



US010644086B2

(12) **United States Patent**
Kim et al.

(10) **Patent No.:** **US 10,644,086 B2**
(45) **Date of Patent:** **May 5, 2020**

(54) **ELECTROLUMINESCENT DISPLAY DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/219,412**

(22) Filed: **Dec. 13, 2018**

(65) **Prior Publication Data**

US 2019/0189712 A1 Jun. 20, 2019

(30) **Foreign Application Priority Data**

Dec. 14, 2017 (KR) 10-2017-0172305

(51) **Int. Cl.**

H01L 51/00 (2006.01)
H01L 27/32 (2006.01)
H01L 51/50 (2006.01)
H01L 51/52 (2006.01)

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

CPC **H01L 27/3246** (2013.01); **H01L 27/3258** (2013.01); **H01L 51/0003** (2013.01); **H01L 51/5012** (2013.01); **H01L 51/5218** (2013.01); **H01L 51/5221** (2013.01); **H01L 27/3262** (2013.01); **H01L 27/3276** (2013.01)

(58) **Field of Classification Search**

CPC H01L 27/3246; H01L 27/3262; H01L 27/3258

See application file for complete search history.

(Continued)

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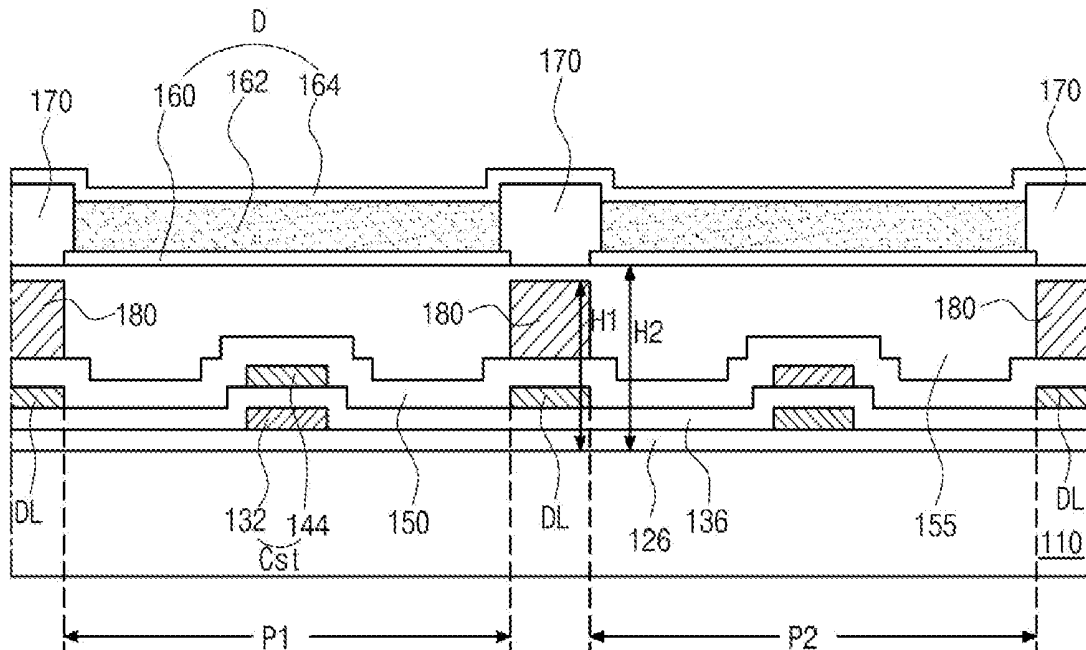
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(57)

ABSTRACT

An electroluminescent display device includes a plurality of pixels that each comprise a portion of a substrate. A pixel dam is disposed over an intermediate layer over the substrate. An overcoat layer is in contact with the pixel dam, the overcoat layer having a planar top surface. An emitting diode is on the overcoat layer and includes a first electrode, a second electrode, and an emitting layer between the first electrode and the second electrode.

