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Lee et al.

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(54) **TRANSFLECTIVE LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME**

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(22) Filed: **May 23, 2011**

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(62) Division of application No. 12/748,907, filed on Mar. 29, 2010, now Pat. No. 7,986,387, which is a division of application No. 11/372,081, filed on Mar. 10, 2006, now Pat. No. 7,714,963.

(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G02F 1/1335 (2006.01)

(52) **U.S. Cl.** **349/114**

(58) **Field of Classification Search** 349/114
See application file for complete search history.

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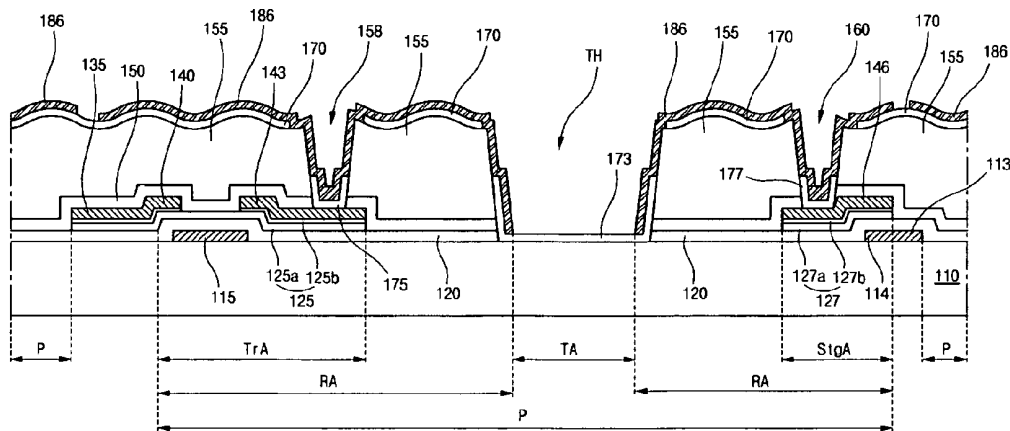
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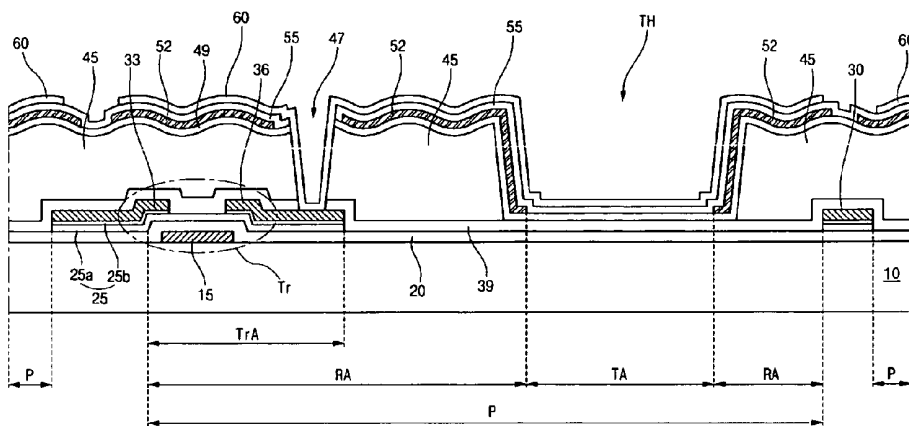
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(57) **ABSTRACT**

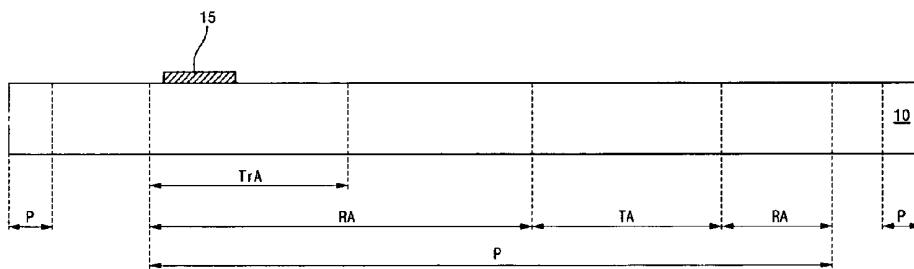
An array substrate for a transmissive liquid crystal display device includes: a substrate; a gate line and a data line on the substrate, the gate line and the data line crossing each other to define a pixel region including a transmissive area and a reflective area surrounding the transmissive area; a thin film transistor having a gate insulating layer, the thin film transistor electrically connected to the gate line and the data line; a first passivation layer having a drain contact hole exposing a drain electrode of the thin film transistor and a through hole exposing the substrate in the transmissive area; a pixel electrode on the first passivation layer, the pixel electrode contacting the substrate in the transmissive area through the through hole; and a reflective plate on the pixel electrode, the reflective plate being electrically connected to the drain electrode through the drain contact hole and to the pixel electrode.

