layer over the organic layer.

7. The method of claim **6**, wherein the dam comprises a single layer.

8. The method of claim **6**, wherein the dam comprises a plurality of layers.

9. The method of claim **6**, wherein the inorganic layer extends to an outer edge of the dam.

10. The method of claim **6**, wherein the groove is defined by an opening sunken from an upper surface of the dam into the inside such that a part of an outer perimeter of the organic layer is accommodated in the groove.

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专利名称(译)	有机发光显示装置及其制造方法		
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[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	MOON SEUNG JUN		
发明人	MOON, SEUNG-JUN		
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摘要(译)

一种有机发光显示装置，包括基板，基板上的显示部分，在显示部分上延伸的有机层，在有机层上延伸的无机层，以及围绕有机层的外周边的坝。坝可以包括凹槽，该凹槽构造成容纳有机层的一部分，该部分延伸超出围绕有机层的坝的周边。一种制造有机发光显示装置的方法，包括在基板上形成显示部分，在与显示部分隔开的区域中形成限定凹槽的挡板，在显示部分上形成有机层并延伸到间隔的区域从显示部分开始，使有机层被坝包围，并在有机层上形成无机层。