20 Claims, 5 Drawing Sheets



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FIG. 1
Related Art

1

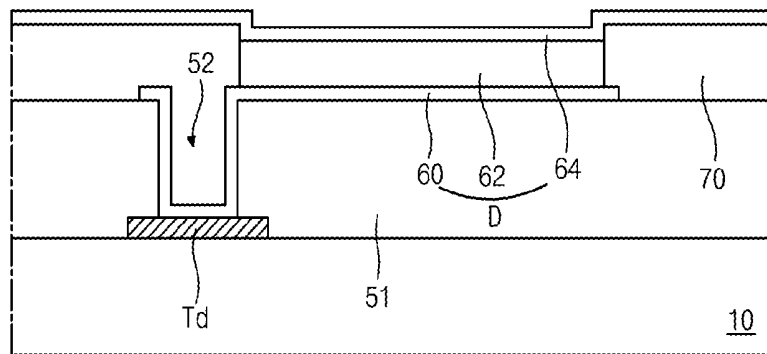


FIG. 2

1

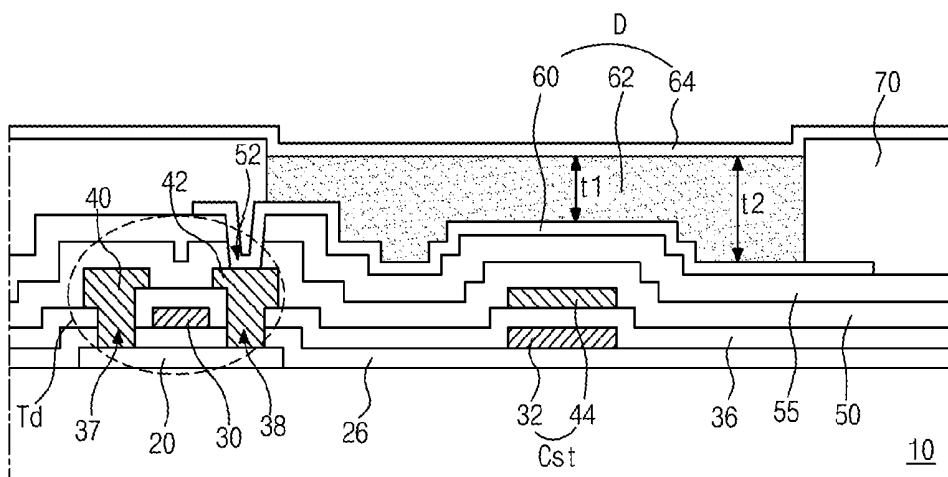


FIG. 3

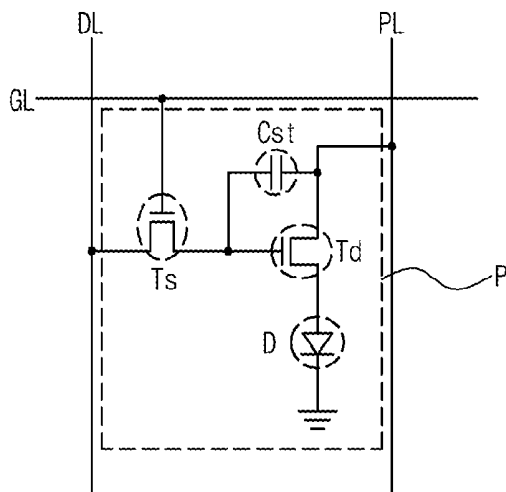


FIG. 4

100

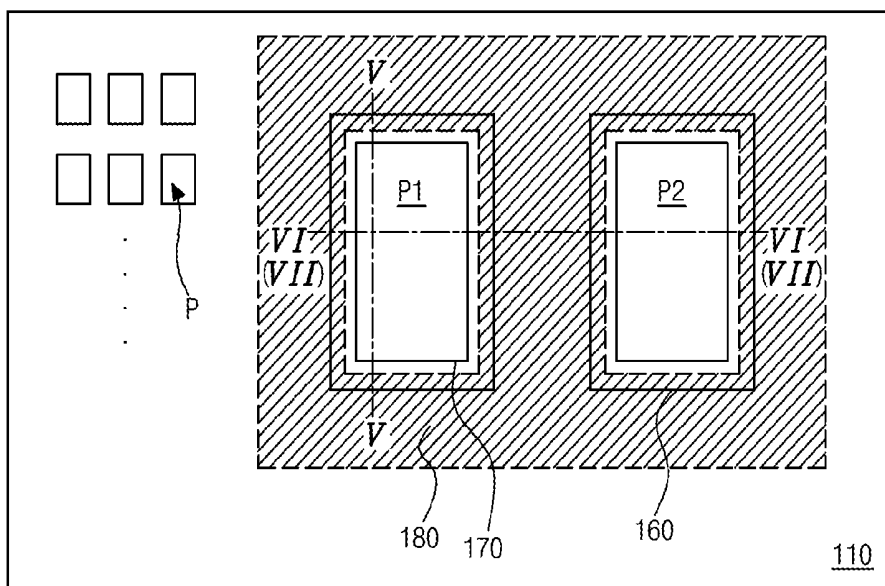


FIG. 5

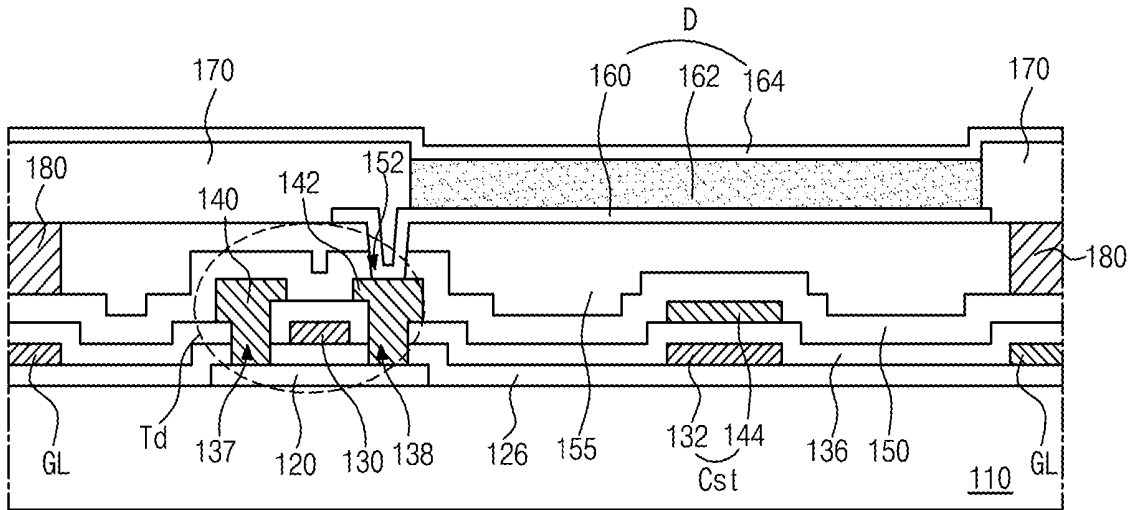


FIG. 6

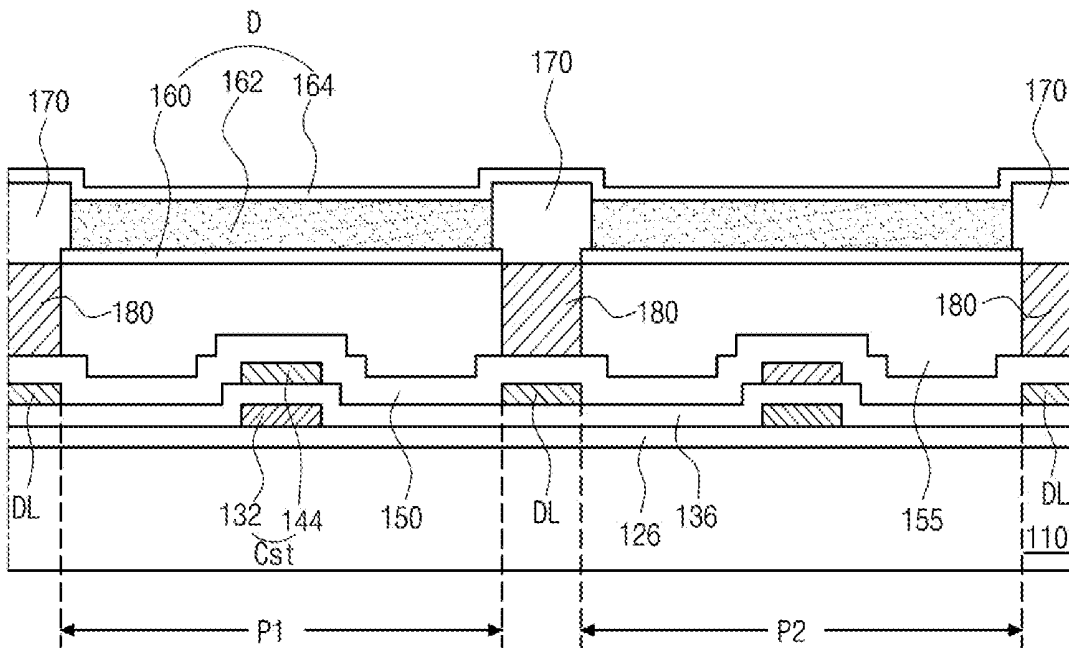


FIG. 7

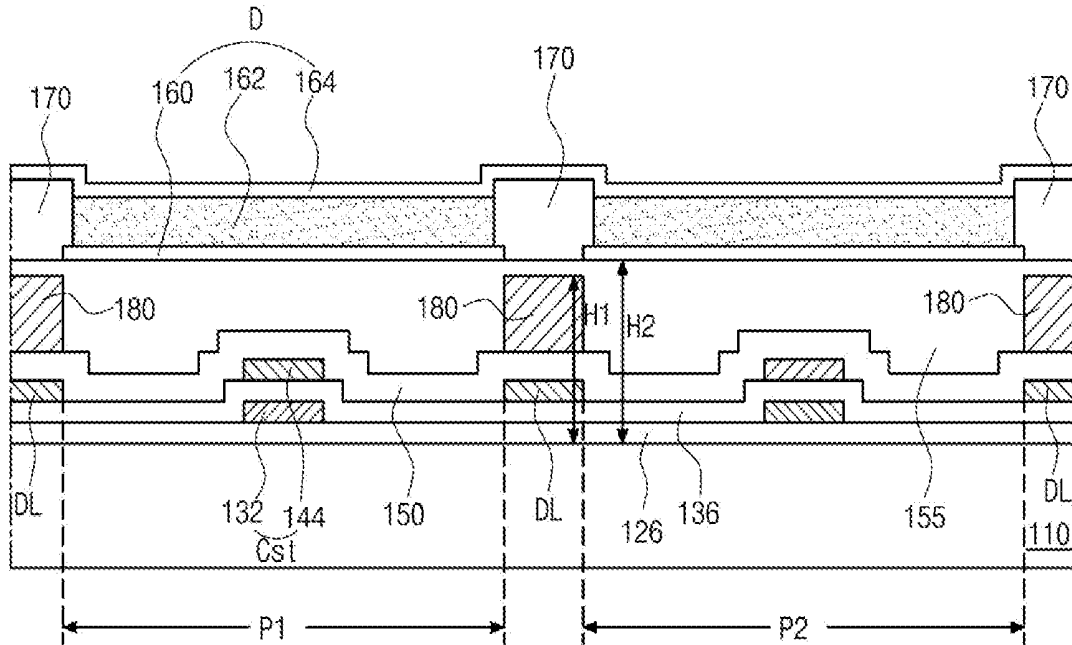


FIG. 8

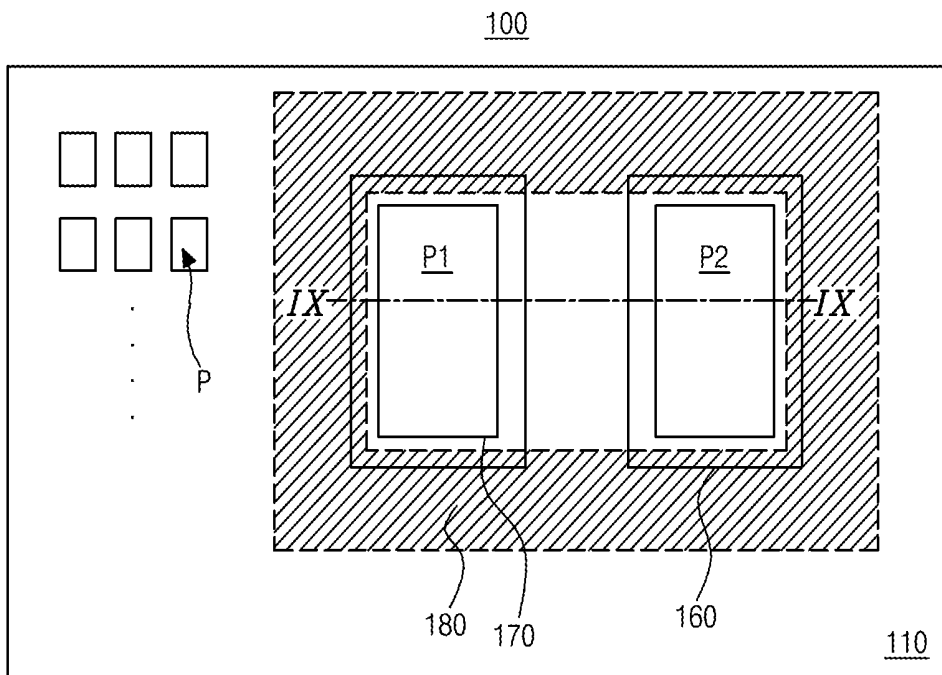
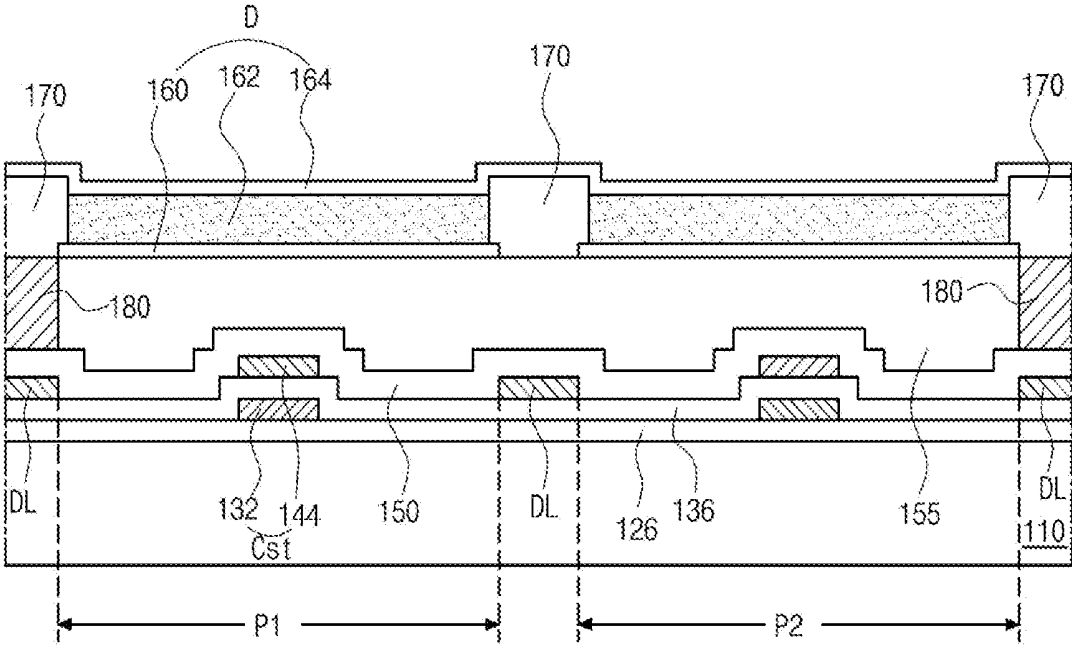


FIG. 9



ELECTROLUMINESCENT DISPLAY DEVICE

CROSS-REFERENCE TO RELATED
APPLICATIONS

The present application claims the benefit of Republic of Korea Patent Application No. 10-2017-0172305 filed in the Republic of Korea on Dec. 14, 2017, which is hereby incorporated by reference in its entirety.

BACKGROUND

Field of Technology

The present disclosure relates to a display device, and more particularly, to an electroluminescent display device being capable of improving a uniformity of an emitting layer.

Discussion of the Related Art

An electroluminescent (EL) display device among new flat panel display devices is a self-emission type such that there are advantages in a viewing angle, a contrast ratio in comparison to a liquid crystal display device. In addition, since a backlight unit is not required in the EL display device, there are advantages of a thin profile and low power consumption.

Moreover, the EL display device can be driven by DC low voltage and has fast response time. Furthermore, the EL display device is stable against outer impacts and has advantages in an operation temperature and production cost.

In an active matrix type EL display device, a voltage, which control a current applied to a pixel, is charged in a storage capacitor such that a voltage is maintained during one frame. As a result, the EL display device has an emission state in a frame regardless of a number of gate lines.

FIG. 1 is a schematic cross-sectional view of the related art EL display device.

As shown in FIG. 1, the related art EL display device 1 includes a substrate 10, a driving thin film transistor (TFT) Td on the substrate 10 and an emitting diode D connected to the driving TFT Td.

The substrate 10 may be a glass substrate or a plastic substrate.

Although not shown, the driving TFT Td includes a semiconductor layer, a gate electrode, a source electrode and a drain electrode.

An insulating layer 51, which includes a drain contact hole 52 exposing the drain electrode of the driving TFT Td, is formed to cover the driving TFT Td.

The emitting diode D is formed on the insulating layer 51 and includes a first electrode 60, which is connected to the drain electrode of the driving TFT Td through the drain contact hole 52, an emitting layer 62 on the first electrode 60 and a second electrode 64 on the emitting layer 62.

For example, the first electrode 60 may be an anode, and the second electrode 62 may be a cathode.