2 Claims, 21 Drawing Sheets

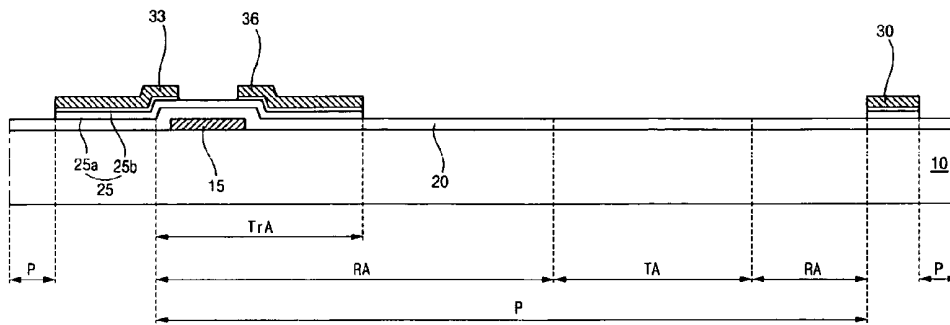




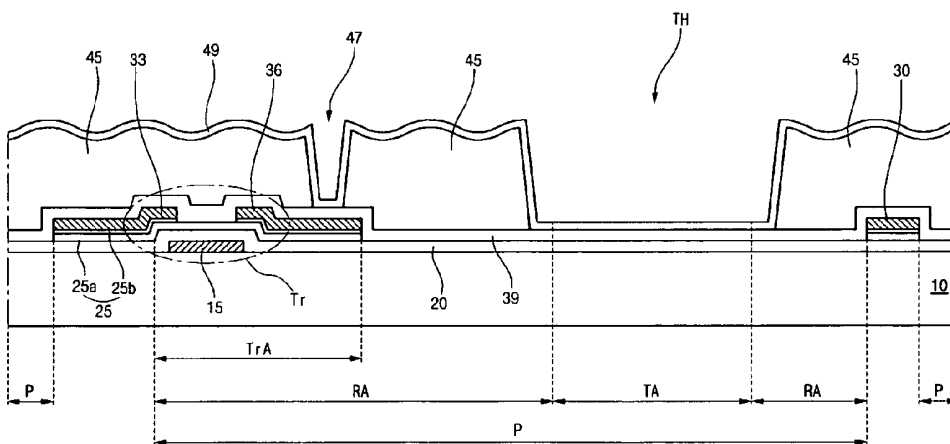
(related art)
FIG. 1



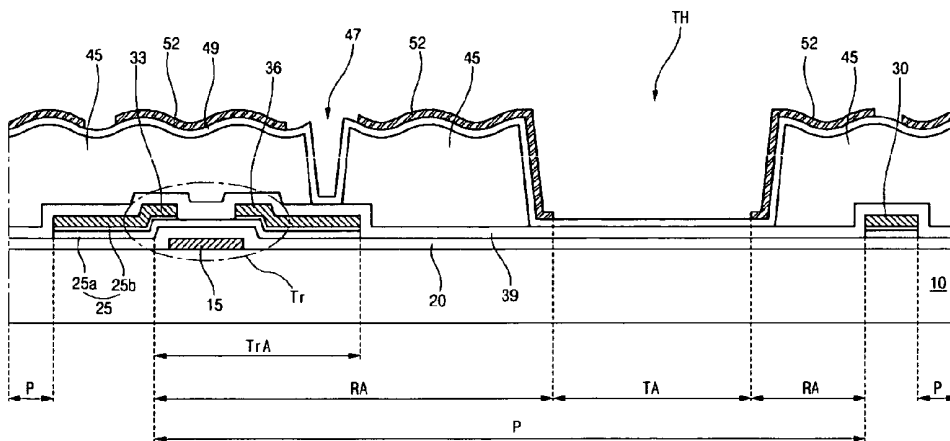
(related art)
FIG. 2A



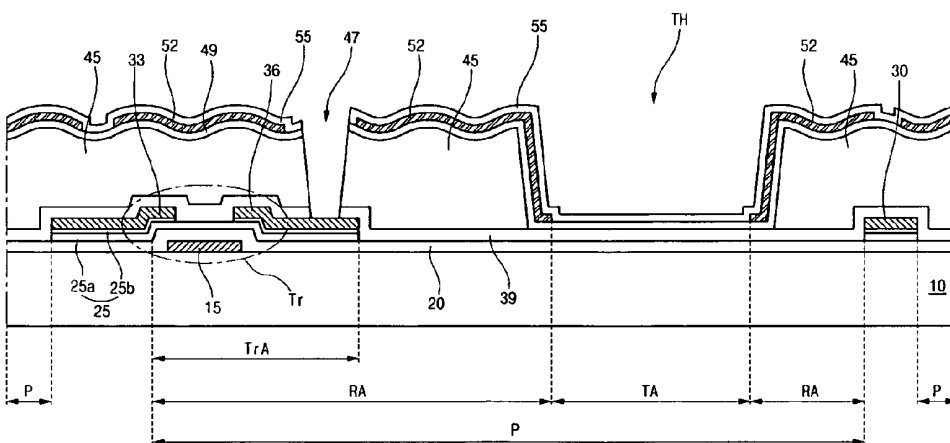
(related art)
FIG. 2B



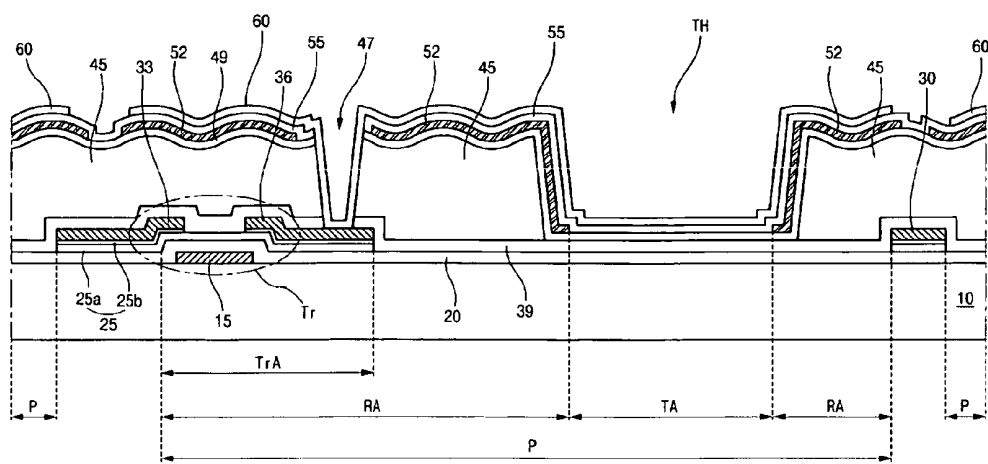
(related art)
FIG. 2C



(related art)
FIG. 2D



(related art)
FIG. 2E



(related art)
FIG. 2F

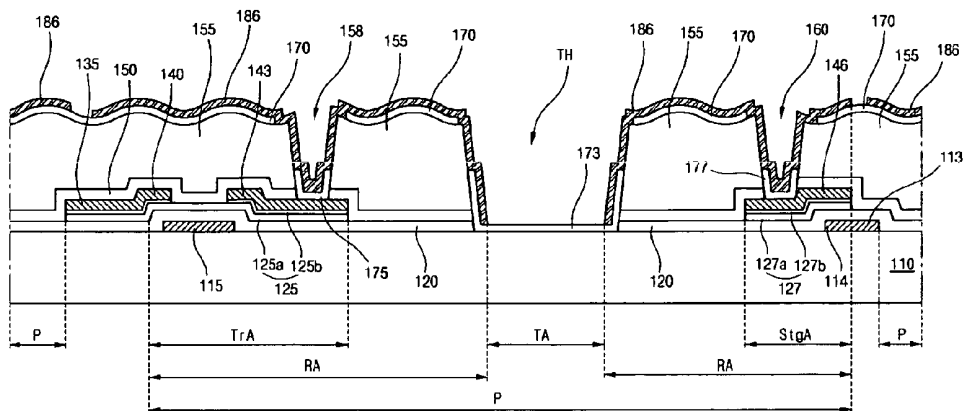


FIG. 4