A bank 70 covering an edge of the first electrode 60 is formed on the insulating layer 51. The bank 70 includes an opening, which exposes a center of the first electrode 60, and the emitting layer 62 is formed in the opening of the bank 70.

On the other hand, the emitting layer is formed by a thermal deposition process. However, there is a limitation in the application of the thermal deposition process for the large size EL display device.

Recently, a solution process for the emitting layer is introduced. However, when the emitting layer is formed by the solution process, the emission efficiency and the lifespan of the EL display device 1 is significantly decreased.

SUMMARY

The present disclosure is directed to an electroluminescent display device that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

To achieve these and other advantages and in accordance with the purpose of the present disclosure, as embodied and broadly described herein, an electroluminescent display device includes pixels that each include a portion of a substrate, an intermediate layer over the substrate, the intermediate layer having an uneven top surface, a pixel dam over the intermediate layer and surrounding one or more of the plurality of pixels, an overcoat layer in contact with the pixel dam, the overcoat layer having a planar top surface, and an emitting diode on the overcoat layer in contact with the pixel dam, the overcoat layer having a planar top surface, and an emitting diode on the overcoat layer and including a first electrode and a second electrode, and an emitting layer between the first electrode and the second electrode.

In some embodiments, an electroluminescent display device includes a plurality of pixels, each pixel comprising a portion of a substrate, an intermediate layer over the substrate, the intermediate layer having an uneven top surface, a pixel dam over the intermediate layer and surrounding one or more of the plurality of pixels, an overcoat layer in contact with the pixel dam, the overcoat layer having a planar top surface, an emitting diode on the overcoat layer and including a first electrode, a second electrode, and an emitting layer between the first electrode and the second electrode, and a bank above at least a portion of the pixel dam and confining the emitting layer of the emitting diode.

Additional features and advantages of the disclosure will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the disclosure. The objectives and other advantages of the disclosure will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

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

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and together with the description serve to explain the principles of the disclosure.

FIG. 1 is a schematic cross-sectional view of the related art EL display device.

FIG. 2 is a schematic cross-sectional view illustrating a thickness deviation of an emitting layer.