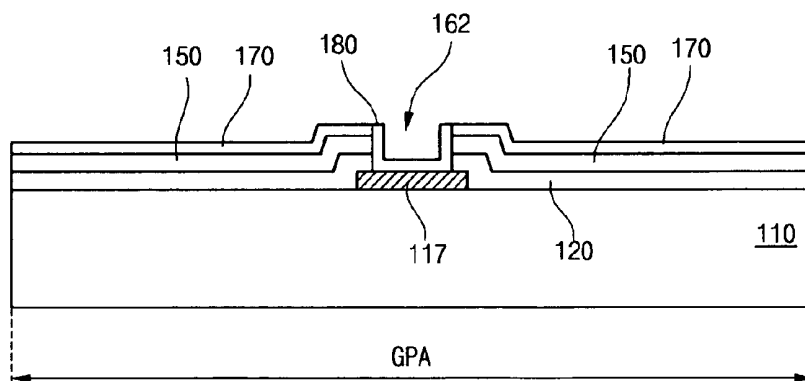


FIG. 5

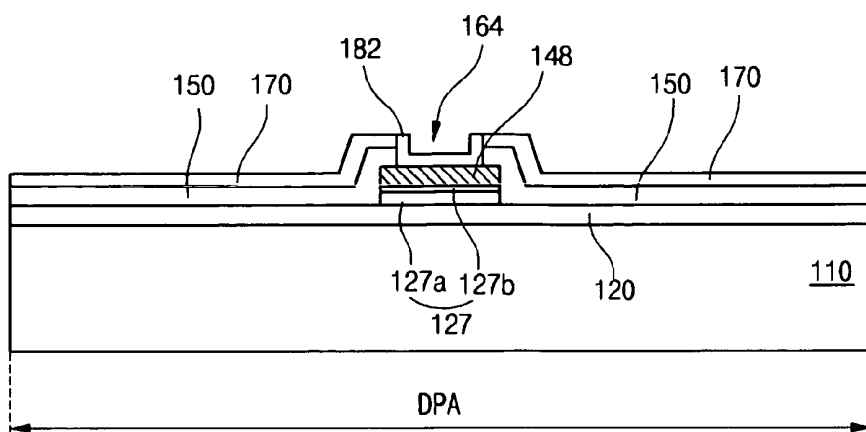


FIG. 6

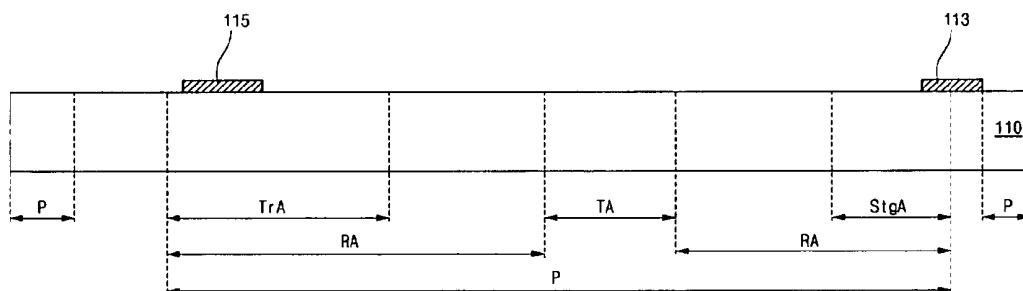


FIG. 7A

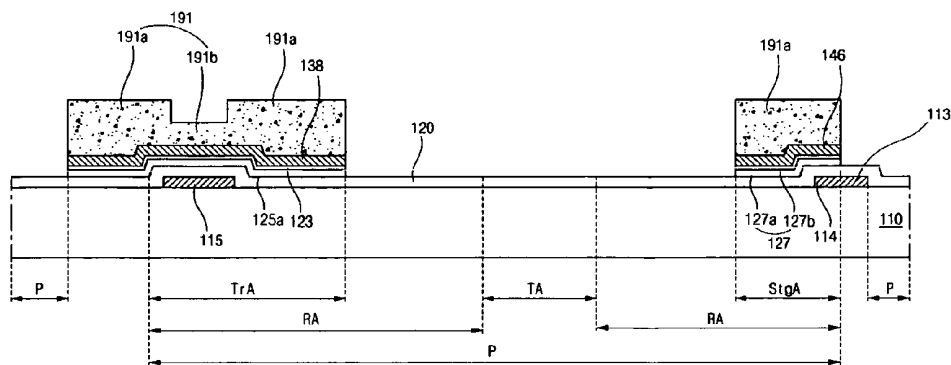


FIG. 7B

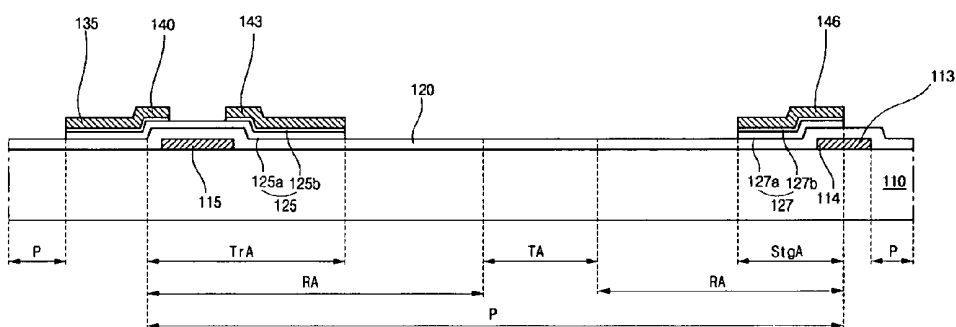


FIG. 7C

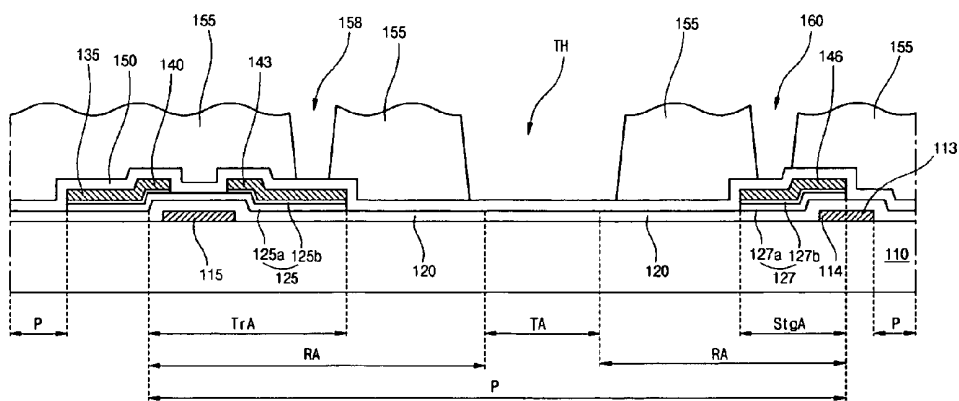


FIG. 7D

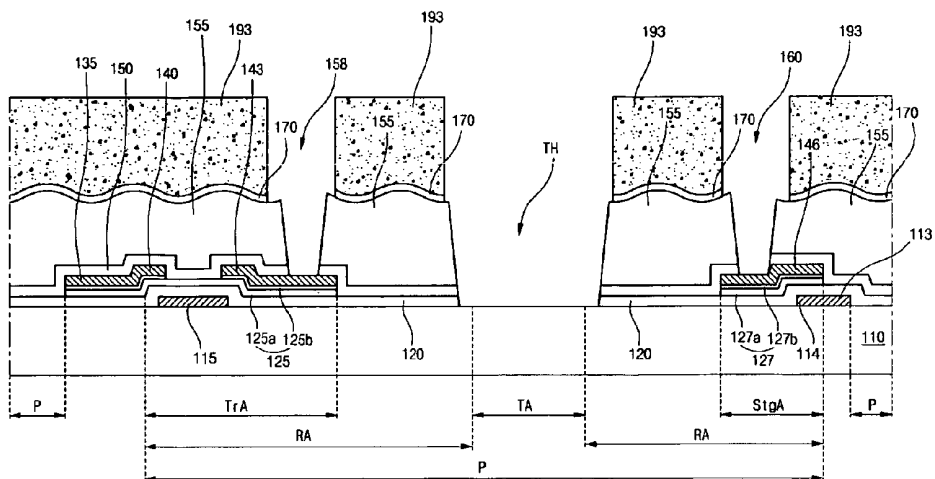


FIG. 7E

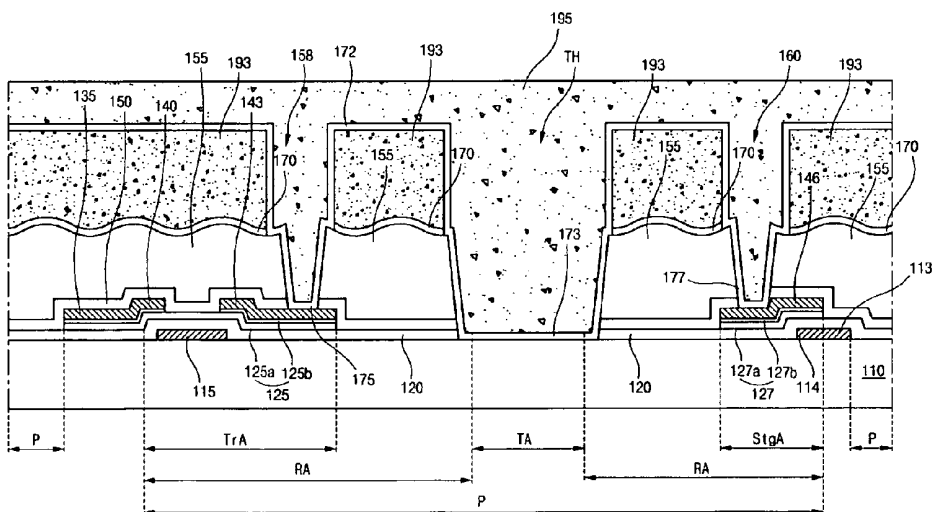
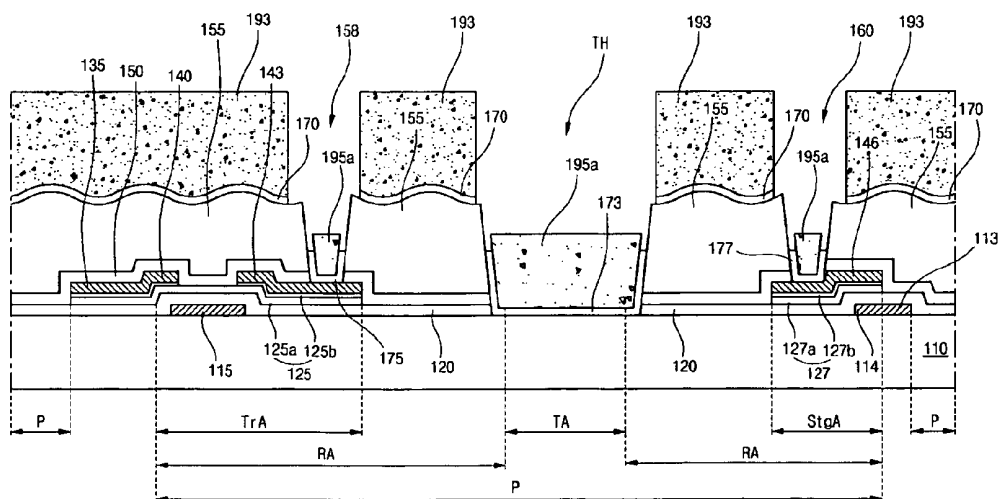
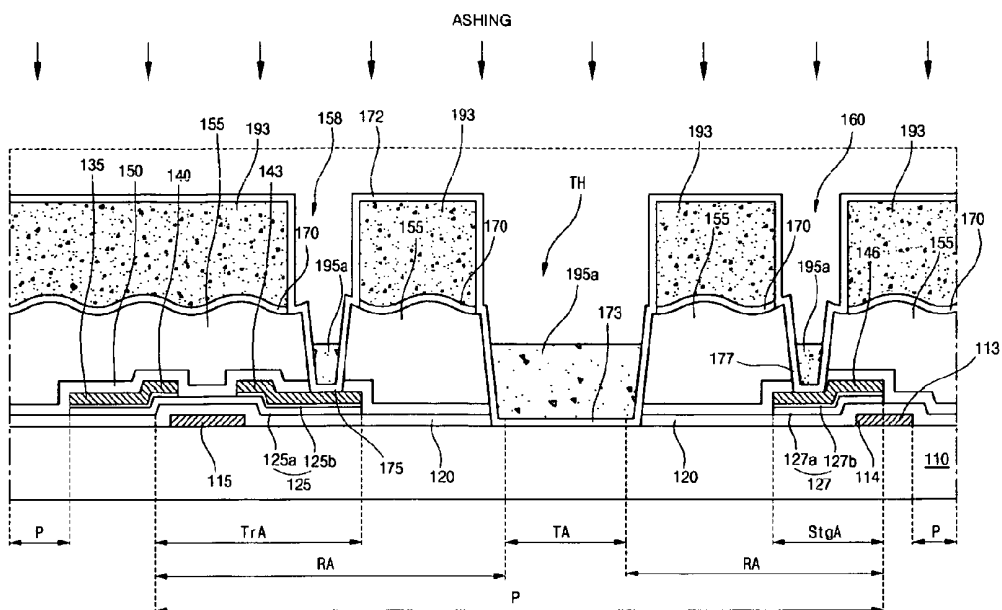