FIG. 3 is a schematic circuit diagram of an EL display device according to the present disclosure.

FIG. 4 is a schematic plan view of an EL display device according to a first embodiment of the present disclosure.

FIG. 5 is a cross-sectional view taken along the line V-V of FIG. 4 according to a first embodiment of the present disclosure.

FIG. 6 is a cross-sectional view taken along the line VI-VI of FIG. 4 according to a first embodiment of the present disclosure.

FIG. 7 is a schematic cross-sectional view of an EL display device according to a second embodiment of the present disclosure.

FIG. 8 is a schematic plan view of an EL display device according to a third embodiment of the present disclosure.

FIG. 9 is a cross-sectional view taken along the line IX-IX of FIG. 8 according to a third embodiment of the present disclosure.

DETAILED DESCRIPTION

As mentioned above, when the emitting layer is formed by the solution process, the emitting layer has a thickness deviation in an effective emission area such that the emission efficiency and the lifespan of the emitting diode and the EL display device are decreased.

Referring to FIG. 2, which is a schematic cross-sectional view illustrating a thickness deviation of an emitting layer, the EL display device 1 includes the substrate 10, the driving thin film transistor (TFT) Td on the substrate 10 and the emitting diode D connected to the driving TFT Td.

The semiconductor layer 20 is formed on the substrate 10 being formed of glass or plastic. The semiconductor layer 20 may include an oxide semiconductor material or polycrystalline silicon.

A gate insulating layer 26 is formed on the semiconductor layer 20. The gate insulating layer 26 may be formed of an inorganic insulating material such as silicon oxide or silicon nitride.

A gate electrode 30, which is formed of a conductive material, e.g., metal, is formed on the gate insulating layer 26 to correspond to a center of the semiconductor layer 20. In addition, a first capacitor electrode 32 is formed on the gate insulating layer 26.

An interlayer insulating layer 36, which is formed of an insulating material, is formed over an entire surface of the substrate 10 to cover the gate electrode 30 and the first capacitor electrode 32. The interlayer insulating layer 36 may be formed of an inorganic insulating material, e.g., silicon oxide or silicon nitride.

The interlayer insulating layer 36 includes first and second contact holes 37 and 38 exposing both sides of the semiconductor layer 20. The first and second contact holes 37 and 38 are positioned at both sides of the gate electrode 30 to be spaced apart from the gate electrode 30.

A source electrode 40 and a drain electrode 42, which are formed of a conductive material, e.g., metal, are formed on the interlayer insulating layer 36. In addition, a second capacitor electrode 44, which overlaps the first capacitor electrode 32, is formed on the interlayer insulating layer 36.

The semiconductor layer 20, the gate electrode 30, the source electrode 40 and the drain electrode 42 constitute the driving TFT Td. The first and second capacitor electrodes 32 and 44 and the interlayer insulating layer 36 therebetween constitute a storage capacitor Cst.

Although not shown, a gate line extending along a first direction, a data line extending a second direction, a switching TFT and a power line are formed on or over the substrate 10. The switching TFT is connected to the gate line and the data line, and the power line is parallel to one of the gate line and the data line.

The gate line and the data line cross to each other to define a pixel region, and the driving TFT Td is connected to the switching TFT.

A passivation layer 50 and an overcoat layer 55, which includes a drain contact hole 52 exposing the drain electrode 42 of the driving TFT Td, is formed to cover the driving TFT Td and the storage capacitor Cst.

The passivation layer 50 may be formed of an inorganic insulating material, e.g., silicon oxide or silicon nitride, and the overcoat layer 55 may be formed of an organic insulating material, e.g., benzocyclobutene or photo-acryl.

The first electrode 60, which is connected to the drain electrode 42 of the driving TFT Td through the drain contact hole 52, is formed on the overcoat layer 55. In addition, the bank 70 covering the edge of the first electrode 60 is formed on the overcoat layer 55. The bank 70 has an opening to expose a center of the first electrode 60.

The emitting layer 62 and the second electrode 64 are sequentially stacked on the first electrode 60.

The first and second electrodes 60 and 64 and the emitting layer 62 therebetween constitute the emitting diode D.

A surface of the overcoat layer 55 is uneven such that a step difference is provided. Accordingly, the first electrode 60 on the overcoat layer 55 also has a step difference. For example, the step difference results from the first and second capacitor electrodes 32 and 44.

The emitting layer 62, which is formed by the solution process, has a flat top surface in the effective emission area and a thickness deviation (thickness difference) by the step difference. Namely, the emitting layer 62 has a first thickness t1 in a higher portion of the overcoat layer 55, e.g., in a region of the storage capacitor Cst, and a second thickness t2 in a lower portion of the overcoat layer 55.

A partial thermal degradation of the emitting layer 62 is generated by the thickness deviation of the emitting layer 62 such that the emission efficiency and the lifespan of the emitting diode D and the EL display device 1 are decreased.

Reference will now be made in detail to the preferred embodiments, examples of which are illustrated in the accompanying drawings.

FIG. 3 is a schematic circuit diagram of an EL display device according to the present disclosure.

As shown in FIG. 3, an EL display device includes a gate line GL, a data line DL, a power line PL, a switching thin film transistor (TFT) Ts, a driving TFT Td, a storage capacitor Cst, and an emitting diode D. The gate line GL and the data line DL cross each other to define a pixel region P.

The switching TFT Ts is connected to the gate and data line GL and DL, and the driving TFT Td and the storage capacitor Cst are connected to the switching TFT Ts and the power line PL. The emitting diode D is connected to the driving TFT Td.

In the EL display device, when the switching TFT Ts is turned on by a gate signal applied through the gate line GL, a data signal from the data line DL is applied to the gate electrode of the driving TFT Td and an electrode of the storage capacitor Cst.

When the driving TFT Td is turned on by the data signal, an electric current is supplied to the emitting diode D from the power line PL. As a result, the emitting diode D emits light. In this case, when the driving TFT Td is turned on, a level of an electric current applied from the power line PL to the emitting diode D is determined such that the emitting diode D can produce a gray scale.

The storage capacitor Cst serves to maintain the voltage of the gate electrode of the driving TFT Td when the switching TFT Ts is turned off. Accordingly, even if the

switching TFT Ts is turned off, a level of an electric current applied from the power line PL to the emitting diode D is maintained to next frame. Accordingly, the EL display device displays an image.

FIG. 4 is a schematic plan view of an EL display device according to a first embodiment of the present disclosure.

As shown in FIG. 4, the EL display device 100 includes a substrate 110, where a plurality of pixel regions P are defined, a pixel dam 180 disposed on the substrate 110 and the surrounding each pixel region P, an overcoat layer (not shown) in a region surrounded by the pixel dam 180 and provide a flat top surface, an emitting diode (not shown), which is disposed on the overcoat layer and includes a first electrode 160, an emitting layer (not shown) and a second electrode (not shown), and a bank 170 covering an edge of the first electrode 160 and corresponding to the pixel dam 180.

The overcoat layer is formed by coating an organic insulating material, such as an epoxy resin, photo-acryl, polyimide or benzocyclobutene. The overcoat layer fills a space defined by the pixel dam 180 and covers a step difference below the overcoat layer such that a flat top surface is provided.

Namely, in the related art EL display device, since an organic insulating material for the overcoat layer is coated and spread over an entire surface of the substrate, the step difference is reflected on the overcoat layer such that the overcoat layer has a height deviation (difference) from the substrate.

As a result, the first electrode on the overcoat layer also has a height deviation from the substrate by the step difference such that the emitting layer, which is formed on the first electrode by the solution process, has a thickness deviation.

However, in the EL display device 100 of the present disclosure, since the pixel dam 180, which surrounds a region on the substrate 110, serves as a buffer against the flow of the of the organic insulating material in the coating process, the organic insulation material inside the region, which is surrounded by the pixel dam 180, covers the step difference such that the overcoat layer has a uniform height from the substrate 110 and a top surface of the overcoat layer and a top surface of the pixel dam 180 are coplanar. Namely, the overcoat layer provides a flat top surface.