FIG. 7F



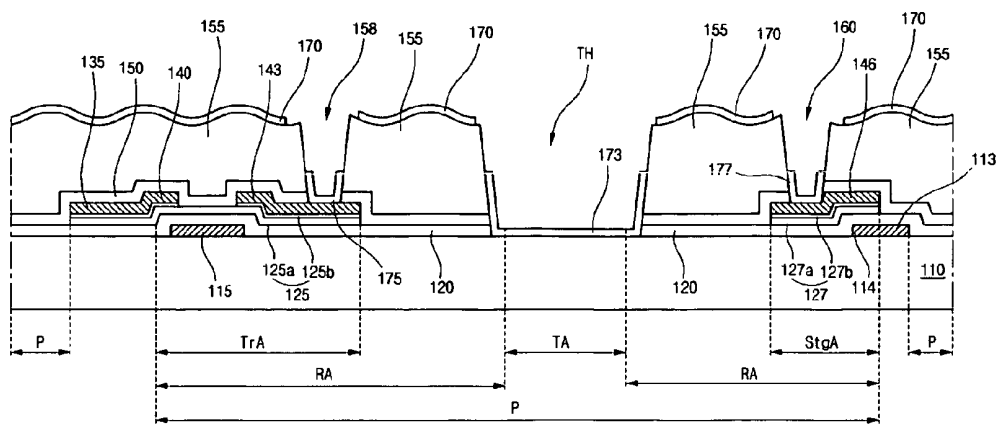


FIG. 7I

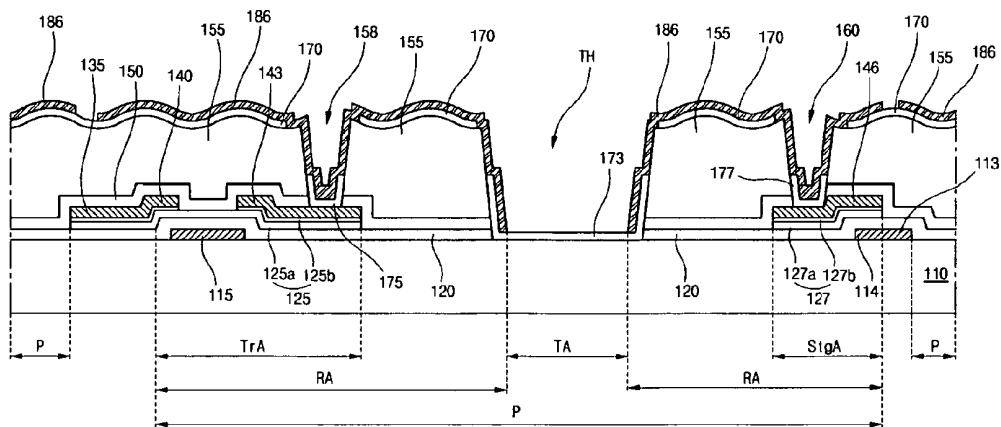


FIG. 7J

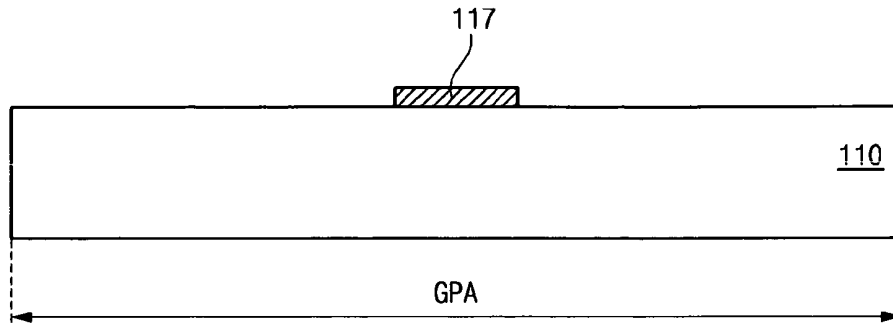


FIG. 8A

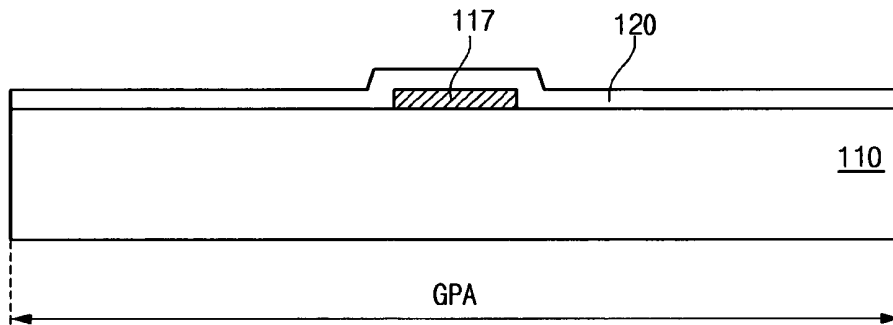


FIG. 8B

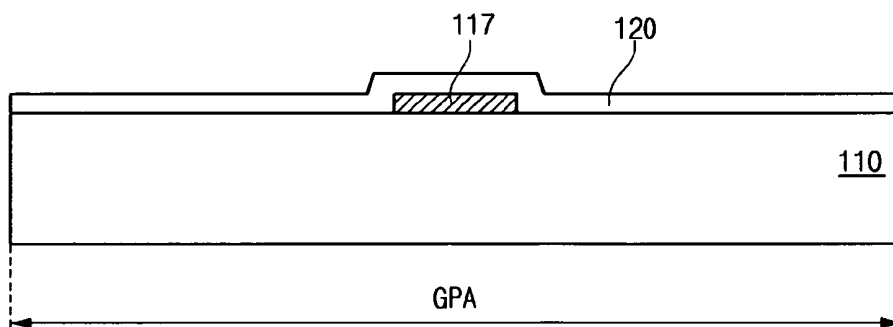


FIG. 8C

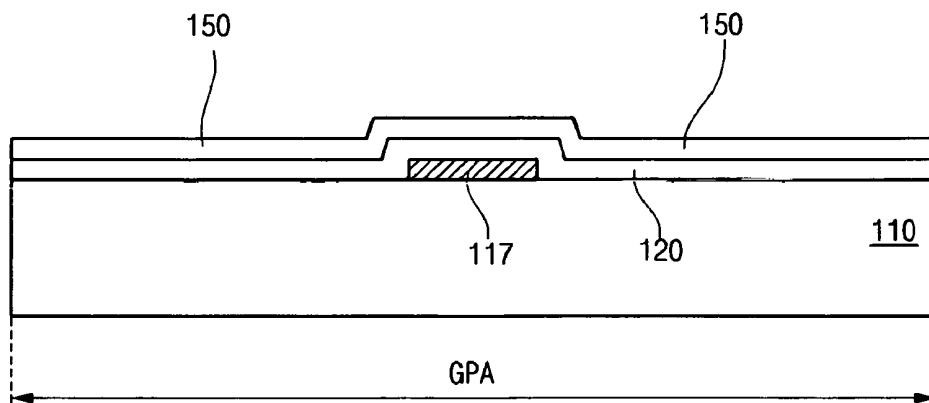


FIG. 8D

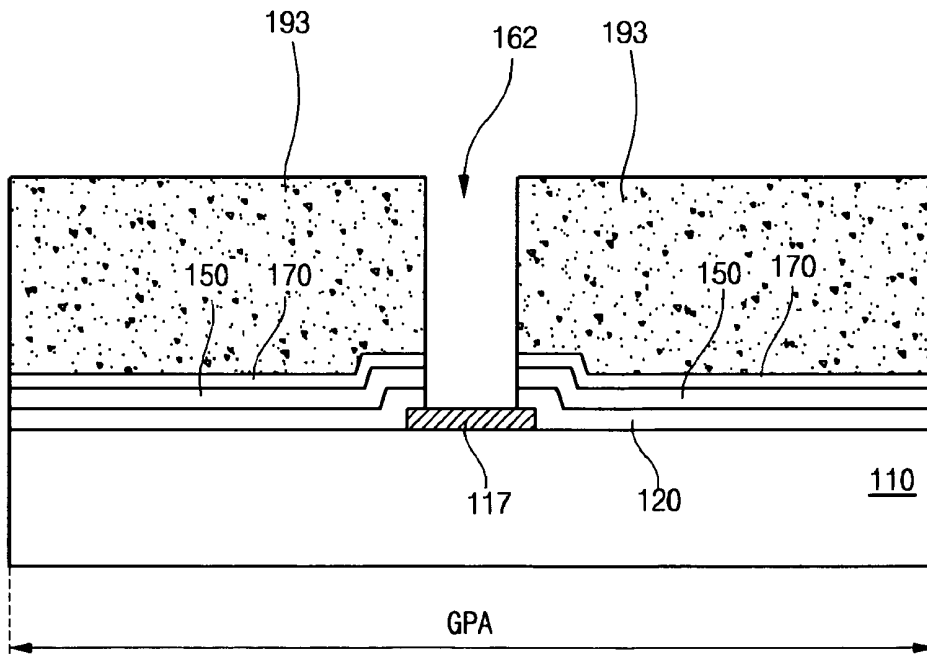


FIG. 8E

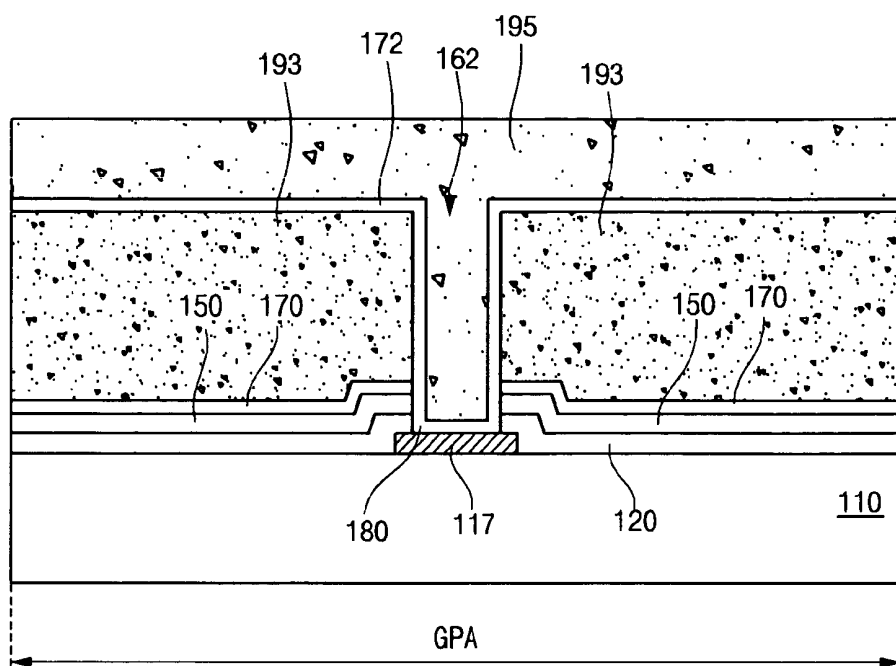


FIG. 8F

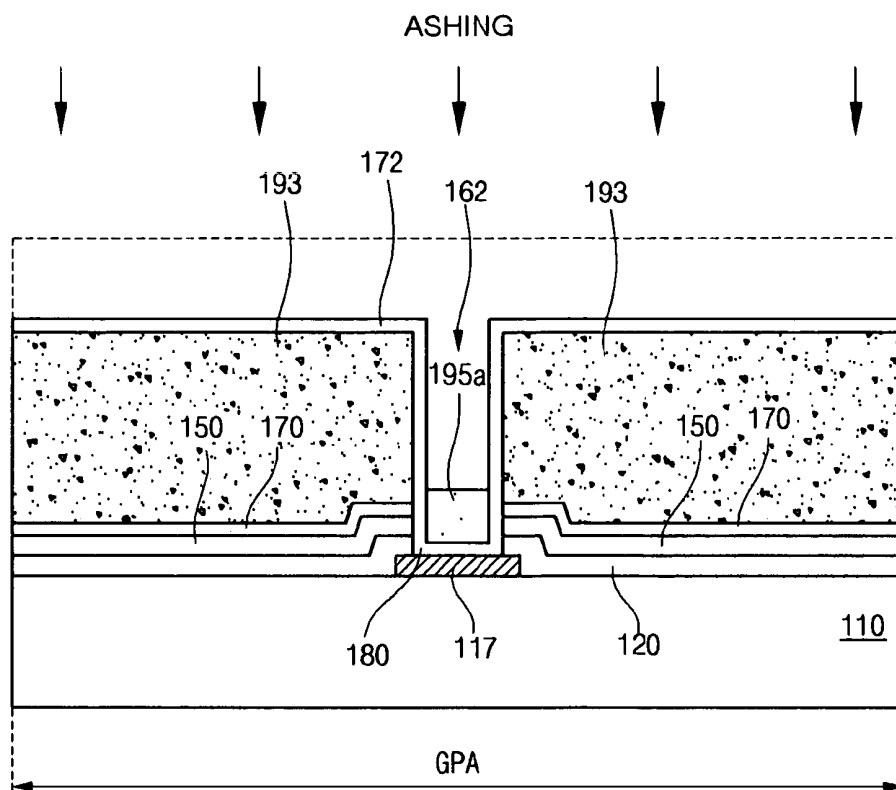


FIG. 8G

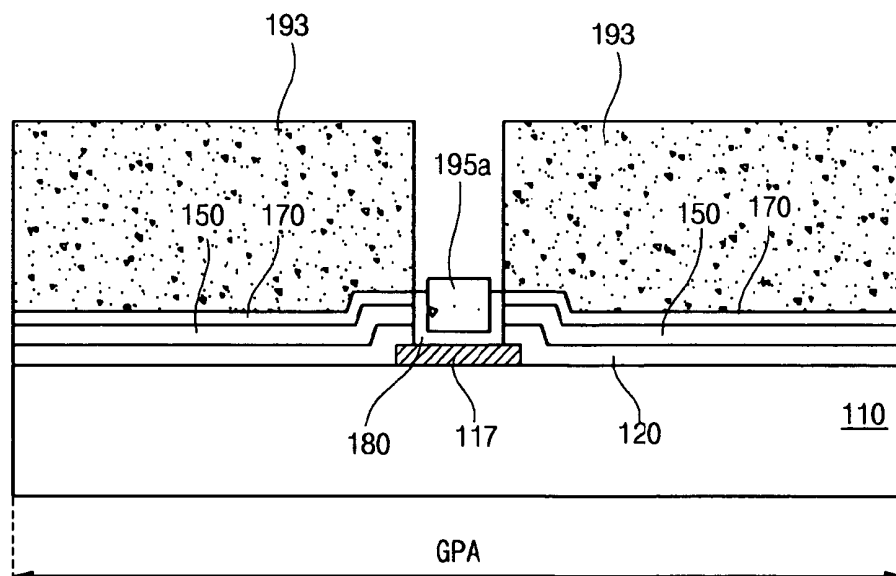


FIG. 8H

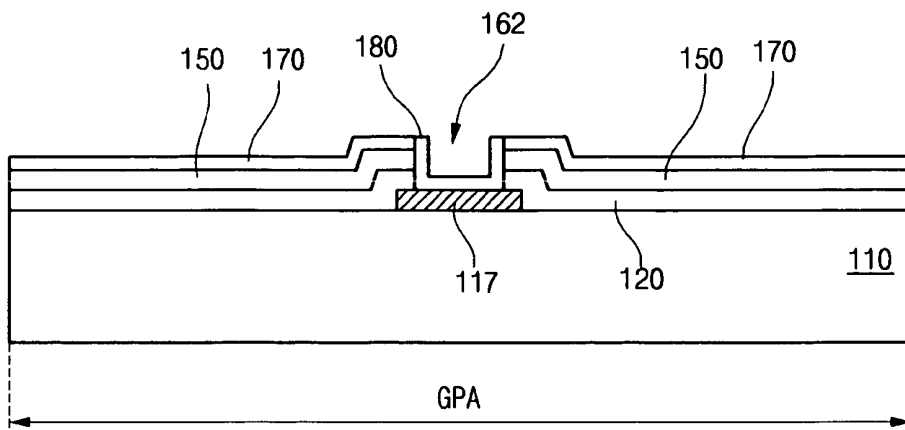


FIG. 8I

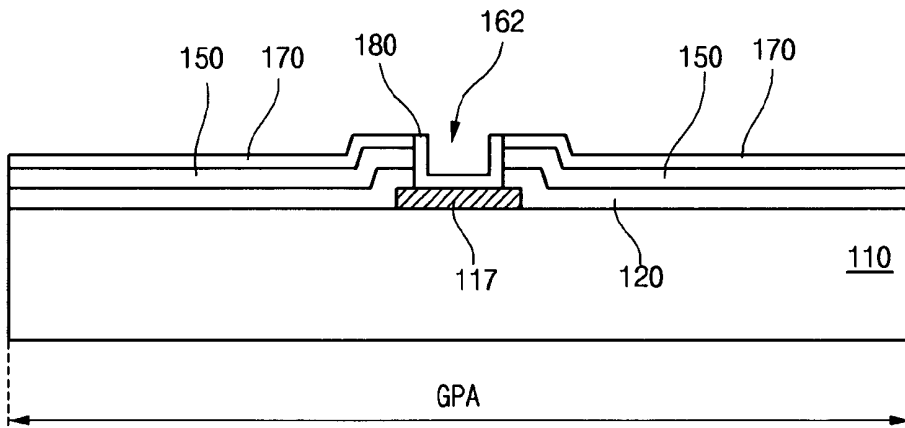


FIG. 8J

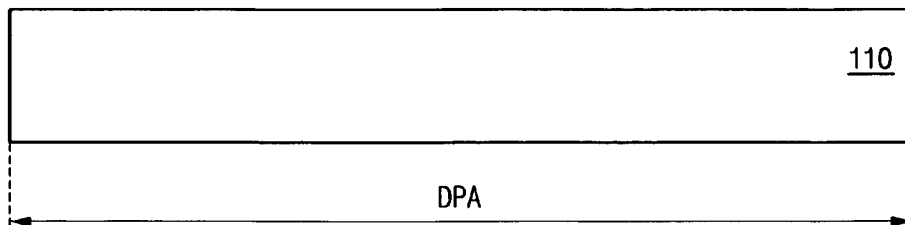


FIG. 9A

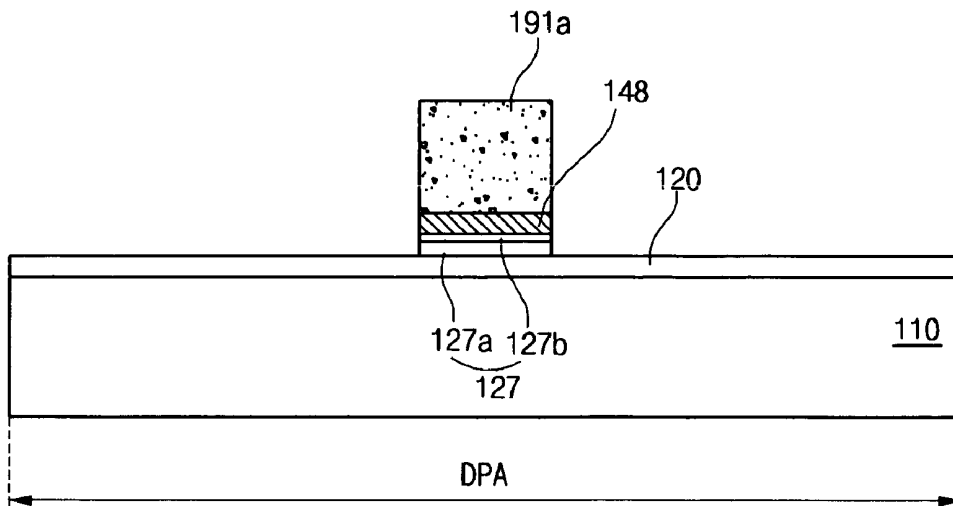


FIG. 9B

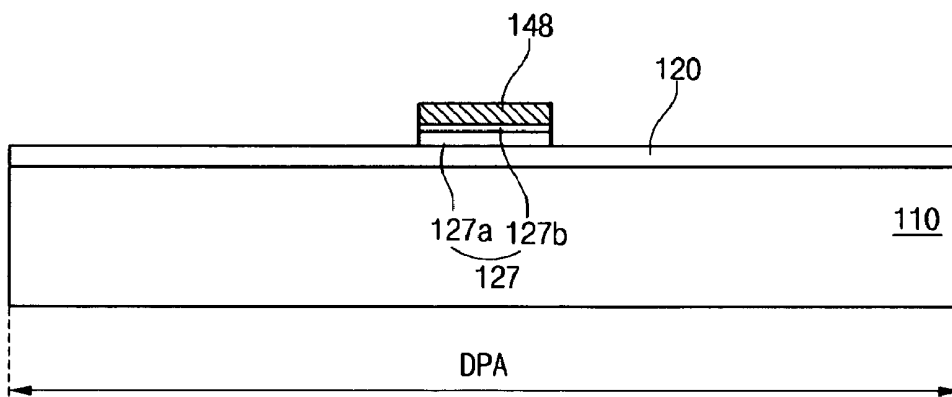


FIG. 9C

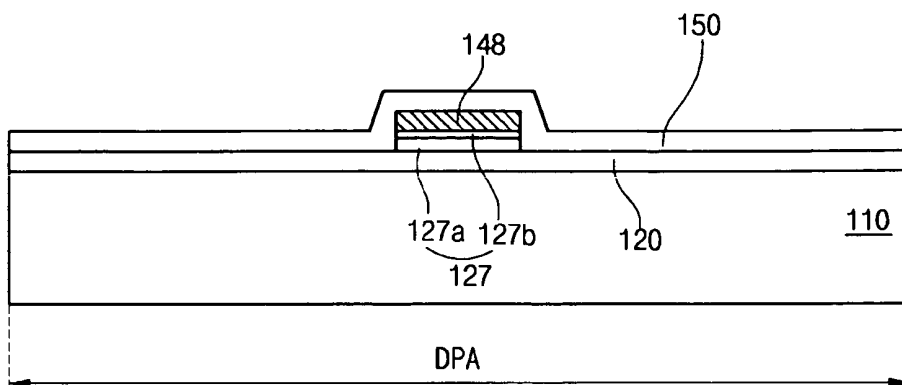


FIG. 9D

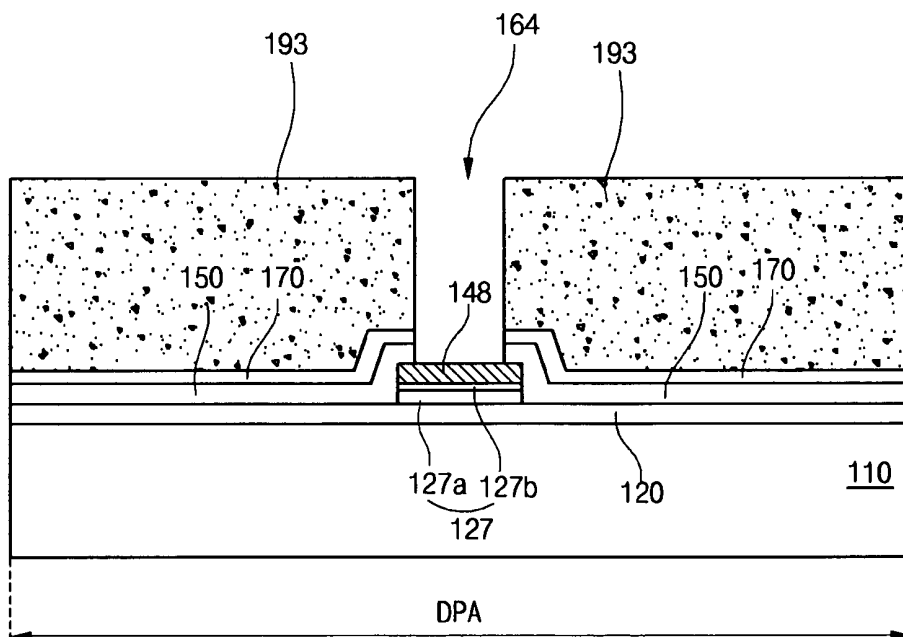


FIG. 9E

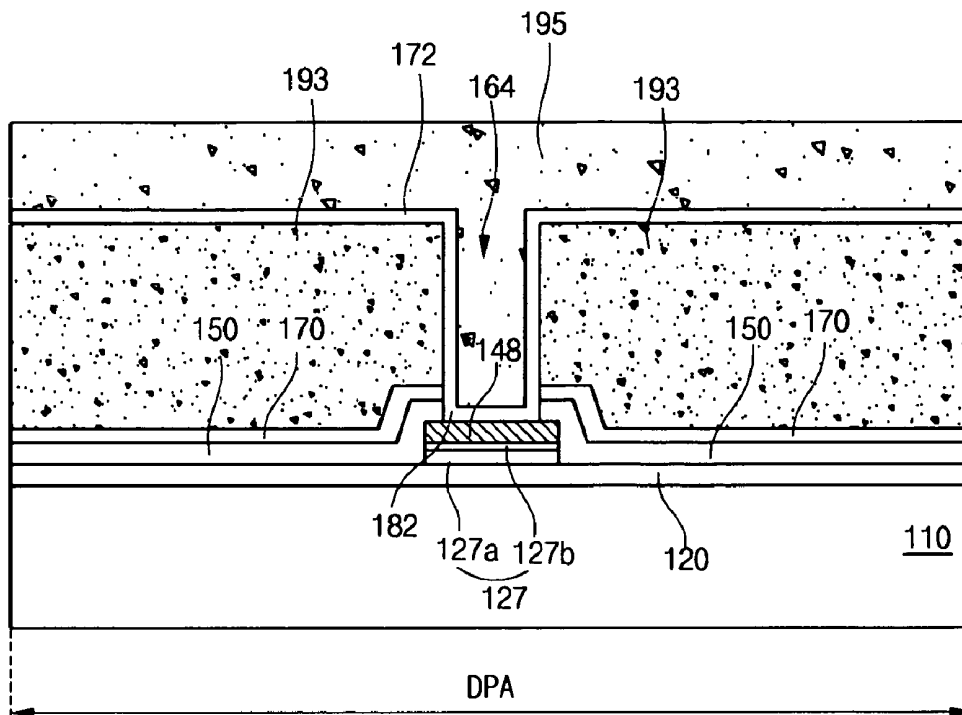


FIG. 9F

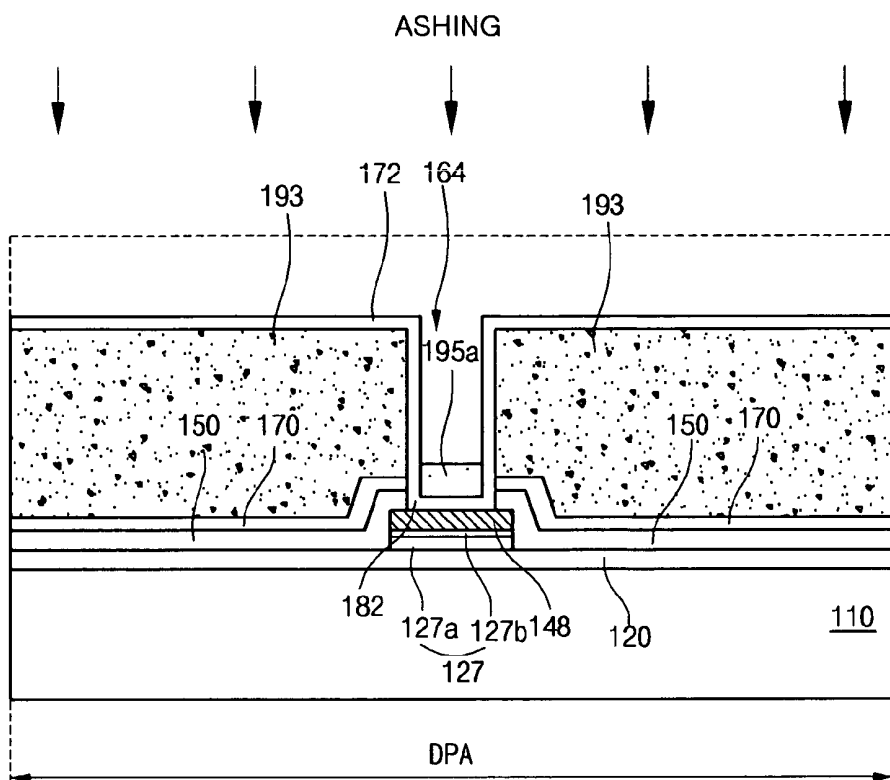


FIG. 9G

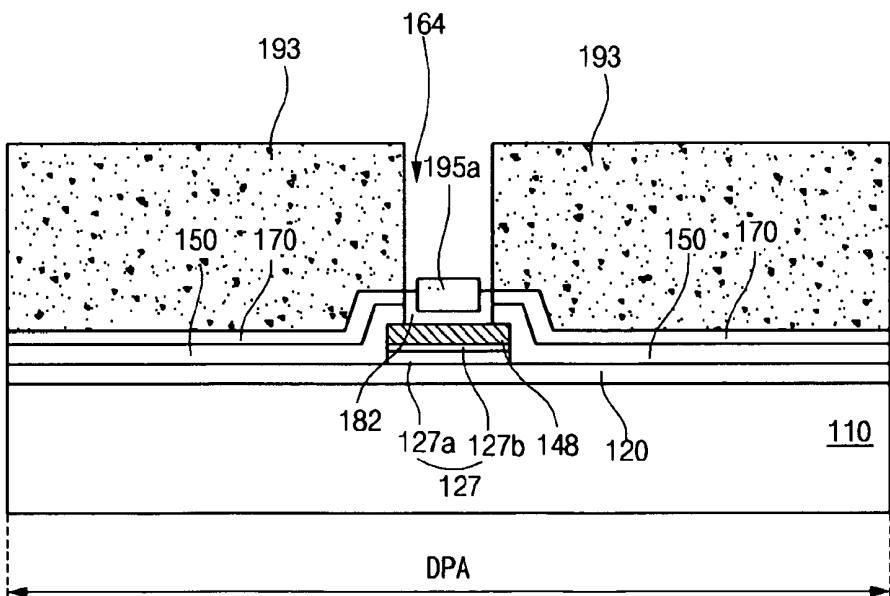


FIG. 9H

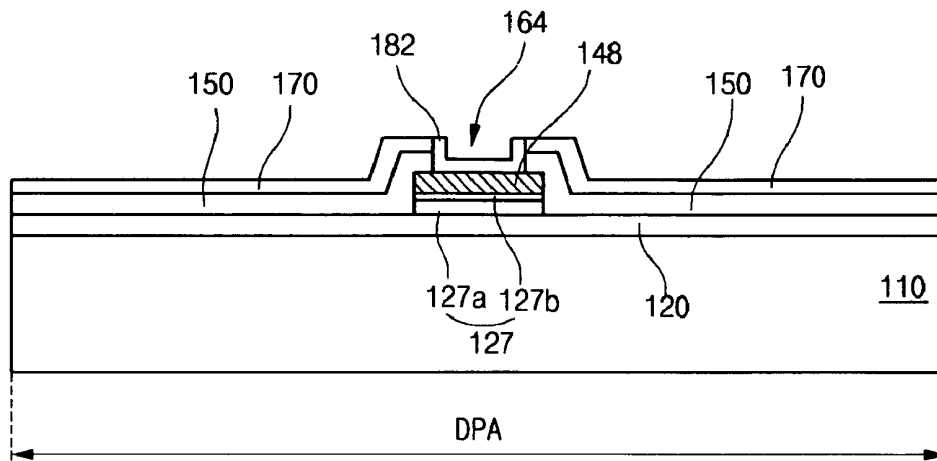


FIG. 9I

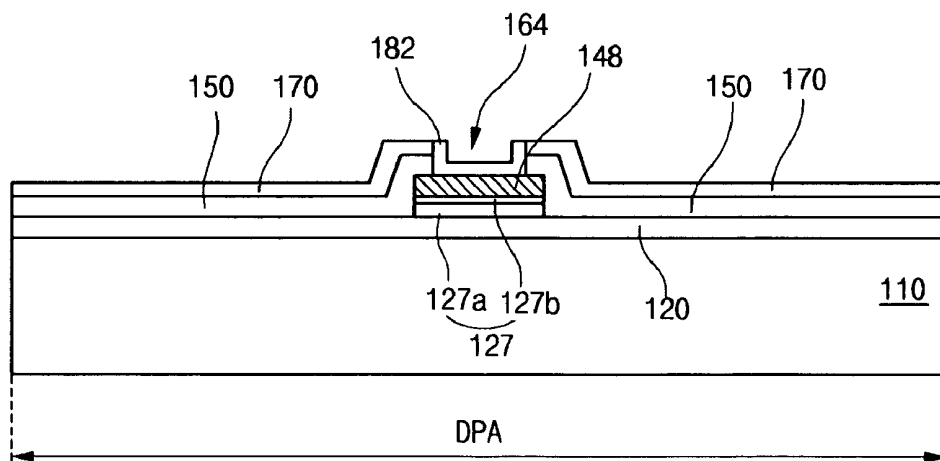


FIG. 9J

**TRANSFLECTIVE LIQUID CRYSTAL
DISPLAY DEVICE AND METHOD OF
FABRICATING THE SAME**

This application is a divisional application of application Ser. No. 12/748,907, filed Mar. 29, 2010, now U.S. Pat. No. 7,986,387, which is a divisional of application Ser. No. 11/372,081, filed Mar. 10, 2006, now U.S. Pat. No. 7,714,963, which claims the benefit of Korean Patent Application No. 2005-0084196, filed on Sep. 9, 2005.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid crystal display (LCD) device and a method of fabricating a liquid crystal display device, and more particularly, to an array substrate for a transmissive liquid crystal display device and a method of fabricating the same.

2. Discussion of the Related Art

As the information age advances, display devices for displaying information are actively being developed. More particularly, flat panel display (FPD) devices having a thin profile, light weight and low power consumption are actively being pursued. FPD devices can be classified as either an emissive type or a non-emissive type depending on their light emission capability. In an emissive type FPD device, an image is displayed using light that emanates from the FPD device. In a non-emissive type FPD device, an image is displayed using