In other words, the pixel dam 180 confines the organic insulating material into the region, which is surrounded by the pixel dam 180, such that the step difference is not reflected on the overcoat layer. In the example shown in FIG. 4, a portion of the pixel dam 180 is disposed between adjacent pixel regions. As a result, the overcoat layer has the flat top surface.

The first electrode 160, which is formed on the overcoat layer, also has a flat top surface such that the emitting layer, which is formed on the first electrode 160, has a uniform thickness. Accordingly, the degradation of the emission efficiency and the lifespan resulting from the thickness deviation of the emitting layer is prevented.

FIG. 5 is a cross-sectional view taken along the line V-V of FIG. 4, and FIG. 6 is a cross-sectional view taken along the line VI-VI of FIG. 4.

Referring to FIGS. 5 and 6 with FIG. 4, the EL display device 100 includes the substrate 110, where a first pixel region P1 and a second pixel region P2 are defined, a driving TFT Td on the substrate 110, the pixel dam 180, which is disposed on or over the substrate 110 and surrounds the first and second pixel regions P1 and P2 adjacent to each other, the overcoat layer 155, which is surrounded by the pixel dam 180 and has a flat top surface, and the emitting diode D. The

emitting diode D is disposed on the overcoat layer 155 and is connected to the driving TFT Td.

The substrate 110 may be a glass substrate or a flexible plastic substrate. For example, the substrate 110 may be a polyimide substrate.

A semiconductor layer 120 is formed on the substrate 110. The semiconductor layer 120 may include an oxide semiconductor material or polycrystalline silicon.

When the semiconductor layer 120 includes the oxide semiconductor material, a light-shielding pattern (not shown) may be formed under the semiconductor layer 120. The light to the semiconductor layer 120 is shielded or blocked by the light-shielding pattern such that thermal degradation of the semiconductor layer 120 can be prevented. On the other hand, when the semiconductor layer 120 includes polycrystalline silicon, impurities may be doped into both sides of the semiconductor layer 120.

Although not shown, a buffer layer may be formed between the substrate 110 and the semiconductor layer 120.

A gate insulating layer 122 is formed on the semiconductor layer 120 and over an entire surface of the substrate 110. The gate insulating layer 122 may be formed of an inorganic insulating material such as silicon oxide or silicon nitride.

A gate electrode 130, which is formed of a conductive material, e.g., metal, is formed on the gate insulating layer 122 to correspond to a center of the semiconductor layer 120. In addition, the gate line GL and a first capacitor electrode 132 are formed on the gate insulating layer 122. The gate line GL extends along the first direction, and the first capacitor electrode 132 may be connected to the gate electrode 130.

In FIG. 5, the gate insulating layer 122 is formed on an entire surface of the first substrate 110. Alternatively, the gate insulating layer 122 may be patterned to have the same shape as the gate electrode 130.

An interlayer insulating layer 136, which is formed of an insulating material, is formed on the gate electrode 130. The interlayer insulating layer 136 may be formed of an inorganic insulating material, e.g., silicon oxide or silicon nitride, or an organic insulating material, e.g., benzocyclobutene or photo-acryl.

The interlayer insulating layer 136 includes first and second contact holes 137 and 138 exposing both sides of the semiconductor layer 120. The first and second contact holes 137 and 138 are positioned at both sides of the gate electrode 130 to be spaced apart from the gate electrode 130.

In FIG. 5, the first and second contact holes 137 and 138 are formed through the gate insulating layer 122. Alternatively, when the gate insulating layer 122 is patterned to have the same shape as the gate electrode 130, the first and second contact holes 137 and 138 is formed only through the interlayer insulating layer 136.

A source electrode 140 and a drain electrode 142, which are formed of a conductive material, e.g., metal, are formed on the interlayer insulating layer 136. In addition, the data line DL along the second direction and a second capacitor electrode 144 are formed on the interlayer insulating layer 136.

The power line PL (of FIG. 3), which is spaced apart from and parallel to the data line DL, may further formed on the interlayer insulating layer 136. In FIG. 6, the data line DL is positioned between the first and second pixel regions P1 and P2. The power line PL may be disposed between the data line DL and the first pixel region P1 or between the data line DL and the second pixel region P2.

The source electrode 140 and the drain electrode 142 are spaced apart from each other with respect to the gate

electrode **130** and respectively contact both sides of the semiconductor layer **120** through the first and second contact holes **137** and **138**. The data line DL crosses the gate line GL to define the pixel region P. The second capacitor electrode **144** may be connected to the source electrode **140** and overlap the first capacitor electrode **132**. As a result, the first and second capacitor electrodes **132** and **144** and the inter-layer insulating layer **136** as a dielectric layer therebetween constitute the storage capacitor Cst.

The power line PL may be disposed at the same layer as the gate line GL and may be spaced apart from and parallel to the gate line GL.

The semiconductor layer **120**, the gate electrode **130**, the source electrode **140** and the drain electrode **142** constitute the driving TFT Td. In the driving TFT Td, the gate electrode **130**, the source electrode **140**, and the drain electrode **142** are positioned over the semiconductor layer **122**. Namely, the driving TFT Td has a coplanar structure.

Alternatively, in the driving TFT Td, the gate electrode may be positioned under the semiconductor layer, and the source and drain electrodes may be positioned over the semiconductor layer such that the driving TFT Td may have an inverted staggered structure. In this instance, the semiconductor layer may include amorphous silicon.

As mentioned above, the switching TFT Ts may be further formed in the substrate **110**. The switching TFT Ts may have a structure being substantially same as the driving TFT Td.

The gate electrode **130** of the driving TFT Td may be connected to a drain electrode of the switching TFT Ts, and the source electrode **140** of the driving TFT Td may be connected to the power line PL. A gate electrode and a source electrode of the switching TFT Ts may be connected to the gate line GL and the data line DL, respectively.

A passivation layer **150** is formed on the driving TFT Td. The passivation layer **150** may be formed of an inorganic insulating material such as silicon oxide or silicon nitride.

The pixel dam **180** surrounding each of the first and second pixel regions P1 and P2 is formed on the passivation layer **150**. Namely, the pixel dam **180** corresponds to the gate line GL and the data line DL and has an opening in correspondence to each of the first and second pixel regions P1 and P2. As a result, the passivation layer **150** in the first and second pixel regions P1 and P2 is exposed through the opening of the pixel dam **180**.

In addition, the overcoat layer **155** is formed on the passivation layer **150** in the first and second pixel regions P1 and P2. The overcoat layer **155** is surrounded by the pixel dam **180** such that the overcoat layer **155** in the first pixel region P1 and the overcoat layer **155** in the second pixel region P2 is separated or divided by the pixel dam **180**.

The overcoat layer **155** is formed by a coating process (solution process). The pixel dam **180** confines a coating solution inside the pixel region P such that the overcoat layer **155** has a flat top surface.

The storage capacitor Cst is formed in each of the first and second pixel regions P1 and P2 such that a step difference is provided on the passivation layer **150**. In other words, the passivation layer **150** has a height deviation from the substrate **110**. In FIGS. 5 and 6, the step difference is resulted by the first and second capacitor electrodes **132** and **144** of the storage capacitor Cst. Alternatively, the step difference may be resulted by an electrode pattern or a line, which is referred to as a step difference pattern, between the substrate **110** and the overcoat layer **155**.

However, in the EL display device **100** of the present disclosure, due to the pixel dam **180** surrounding the first and second pixel regions P1 and P2, the step difference of

the passivation layer **150** by the storage capacitor Cst is not reflected on the overcoat layer **155** such that the overcoat layer **155** has a flat top surface without a height deviation.

The pixel dam **180** and the overcoat layer **155** have substantially the same height from the substrate **110**. Accordingly, the pixel dam **180** and the overcoat layer **155** may form a flat top surface.

Each of the pixel dam **180** and the overcoat layer **155** is formed of an organic insulating material. The pixel dam **180** and the overcoat layer **155** may be formed of different materials. For example, the pixel dam **180** may be formed of one of epoxy resin, photo-acryl, polyimide and benzocyclobutene, and the overcoat layer **180** may be formed of the other one of epoxy resin, photo-acryl, polyimide and benzocyclobutene. Alternatively, the pixel dam **180** and the overcoat layer **155** may be formed of the same material.

After the pixel dam **180** is formed on the passivation layer **150**, an organic insulating material is coated in the pixel region, which is surrounded by the pixel dam **180**, to form the overcoat layer **155**. For example, the coating process may be an inkjet coating process, a slit coating process, a spin coating process, a printing process or a drop coating process, but it is not limited thereto.

Alternatively, the pixel dam **180** may be formed in a process for forming the passivation layer **150**. For example, after an inorganic insulating material layer is formed over the substrate **110**, where the driving TFT Td, the data line DL and the storage capacitor Cst are formed, a mask process is performed on the inorganic insulating material layer to form the pixel dam **180** having a relatively high thickness at a boundary of the pixel region P and the passivation layer **150** having a relatively low thickness at the pixel region P. In this instance, the pixel dam **180** is formed of an inorganic insulating material, and the overcoat layer **155** is formed of an organic insulating material.

The pixel dam **180** may have a light-absorption property. For example, the pixel dam **180** may include a black particle such as carbon black. In this instance, since the ambient light (external light) is absorbed by the pixel dam **180**, the decrease of the ambient contrast ratio by reflection of the ambient light on the gate line GL and/or the data line DL is prevented.

The substrate **110**, where the pixel dam **180** and the overcoat layer **155** are formed, may be referred to as an array substrate.

A drain contact hole **152** exposing the drain electrode **142** of the driving TFT Td is formed through the overcoat layer **155** and the passivation layer **150**. Namely, after the passivation layer **150**, the pixel dam **180** and the overcoat layer **155** are formed, a mask process is performed to the overcoat layer **155** and the passivation layer **150** such that the drain contact hole **152** may be formed.

The first electrode **160**, which is connected to the drain electrode **142** of the driving TFT Td through the drain contact hole **152**, is formed on the overcoat layer **155**. The first electrode **160** is separated in each pixel region P. The first electrode **160** may be formed of a conductive material having a relatively high work function to serve as an anode. For example, the first electrode **160** may be formed of a transparent conductive material such as indium-tin-oxide (ITO) or indium-zinc-oxide (IZO).

When the EL display device **100** is operated in a top-emission type, a reflection electrode or a reflection layer may be formed under the first electrode **160**. For example, the reflection electrode or the reflection layer may be formed of

silver (Ag) or aluminum-palladium-copper (APC) alloy. The first electrode **160** may have a triple-layered structure of ITO/Ag/ITO.

As mentioned above, since the overcoat layer **155** has a flat top surface without a height deviation due to the pixel dam **180**, the first electrode **160** on the overcoat layer **155** also has a flat top surface without a height deviation.

The bank **170** covering an edge of the first electrode **160** is formed on the pixel dam **180**. Namely, the bank **170** is positioned at a boundary of the pixel region P and overlaps at least a portion of the pixel dam **180**. The bank **170** has an opening in correspondence to the pixel region P. The bank **170** surrounds the pixel region P and exposes a center of the first electrode **160**. A lower surface of the bank in all sides of the pixel region P contacts the pixel dam **180**.

An emitting layer **162** is formed on the first electrode **160**. The emitting layer **162** may be formed by a solution process using a liquid phase emitting material.

Namely, an emitting material ink, in which an emitting material is dissolved in a solvent, is coated and dried to form the emitting layer **162**. For example, the solution process may be an inkjet coating process, a slit coating process, a spin coating process, a printing process or a drop coating process, but it is not limited thereto.

The emitting material **162** includes at least one of an organic emitting material, such as a phosphorescent compound (phosphorescent emitting material) or a fluorescent compound (fluorescent emitting material), and an inorganic emitting material, such as a quantum dot.

The emitting layer **162** may have a single-layered structure of an emitting material layer (EML) including the emitting material. To improve an emitting efficiency of the emitting diode D, the emitting layer **162** may have a multi-layered structure of a hole injection layer (HIL), a hole transporting layer (HTL), the EML, an electron transporting layer (EIL) and an electron injection layer (EIL). The HIL and the HTL may be sequentially stacked between the first electrode **160** and the EML, and the ETL and the EIL may be sequentially stacked on the EML.

The top surface of the overcoat layer **155** and the top surface of the pixel dam **180** are coplanar, and the first electrode **160** is disposed on at least a portion of the overcoat layer **155**. Since the overcoat layer **155** and the first electrode **160** has the flat top surface without a height deviation by the pixel dam **180**, there is no thickness deviation in the emitting layer **162** formed by the solution process, the emitting layer **162** on the top surface of the first electrode **160**.

The second electrode **164** is formed over the substrate **110** including the emitting layer **162**. The second electrode **164** covers an entire surface of the display region. The second electrode **164** may be formed of a conductive material having a relatively low work function to serve as a cathode. For example, the second electrode **164** may be formed of aluminum (Al), magnesium (Mg), Al—Mg alloy, Al-silver alloy.

The first electrode **160**, the second electrode **164** facing the first electrode **160** and the emitting layer **162** therebetween constitute the emitting diode D.

In the EL display device **100**, even when a step difference is generated under the overcoat layer **155**, the pixel dam **180**, which surrounds a region, e.g., each pixel region P, of the substrate **110**, is formed such that the overcoat layer **155** covers the step difference and has the flat top surface without a height deviation (height difference). Accordingly, the thickness uniformity of the emitting layer **162** is improved,

and the emission efficiency and the lifespan of the EL display device **100** are also improved.

FIG. 7 is a schematic plan view of an EL display device according to a second embodiment of the present disclosure. FIG. 7 is a cross-sectional view taken along the line VII-VII of FIG. 4.

Referring to FIG. 7 with FIGS. 4 and 5, the EL display device **100** includes a substrate **110**, where a first pixel region P1 and a second pixel region P2 are defined, a driving TFT Td on the substrate **110**, a pixel dam **180**, which is disposed on or over the substrate **110** and surrounds the first and second pixel regions P1 and P2 adjacent to each other, an overcoat layer **155**, which is surrounded by the pixel dam **180** and has a flat top surface, and an emitting diode D. The emitting diode D is disposed on the overcoat layer **155** and is connected to the driving TFT Td.

A semiconductor layer **120** is formed on the substrate **110**. The semiconductor layer **120** may include an oxide semiconductor material or polycrystalline silicon.

A gate insulating layer **122** of an insulating material is formed on the semiconductor layer **120** and over an entire surface of the substrate **110**.

A gate electrode **130**, which is formed of a conductive material, e.g., metal, is formed on the gate insulating layer **122** to correspond to a center of the semiconductor layer **120**. In addition, the gate line GL and a first capacitor electrode **132** are formed on the gate insulating layer **122**. The gate line GL extends along the first direction, and the first capacitor electrode **132** may be connected to the gate electrode **130**.

An interlayer insulating layer **136**, which is formed of an insulating material, is formed on the gate electrode **130**. The interlayer insulating layer **136** includes first and second contact holes **137** and **138** exposing both sides of the semiconductor layer **120**. The first and second contact holes **137** and **138** are positioned at both sides of the gate electrode **130** to be spaced apart from the gate electrode **130**.

A source electrode **140** and a drain electrode **142**, which are formed of a conductive material, e.g., metal, are formed on the interlayer insulating layer **136**. In addition, the data line DL along the second direction and a second capacitor electrode **144** are formed on the interlayer insulating layer **136**.

The power line PL (of FIG. 3), which is spaced apart from and parallel to the data line DL, may further formed on the interlayer insulating layer **136**. In FIG. 6, the data line DL is positioned between the first and second pixel regions P1 and P2. The power line PL may be disposed between the data line DL and the first pixel region P1 or between the data line DL and the second pixel region P2.

The source electrode **140** and the drain electrode **142** are spaced apart from each other with respect to the gate electrode **130** and respectively contact both sides of the semiconductor layer **120** through the first and second contact holes **137** and **138**. The data line DL crosses the gate line GL to define the pixel region P. The second capacitor electrode **144** may be connected to the source electrode **140** and overlap the first capacitor electrode **132**. As a result, the first and second capacitor electrodes **132** and **144** and the interlayer insulating layer **136** as a dielectric layer therebetween constitute the storage capacitor Cst.