light from an external source that reflects and/or transmits through the FPD. For example, a plasma display panel (PDP) device is a field emission display (FED) device. In another example, an electroluminescent display (ELD) device is an emissive type FPD device. Unlike a PDP and an ELD, a liquid crystal display (LCD) device is a non-emissive type FPD device that uses a backlight as a light source.

Among the various types of FPD devices, liquid crystal display (LCD) devices are widely used as monitors for notebook computers and desktop computers because of their high resolution, color rendering capability and superiority in displaying moving images. The LCD device displays images by controlling a transmittance of light through the device. More particularly, liquid crystal molecules of a liquid crystal interposed between two substrates facing each other control light transmission in response to an electric field generated between electrodes on one of the substrates.

Because the LCD device does not emit light, the LCD device needs to be used with a separate light source. Thus, a backlight is disposed on the rear surface on a liquid crystal panel of the LCD device, and images are displayed with the light emitted from the backlight and transmitted through the liquid crystal panel. Accordingly, the above-mentioned LCD device is referred to as a transmission type LCD device. The transmission type LCD device can display bright images in a dark environment due to the use of a separate light source, such as a backlight, but may cause a large power consumption because of the use of the backlight.

To solve the problem of large power consumption, a reflection type LCD device has been developed. The reflection type LCD device controls a transmittance of light by reflecting the outside natural light or artificial light through a liquid crystal layer. In a reflection type LCD device, a pixel electrode on a lower substrate is formed of a conductive material having a relatively high reflectance and a common electrode on an upper substrate is formed of a transparent conductive material. Although the reflection type LCD device may have lower

power consumption than the transmission type LCD device, it may have low brightness when the outside light is insufficient or weak.