The power line PL may be disposed at the same layer as the gate line GL and may be spaced apart from and parallel to the gate line GL.

The semiconductor layer **120**, the gate electrode **130**, the source electrode **140** and the drain electrode **142** constitute the driving TFT Td.

A passivation layer **150** is formed on the driving TFT Td. The passivation layer **150** may be formed of an inorganic insulating material such as silicon oxide or silicon nitride.

The pixel dam **180** surrounding each of the first and second pixel regions P1 and P2 is formed on the passivation layer **150**. Namely, the pixel dam **180** corresponds to the gate line GL and the data line DL and has an opening in correspondence to each of the first and second pixel regions P1 and P2. As a result, the passivation layer **150** in the first and second pixel regions P1 and P2 is exposed through the opening of the pixel dam **180**. The pixel dam **180** has a first height H1 from the substrate **110**.

In addition, the overcoat layer **155** is formed on the passivation layer **150** in the first and second pixel regions P1 and P2. The overcoat layer **155** is formed by a coating process (solution process). The pixel dam **180** confines a coating solution inside the pixel region P such that the overcoat layer **155** has a flat top surface.

The overcoat layer **155** has a second height H2, which is slightly greater than the first height H1, from the substrate **110**, and covers a top surface of the pixel dam **180**. In the EL display device **100** according to the first embodiment of the present disclosure, the overcoat layer **155** and the pixel dam **180** have substantially the same height such that the overcoat layers **155** in the first pixel region P1 and the second pixel region P2 are separated by the pixel dam **180** positioned between the first and second pixel regions P1 and P2. However, in the EL display device **100** according to the second embodiment of the present disclosure, the overcoat layers **155** in the first pixel region P1 and the second pixel region P2 are connected over the pixel dam **180**.

The overcoat layer **155** is formed using a solution process which coats a top surface of the passivation layer **150** with a liquid phase solution of the overcoat layer **155**. Once the overcoat layer **155** is deposited on the top surface of the passivation layer **150** may be left to dry before forming the emitting diode D. When the pixel dam **180** and the overcoat layer **155** have the same height from the substrate **110**, the overcoat layer **155** in each pixel region P may have a height deviation in a center and an edge by the process of forming the overcoat layer **155**. As the overcoat layer **155** dries, the thickness of the edge may be greater than the thickness of the center due to a coffee ring effect that causes flow of solution towards the edge (e.g., the boundary where the overcoat layer **155** contacts the pixel dam **180**). In addition, when the pixel dam **180** and the overcoat layer **155** are formed of different materials, there may be a problem in an adhesion property of the first electrode **160** by a property difference at a boundary between the pixel dam **180** and the overcoat layer **155**.

However, in the EL display device **100** according to the second embodiment of the present disclosure, since the overcoat layer **155** has the second height H2 being slightly greater than the first height H1 of the pixel dam **180** and covers the top surface of the pixel dam **180**, the above problem is prevented.

A drain contact hole **152** exposing the drain electrode **142** of the driving TFT Td is formed through the overcoat layer **155** and the passivation layer **150**.

The first electrode **160**, which is connected to the drain electrode **142** of the driving TFT Td through the drain contact hole **152**, is formed on the overcoat layer **155**. The first electrode **160** is separated in each pixel region P. The first electrode **160** may be formed of a conductive material having a relatively high work function to serve as an anode.

As mentioned above, since the overcoat layer **155** has a flat top surface without a height deviation due to the pixel

dam **180**, the first electrode **160** on the overcoat layer **155** also has a flat top surface without a height deviation.

The bank **170** covering an edge of the first electrode **160** is formed on the overcoat layer **155**. Namely, the bank **170** is positioned at a boundary of the pixel region P and overlaps the pixel dam **180**. The bank **170** has an opening in correspondence to the pixel region P. The bank **170** surrounds the pixel region P and exposes a center of the first electrode **160**.

An emitting layer **162** is formed on the first electrode **160**. The emitting layer **162** may be formed by a solution process using a liquid phase emitting material.

The emitting material **162** includes at least one of an organic emitting material, such as a phosphorescent compound (phosphorescent emitting material) or a fluorescent compound (fluorescent emitting material), and an inorganic emitting material, such as a quantum dot.

Since the overcoat layer **155** and the first electrode **160** has the flat top surface without a height deviation by the pixel dam **180**, there is no thickness deviation in the emitting layer **162** formed by the solution process.

The second electrode **164** is formed over the substrate **110** including the emitting layer **162**. The second electrode **164** covers an entire surface of the display region. The second electrode **164** may be formed of a conductive material having a relatively low work function to serve as a cathode.

The first electrode **160**, the second electrode **164** facing the first electrode **160** and the emitting layer **162** therebetween constitute the emitting diode D.

In the EL display device **100**, even when a step difference is generated under the overcoat layer **155**, the pixel dam **180**, which surrounds a region, e.g., each pixel region P, of the substrate **110**, is formed such that the overcoat layer **155** covers the step difference and has the flat top surface without a height deviation (height difference). Accordingly, the thickness uniformity of the emitting layer **162** is improved, and the emission efficiency and the lifespan of the EL display device **100** are also improved.

FIG. **8** is a schematic plan view of an EL display device according to a third embodiment of the present disclosure, and FIG. **9** is a cross-sectional view taken along the line IX-IX of FIG. **8**.

Referring to FIGS. **8** and **9** with FIG. **5**, the EL display device **100** includes the substrate **110**, where a first pixel region P1 and a second pixel region P2 are defined, a driving TFT Td on the substrate **110**, the pixel dam **180**, which is disposed on or over the substrate **110** and surrounds the first and second pixel regions P1 and P2 adjacent to each other, the overcoat layer **155**, which is surrounded by the pixel dam **180** and has a flat top surface in the first and second pixel regions P1 and P2, and the emitting diode D. The emitting diode D is disposed on the overcoat layer **155** and is connected to the driving TFT Td.

A semiconductor layer **120** is formed on the substrate **110**. The semiconductor layer **120** may include an oxide semiconductor material or polycrystalline silicon.

A gate insulating layer **122** of an insulating material is formed on the semiconductor layer **120** and over an entire surface of the substrate **110**.

A gate electrode **130**, which is formed of a conductive material, e.g., metal, is formed on the gate insulating layer **122** to correspond to a center of the semiconductor layer **120**. In addition, the gate line GL and a first capacitor electrode **132** are formed on the gate insulating layer **122**. The gate line GL extends along the first direction, and the first capacitor electrode **132** may be connected to the gate electrode **130**.

An interlayer insulating layer **136**, which is formed of an insulating material, is formed on the gate electrode **130**. The interlayer insulating layer **136** includes first and second contact holes **137** and **138** exposing both sides of the semiconductor layer **120**. The first and second contact holes **137** and **138** are positioned at both sides of the gate electrode **130** to be spaced apart from the gate electrode **130**.

A source electrode **140** and a drain electrode **142**, which are formed of a conductive material, e.g., metal, are formed on the interlayer insulating layer **136**. In addition, the data line DL along the second direction and a second capacitor electrode **144** are formed on the interlayer insulating layer **136**.

The power line PL (of FIG. 3), which is spaced apart from and parallel to the data line DL, may further formed on the interlayer insulating layer **136**. In FIG. 9, the data line DL is positioned between the first and second pixel regions P1 and P2. The power line PL may be disposed between the data line DL and the first pixel region P1 or between the data line DL and the second pixel region P2.

The source electrode **140** and the drain electrode **142** are spaced apart from each other with respect to the gate electrode **130** and respectively contact both sides of the semiconductor layer **120** through the first and second contact holes **137** and **138**. The data line DL crosses the gate line GL to define the pixel region P. The second capacitor electrode **144** may be connected to the source electrode **140** and overlap the first capacitor electrode **132**. As a result, the first and second capacitor electrodes **132** and **144** and the interlayer insulating layer **136** as a dielectric layer therebetween constitute the storage capacitor Cst.

The power line PL may be disposed at the same layer as the gate line GL and may be spaced apart from and parallel to the gate line GL.