To solve both the problems of large power consumption and low brightness, a transmissive LCD device combining the capabilities of a transmission type LCD device and reflection type LCD device has been suggested. The transmissive LCD device can select a transmission mode using a backlight while in an indoor environment or a circumstance having no external light source, and a reflection mode using an external light source in an environment where the external light source exists.

FIG. 1 is a cross-sectional view of an array substrate for a transmissive LCD device according to the related art. In FIG. 1, a substrate 10 includes a pixel region "P" defined by a crossing of a gate line (not shown) and a data line 30. The pixel region "P" includes a reflective area "RA" and a transmissive area "TA." The reflective area "RA" includes a transistor area "TrA."

A thin film transistor (TFT) "Tr," including a gate electrode 15, a gate insulating layer 20, a semiconductor layer 25, a source electrode 33 and a drain electrode 36, is formed on the substrate 10 in the transistor area "TrA." The semiconductor layer 25 includes an active layer 25a and an ohmic contact layer 25b. A first passivation layer 39 of an inorganic insulating material is formed on the TFT "Tr" and a second passivation layer 45 of an organic insulating material is formed on the first passivation layer 39. Subsequently, a through hole "TH" is formed in the second passivation layer 45 within the transmissive area "TA." Further, the second passivation layer 45 includes a drain contact hole 47 exposing the drain electrode 36 and an uneven top surface. A third passivation layer 49 of an inorganic insulating material is formed on the second passivation layer 45 and has the drain contact hole 47 exposing the drain electrode 36. A reflective plate 52 of a reflective metallic material layer is formed on the third passivation layer 49. The reflective plates 52 in the adjacent pixel region "P" are separated from each other. A fourth passivation layer 55 of an inorganic insulating material is formed on the reflective plate 52, and a pixel electrode 60 is formed on the fourth passivation layer 55. The pixel electrode 60 is connected to the drain electrode 36 through the drain contact hole 47. As a result, a gate insulating layer 20 of the thin film transistor (TFT) "Tr," the first passivation layer 39, the third passivation layer 49, the fourth passivation layer 55 and the pixel electrode 60 are sequentially formed on the substrate 10 in the transmissive area "TA."

FIGS. 2A to 2F are cross-sectional views showing a fabrication process of an array substrate for a transmissive LCD device according to the related art. As shown in FIG. 2A, after a first metal layer (not shown) of a first metallic material is deposited on a substrate 10, a gate electrode 15 and a gate line (not shown) are formed by patterning the first metal layer through a first mask process including a coating step for a photoresist (PR), an exposure step using a mask, a developing step of the PR and an etching step of the first metal layer. The substrate 10 includes a pixel region "P" divided into a transmissive area "TA" and a reflective area "RA." The reflective area "RA" includes a transistor area "TrA."

As shown in FIG. 2B, a gate insulating layer 20 is formed on the gate electrode 15 and the gate line. An intrinsic amorphous silicon layer (not shown), a doped amorphous silicon layer (not shown) and a second metal layer (not shown) are sequentially deposited on the gate insulating layer 20. Then, a data line 30, a semiconductor layer 25, including an active layer 25a and an ohmic contact layer 25b, a source electrode 33 and a drain electrode 36, are formed by patterning the

second metal layer, the doped amorphous silicon layer and the intrinsic amorphous silicon layer through a second mask process.

As shown in FIG. 2C, a first passivation layer 39 is formed on the source electrode 33, the drain electrode 36 and the data line 30 by depositing an inorganic insulating material. After coating an organic insulating material on the first passivation layer 39, a second passivation layer 45 is formed by patterning the coated organic insulating material through a third mask process. The second passivation layer 45 has an uneven top surface, and includes a drain contact hole 47 and a through hole "TH." The drain contact hole exposes the first passivation layer 39 on the drain electrode 36 and the through hole "TH" exposes the first passivation layer 39 in the transmissive area "TA." In addition, a third passivation layer 49 is formed on the second passivation layer 39 by depositing an inorganic insulating material.

As shown in FIG. 2D, after a third metal layer (not shown) having a relatively high reflectance is deposited on the third passivation layer 49, a reflective plate 52 is formed in the reflective area "RA" of the pixel region "P" by patterning the third metal layer through a fourth mask process. Since the third metal layer corresponding to the drain contact hole 47 and the through hole "TH" is removed, the third passivation layer 49 corresponding to the drain contact hole 47 and the through hole "TH" is exposed through the reflective plate 52.

As shown in FIG. 2E, after an inorganic insulating material is deposited on the reflective plate 52, a fourth passivation layer 55 is formed by patterning the deposited inorganic insulating material through a fifth mask process. Since the fourth passivation layer 55, the third passivation layer 49 and the first passivation layer 39 corresponding to the drain contact hole 47 are removed, the drain electrode 36 is exposed through the drain contact hole 47.

As shown in FIG. 2F, after a transparent conductive material is deposited on the fourth passivation layer 55. Then, a pixel electrode 60 is formed in the pixel region "P" by patterning the deposited transparent conductive material through a sixth mask process. Thus, the pixel electrode 60 is connected to the drain electrode 36 through the drain contact hole 47.

As described above, an array substrate for a transmissive LCD device according to the related art is fabricated through a six-mask process. Each mask process includes several steps, such as coating PR, exposure of the PR using a mask, a developing the PR, etching using the developed PR and stripping the developed PR. Accordingly, mask processes are expensive in terms of both fabrication time and material cost. In addition, each mask process introduces an additional probability of yield reduction.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a transmissive LCD device and a method of fabricating the same that substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide an array substrate for a transmissive LCD device that is fabricated through a five-mask process, and a method of fabricating the same.

Another object of the present invention is to provide an array substrate for a transmissive LCD device having an improved production efficiency, and a method of fabricating the same.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be

apparent from the description, or may be learned by practice of the invention. These and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, an array substrate for a transmissive liquid crystal display device includes: a substrate; a gate line and a data line on the substrate, the gate line and the data line crossing each other to define a pixel region including a transmissive area and a reflective area surrounding the transmissive area; a thin film transistor electrically connected to the gate line and the data line; a first passivation layer on the thin film transistor, the first passivation layer having a drain contact hole exposing a drain electrode of the thin film transistor and a through hole exposing the substrate in the transmissive area; a pixel electrode on the first passivation layer, the pixel electrode contacting the substrate in the transmissive area through the through hole; a reflective plate on the pixel electrode, the reflective plate being electrically connected to the drain electrode through the drain contact hole and contacting the pixel electrode.

In another aspect, a method of fabricating an array substrate for a transmissive liquid crystal display device includes: forming a gate line and a data line on a substrate, the gate line and the data line crossing each other to define a pixel region including a transmissive area and a reflective area surrounding the transmissive area; forming a gate insulating layer between the gate line and the data line; forming a thin film transistor connected to the gate line and the data line; forming a first passivation layer on the thin film transistor, the first passivation layer having a drain contact hole exposing a drain electrode of the thin film transistor and a through hole exposing the gate insulating layer on the substrate in the transmissive area; forming a second passivation layer on the first passivation layer; forming a first photoresist pattern on the second passivation layer, the first photoresist pattern exposing the drain contact hole and the through hole; etching the second passivation layer and the gate insulating layer using the first photoresist pattern as an etch mask such that the drain electrode is exposed through the drain contact hole and the substrate is exposed through the through hole; forming a transparent conductive material layer on the first photoresist pattern; forming a first photoresist layer on the transparent conductive material layer; anisotropically removing the first photoresist layer to form a second photoresist pattern on the transparent conductive material layer in the drain contact hole and the through hole; etching the transparent conductive material layer using the second photoresist pattern as an etch mask to form a drain terminal in the drain contact hole and a pixel electrode in the through hole; removing the first and second photoresist patterns; and forming a reflective plate on the drain terminal and the pixel electrode, the reflective plate contacting the drain terminal and the pixel electrode.

In another aspect, an array substrate for a transmissive liquid crystal display device includes: a substrate; a gate line and a data line on the substrate, the gate line and the data line crossing each other to define a pixel region including a transmissive area and a reflective area surrounding the transmissive area; a thin film transistor electrically connected to the gate line and the data line; a first passivation layer on the thin film transistor, the first passivation layer having a drain contact hole exposing a drain electrode of the thin film transistor and a through hole exposing the substrate in the transmissive area; a pixel electrode contacting the substrate in the transmissive area and a first sidewall of the through hole; a drain

terminal contacting the drain electrode and a second sidewall of the drain contact hole; and a reflective plate on the first passivation layer, the reflective plate contacting the pixel electrode on the first sidewall of the through hole and covering the drain terminal.

In another aspect, a method of fabricating an array substrate for a transfective liquid crystal display device includes: forming a gate line and a data line on a substrate, the gate line and the data line crossing each other to define a pixel region including a transmissive area and a reflective area surrounding the transmissive area; forming a gate insulating layer between the gate line and the data line; forming a thin film transistor connected to the gate line and the data line; forming a first passivation layer on the thin film transistor, the first passivation layer having a drain contact hole exposing a drain electrode of the thin film transistor and a through hole exposing the gate insulating layer on the substrate in the transmissive area; forming a second passivation layer on the first passivation layer; forming a first photoresist pattern on the second passivation layer, the first photoresist pattern exposing the drain contact hole and the through hole; etching the second passivation layer and the gate insulating layer using the first photoresist pattern as an etch mask such that the drain electrode is exposed through the drain contact hole and the substrate is exposed through the through hole; forming a transparent conductive material layer on the first photoresist pattern and on the second passivation layer; changing the crystalline state of the transparent conductive material layer such that the crystalline state of first portions of the transparent conductive material layer on the first passivation layer are different than second portions of the transparent conductive material layer over the first passivation layer; forming a first photoresist layer on the transparent conductive material layer; anisotropically removing the first photoresist layer to form a second photoresist pattern on the transparent conductive material layer in the drain contact hole and the through hole; selectively etching the second portions of the transparent conductive material layer to form a drain terminal in the drain contact hole and a pixel electrode in the through hole; removing the first and second photoresist patterns; and forming a reflective plate on the drain terminal and the pixel electrode, the reflective plate contacting the drain terminal and the pixel electrode.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a cross-sectional view of an array substrate for a transfective LCD device according to the related art.

FIGS. 2A to 2F are cross-sectional views showing a fabrication process of an array substrate for a transfective LCD device according to the related art.

FIG. 3 is a plane view of an array substrate for a transfective LCD device according to an embodiment of the present invention.

FIG. 4 is a cross-sectional view along line "IV-IV" of FIG. 3.

FIG. 5 is a cross-sectional view along line "V-V" of FIG. 3.

FIG. 6 is a cross-sectional view along line "VI-VI" of FIG. 3.

FIGS. 7A to 7J are cross-sectional views, which along line "IV-IV" of FIG. 3, showing a fabricating process of an array substrate for a transfective LCD device according to an embodiment of the present invention.

FIGS. 8A to 8J are cross-sectional views, which are along line "V-V" of FIG. 3, showing a fabricating process of an array substrate for a transfective LCD device according to an embodiment of the present invention.

FIGS. 9A to 9J are cross-sectional views, which are along line "VI-VI" of FIG. 3, showing a fabricating process of an array substrate for a transfective LCD device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, similar reference numbers will be used to refer to the same or similar parts.

FIG. 3 is a plan view of an array substrate for a transfective LCD device according to an embodiment of the present invention. As shown in FIG. 3, a gate line 113 and a data line 135 are formed on a substrate 110. The gate line 113 and the data line 135 cross each other, to thereby define a pixel region "P." A thin film transistor (TFT) "Tr," as a switching element, is electrically connected to the gate line 113 and the data line 135. The TFT "Tr" includes a gate electrode 115, a gate insulating layer (not shown), a semiconductor layer 125, a source electrode 140 and a drain electrode 143. The semiconductor layer 125 has an active layer and an ohmic contact layer. A gate pad 117 is formed at one end of the gate line 113, and a data pad 148 is formed at one end of the data line 135. Although not shown in FIG. 3, an external driving circuit contacts the gate pad 117 and the data pad 148, and supplies a gate signal and a data signal through the gate pad 117 and the data pad 148, respectively.

The pixel region "P" includes a transmissive area "TA" at a central portion thereof and a reflective area "RA" surrounding the transmissive area "TA." A second passivation layer (not shown) of an organic insulating material has a through hole (TH) corresponding to the transmissive area "TA," and a reflective plate 186 is formed to correspond to the reflective area "RA." The second passivation layer has an uneven top surface to prevent a mirror reflection at the reflective plate 186. The reflective plate 186 is electrically connected to the drain electrode 143 of the TFT "Tr" through a drain contact hole 158. A pixel electrode 173 of a transparent conductive material is formed in the transmissive area "TA." Thus, the pixel electrode is formed at a bottom and a sidewall of the through hole "TH," and contacts the reflective plate 186 at edge portions.