The semiconductor layer **120**, the gate electrode **130**, the source electrode **140** and the drain electrode **142** constitute the driving TFT Td.

A passivation layer **150** is formed on the driving TFT Td. The passivation layer **150** may be formed of an inorganic insulating material such as silicon oxide or silicon nitride.

The pixel dam **180** surrounding the first and second pixel regions P1 and P2 as a whole is formed on the passivation layer **150**. Namely, the pixel dam **180** has an opening in correspondence to both of the first and second pixel regions P1 and P2.

In other words, the pixel dam **180** surrounds a pixel unit including adjacent two pixel regions P1 and P2, and there is no pixel dam **180** between the first and second pixel regions P1 and P2. In FIG. 8, adjacent two pixel regions P1 and P2 form the pixel unit. Alternatively, at least one pixel region between the first and second pixel regions P1 and P2 may be included in the pixel unit. In addition, four pixel regions, which is arranged by 2*2 matrix, form the pixel unit, and the pixel dam **180** may surround four pixel regions as a whole.

The overcoat layer **155** is formed on the passivation layer **150** in the pixel unit of the first and second pixel regions P1 and P2. The overcoat layer **155** is formed by a coating process (solution process). The pixel dam **180** confines a coating solution inside the pixel region P such that the overcoat layer **155** has a flat top surface.

A drain contact hole **152** exposing the drain electrode **142** of the driving TFT Td is formed through the overcoat layer **155** and the passivation layer **150**.

The first electrode **160**, which is connected to the drain electrode **142** of the driving TFT Td through the drain contact hole **152**, is formed on the overcoat layer **155**. The first electrode **160** is separated in each pixel region P. The

first electrode **160** may be formed of a conductive material having a relatively high work function to serve as an anode.

As mentioned above, since the overcoat layer **155** has a flat top surface without a height deviation due to the pixel dam **180**, the first electrode **160** on the overcoat layer **155** also has a flat top surface without a height deviation.

The bank **170** covering an edge of the first electrode **160** is formed on the overcoat layer **155**. Namely, the bank **170** is positioned at a boundary of the pixel region P. The bank **170** has an opening in correspondence to the pixel region P. The bank **170** surrounds the pixel region P and exposes a center of the first electrode **160**.

Namely, the opening of the bank **170** corresponds to each of the first and second pixel regions P1 and P2, and the opening of the pixel dam **180**, which corresponds to the first and second pixel regions P1 and P2 as a whole, is greater than the opening of the bank **170**.

In three sides of each pixel region P, a lower surface of the bank **170** contacts the pixel dam **180**. In the other one side of each pixel region P, the lower surface of the bank **170** contacts the overcoat layer **155**. Alternatively, when the pixel dam **180** surrounds the first pixel P1, the second pixel P2 and a third pixel, which is positioned between the first and second pixels P1 and P2, the lower surface of the bank **170** in two sides of the third pixel region contacts the pixel dam **180**, and the lower surface of the bank **170** in the other two sides of the third pixel region contacts the overcoat layer **155**.

Namely, in the EL display device **100** according to the third embodiment of the present disclosure, the lower surface of the bank **170** in at least two sides of the pixel region contacts the pixel dam **180**, and the lower surface of the bank **170** in at least one side of the third pixel region contacts the overcoat layer **155**.

An emitting layer **162** is formed on the first electrode **160**. The emitting layer **162** may be formed by a solution process using a liquid phase emitting material.

The emitting material **162** includes at least one of an organic emitting material, such as a phosphorescent compound (phosphorescent emitting material) or a fluorescent compound (fluorescent emitting material), and an inorganic emitting material, such as a quantum dot.

Since the overcoat layer **155** and the first electrode **160** has the flat top surface without a height deviation by the pixel dam **180**, there is no thickness deviation in the emitting layer **162** formed by the solution process.

The second electrode **164** is formed over the substrate **110** including the emitting layer **162**. The second electrode **164** covers an entire surface of the display region. The second electrode **164** may be formed of a conductive material having a relatively low work function to serve as a cathode.

The first electrode **160**, the second electrode **164** facing the first electrode **160** and the emitting layer **162** therebetween constitute the emitting diode D.

In the EL display device **100**, even when a step difference is generated under the overcoat layer **155**, the pixel dam **180**, which surrounds a region, e.g., each pixel region P, of the substrate **110**, is formed such that the overcoat layer **155** covers the step difference and has the flat top surface without a height deviation (height difference). Accordingly, the thickness uniformity of the emitting layer **162** is improved, and the emission efficiency and the lifespan of the EL display device **100** are also improved.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present disclosure without departing from the spirit or scope of the disclosure. Thus, it is intended that the present disclosure

cover the modifications and variations of this disclosure provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. An electroluminescent display device comprising:
 - a plurality of pixels, each pixel comprising a portion of a substrate;
 - an intermediate layer over the substrate, the intermediate layer having an uneven top surface;
 - a pixel dam over the intermediate layer and surrounding one or more of the plurality of pixels;
 - an overcoat layer in contact with the pixel dam, the overcoat layer having a planar top surface; and
 - an emitting diode on the overcoat layer and including a first electrode, a second electrode, and an emitting layer between the first electrode and the second electrode, wherein the pixel dam has a light-absorption property.
2. The electroluminescent display device according to claim 1, wherein the intermediate layer is a passivation layer or an insulating layer.
3. The electroluminescent display device according to claim 1, wherein the pixel dam and the intermediate layer are formed of a same material and formed by a same process as each other.
4. The electroluminescent display device according to claim 1, wherein the pixel dam and the overcoat layer are formed of different materials.
5. The electroluminescent display device according to claim 1, wherein a top surface of the pixel dam and the top surface of the overcoat layer are coplanar.
6. The electroluminescent display device according to claim 1, wherein a top surface of the pixel dam is lower than the top surface of the overcoat layer.
7. The electroluminescent display device according to claim 1, wherein the overcoat layer is formed by a solution process.
8. The electroluminescent display device according to claim 1, wherein a portion of the pixel dam is disposed between adjacent pixels of the plurality of pixels.
9. The electroluminescent display device according to claim 1, further comprising:
 - a bank above the pixel dam, the bank configured to confine the emitting layer of the emitting diode and cover an edge of the first electrode.
10. The electroluminescent display device according to claim 9, wherein at least a portion of a bottom surface of the bank contacts the pixel dam.

11. The electroluminescent display device according to claim 10, wherein another portion of the bottom surface of the bank contacts the top surface of the overcoat layer.

12. The electroluminescent display device according to claim 1, wherein the emitting layer is formed by a solution process.

13. The electroluminescent display device according to claim 1, further comprising:

- a thin film transistor between the substrate and the intermediate layer, the first electrode connected to the thin film transistor.

14. An electroluminescent display device comprising:

- a plurality of pixels, each pixel comprising a portion of a substrate;

- an intermediate layer over the substrate, the intermediate layer having an uneven top surface;

- a pixel dam over the intermediate layer and surrounding one or more of the plurality of pixels;

- an overcoat layer in contact with the pixel dam, the overcoat layer having a planar top surface;

- an emitting diode on the overcoat layer and including a first electrode, a second electrode, and an emitting layer between the first electrode and the second electrode; and

- a bank above at least a portion of the pixel dam and confining the emitting layer of the emitting diode, wherein a portion of a bottom surface of the bank contacts the pixel dam.

15. The electroluminescent display device of claim 14, wherein the intermediate layer is a passivation layer or an insulating layer.

16. The electroluminescent display device according to claim 14, wherein a top surface of the pixel dam and the top surface of the overcoat layer are coplanar.

17. The electroluminescent display device according to claim 14, wherein a top surface of the pixel dam is lower than the top surface of the overcoat layer.

18. The electroluminescent display device according to claim 14, wherein a portion of the pixel dam is disposed between adjacent pixels of the plurality of pixels.

19. The electroluminescent display device according to claim 14, wherein the bank covers an edge of the first electrode.

20. The electroluminescent display device according to claim 14, wherein another portion of the bottom surface of the bank contacts the top surface of the overcoat layer.

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