A storage capacitor "StgC" is formed in a boundary of the pixel region "P." The storage capacitor "StgC" includes a first storage electrode 114 of a portion of the gate line 113, a dielectric layer (not shown) of the gate insulating layer on the first storage electrode 114 and a second storage electrode 146 on the dielectric layer over the first storage electrode 114. The second storage electrode 146 is electrically connected to the reflective plate 186 through a storage contact hole 160.

In this embodiment, the storage capacitor "StgC" has a storage-on-gate structure where the gate line 113 is used as the first storage electrode 114, more particularly, a storage-on-previous gate structure where an n^{th} pixel region uses a $(n-1)^{\text{th}}$ gate line as a first storage capacitor. In another

embodiment, however, a storage capacitor can have a storage-on-common structure, where a common line parallel to the gate line is used as a first storage electrode, and a metal pattern overlapping the common line and connected to a pixel electrode through a contact hole is used as a second storage electrode.

FIG. 4 is a cross-sectional view along line "IV-IV" of FIG. 3, and FIG. 5 is a cross-sectional view along line "V-V" of FIG. 3. In addition, FIG. 6 is a cross-sectional view along line "VI-VI" of FIG. 3. As shown in FIGS. 4 to 6, a substrate 110 has a pixel region "P" defined by a crossing of a gate line 113 and a data line 135. A gate pad area "GPA" is at one end of the gate line 113 and a data pad area "DPA" is at one end of the data line 135. A gate pad 117 is formed in the gate pad area "GPA" and a data pad 148 is formed in the data pad area "DPA." The pixel region "P" includes a transmissive area "TA" corresponding to a through hole "TH" and a reflective area "RA" corresponding to a reflective plate 186. A transistor area "TrA" where a thin film transistor (TFT) "Tr" is formed and a storage capacitor area "StgA" where a storage capacitor "StgC" is formed can be defined in the reflective area "RA."

The gate line 113 is formed on the substrate 110 and a gate electrode 115 extending from the gate line 113 is formed in the transistor area "TrA" of the reflective area "RA." A gate insulating layer 120 is formed on the gate electrode 115, and a semiconductor layer 125 is formed on the gate insulating layer 120. The semiconductor layer 125 can include an active layer 125a, such as intrinsic amorphous silicon, and an ohmic contact layer 125b, such as, impurity-doped amorphous silicon. The ohmic contact layer 125b is separated into two portions so as to expose the active layer 125a between the two portions. Source and drain electrodes 140 and 143 are formed on the ohmic contact layer 125b. The gate electrode 115, the semiconductor layer 125, the source electrode 140 and the drain electrode 143 constitute the thin film transistor (TFT) "Tr" as a switching element. The data line 135 crossing the gate line 113 to define the pixel region "P" is formed on the gate insulating layer 120. The data line 135 is connected to the source electrode 140 of the TFT "Tr."

The gate pad 117 is formed in the gate pad area "GPA" for connection to one end of the gate line 113 and the data pad 148 is formed in the data pad area "DPA" for connection to one end of the data line 135. In the storage area "StgA," a second storage electrode 146 having an island shape is formed over the gate insulating layer 120 on the gate line 113. The second storage electrode 146 can be formed of the same material as the source and drain electrodes 140 and 143.

A first passivation layer 150 of an inorganic insulating material is formed on the TFT "Tr," and a second passivation layer 155 of an organic insulating material is formed on the first passivation layer 150 corresponding to the reflective area "RA." The second passivation layer 155 has an uneven top surface contour that is like the top surface of the reflective plate 186, which is subsequently formed over the second passivation layer 155. A portion of the second passivation layer 155 corresponding to the transmissive area "TA" is removed to form the through hole "TH" exposing the substrate 110. In addition, portions of the second passivation layer 155 corresponding to the gate pad area "GPA" and the data pad area "DPA" are removed to expose the gate pad 117 and the data pad 148. The second passivation layer 155 has a drain contact hole 158 exposing the drain electrode 143 and a storage contact hole 160 exposing the second storage electrode 146 formed by removing portions of the second passivation layer 155.

A third passivation layer 170 of an inorganic insulating material is formed on the second passivation layer 155. Por-

tions of the third passivation layer 170 corresponding to the through hole "TH," the drain contact hole 158 and the storage contact hole 160 are removed. In addition, portions of the third passivation layer 170 corresponding to the gate pad 117 and the data pad 148 are removed to form a gate pad contact hole 162 and a data pad contact hole 164, respectively. As a result, the through hole "TH" is formed through the third passivation layer 170, the second passivation layer 155, the first passivation layer 150 and the gate insulating layer 120 in the transmissive area "TA" to expose the substrate 110. The drain contact hole 158 is formed through the third passivation layer 170, the second passivation layer 155 and the first passivation layer 150 in the transistor area "TrA" to expose the drain electrode 143. The storage contact hole 160 is formed through the third passivation layer 170, the second passivation layer 155 and the first passivation layer 150 in the storage area "StgA" to expose the second storage electrode 146. In addition, the gate pad contact hole is formed through the third passivation layer 170, the first passivation layer 150 and the gate insulating layer 120 in the gate pad area "GPA" to expose the gate pad 117, and the data pad contact hole 164 is formed through the third passivation layer 170 and the first passivation layer 150 in the data pad area "DPA" to expose the data pad 148.

A pixel electrode 173 of a transparent conductive material is formed on the bottom and sidewall of the through hole "TH." Accordingly, the pixel electrode 173 contacts the substrate 110 in the transmissive area "TA." Similarly, a drain terminal 175 of a transparent conductive material is formed in the bottom and sidewall of the drain contact hole 158 to contact the drain electrode 143, and the storage terminal 177 of a transparent conductive material is formed on bottom and sidewall of the storage contact hole 160 to contact the second storage electrode 146. In addition, a gate pad terminal 180 is formed on the bottom and sidewall of the gate pad contact hole 162 to contact the gate pad 117, and a data pad terminal 182 of a transparent conductive material is formed on the bottom and sidewall of the data pad contact hole 164 to contact the data pad 148.

A reflective plate 186 of a metallic material having a relatively high reflectance is formed on the third passivation layer 170 in the reflective area "RA." The reflective plate 186 is connected to the pixel electrode 173, the drain terminal 175 and the storage terminal 177. The reflective plate 186 contacts the pixel electrode on the sidewall of the through hole "TH." In addition, the reflective plate 186 contacts the drain terminal 175 on the bottom and the sidewall of the drain contact hole 158, and contacts the storage terminal 177 on the bottom and the sidewall of the storage contact hole 160. The reflective plate 186 is independently formed in each pixel region "P" and functions as a reflective electrode because the reflective plate 186 is electrically connected to the drain electrode 143.

FIGS. 7A to 7J, 8A to 8J, and 9A to 9J are cross-sectional views showing a fabricating process of an array substrate for a transmissive LCD device according to an embodiment of the present invention. FIGS. 7A to 7J are along line "IV-IV" of FIG. 3. In addition, FIGS. 8A to 8J are along line "V-V" of FIG. 3, and FIGS. 9A to 9J are along a line "VI-VI" of FIG. 3.

In FIGS. 7A, 8A and 9A, after a first metal layer (not shown) is formed on a substrate 110, the first metal layer is patterned through a first mask process to form a gate line 113, a gate electrode 115 extending from the gate line 113 in a transistor area "TrA" of a pixel region "P" and a gate pad 117 at one end of the gate line 113. In the first mask process, a first photoresist (PR) layer (not shown) can be formed on the first metal layer and can be exposed through a first mask (not

shown) having a transmissive region and a blocking region. The exposed first PR layer is developed to form a first PR pattern, and the first metal layer is etched using the first PR pattern as an etch mask to form the gate line 113, the gate electrode 115 and the gate pad 117.

In FIGS. 7B, 8B and 9B, a gate insulating layer 120 is formed on the gate line 113, the gate electrode 115 and the gate pad 117 by depositing an inorganic insulating material, such as silicon oxide (SiO_2) and silicon nitride (SiN_x). An intrinsic amorphous silicon layer (not shown), an impurity-doped amorphous silicon layer (not shown) and a second metal layer are sequentially formed on the gate insulating layer 120. Through a second mask process, the second metal layer is patterned to form a source electrode 140, a drain electrode 143, a data line 135 and a data pad 148, and the impurity-doped amorphous silicon layer and the intrinsic amorphous silicon layer are patterned to form a semiconductor layer 125 including an active layer 125a and an ohmic contact layer 125b. In the second mask process, a second PR layer (not shown) can be formed on the second metal layer, and can be exposed through a second mask (not shown) having a transmissive region, a blocking region and a half-transmissive region such that a transmittance of the half-transmissive region is greater than a transmittance of the blocking region and smaller than a transmittance of the transmissive region. Since the half-transmissive region of the second mask can be obtained from a slit pattern or a half-tone pattern, an exposure step using the second mask is referred to as a diffraction exposure or a half-tone exposure. The exposed second PR layer is developed to form a second PR pattern 191 corresponding to the transistor area "TrA," the storage area "StgA" and the data pad area "DPA."

The second PR pattern 191 includes a first portion 191a having a first thickness and a second portion 191b having a second thickness smaller than the first thickness. The first portion 191a of the second PR pattern 191 corresponds to a portion where the second metal layer, the impurity-doped amorphous silicon layer and the intrinsic amorphous silicon layer remain in a subsequent process, and the second portion 191b of the second PR layer 191 corresponds to another portion where the second metal layer is removed and the impurity-doped amorphous silicon layer and the intrinsic amorphous silicon layer remain in a subsequent process. In the transistor area "TrA," for example, the first portion 191a of the second PR layer 191 corresponds to a portion for source and drain electrodes and the second portion 191b of the second PR layer corresponds to another portion for a channel region. Accordingly, the first portion 191a of the second PR layer 191 corresponds to a data line, a source electrode, a drain electrode, a second storage electrode and a data pad of a subsequent process, while the second portion 191b of the second PR layer 191 corresponds to the channel region between the source and drain electrodes.

The second metal layer, the impurity-doped amorphous silicon layer and the intrinsic amorphous silicon layer are etched using the second PR pattern 191 having the first and second portions 191a and 191b as an etch mask to form a source-drain pattern 138, an impurity-doped amorphous silicon pattern 123 under the source-drain pattern 138 and an active layer 125a under the impurity-doped amorphous silicon pattern 123 in the transistor area "TrA." At the same time, a data line 135 crossing the gate line 113, a data pad 148 at one end of the data line 135 and a second storage electrode 146 overlapping the gate line 113 are formed by etching the second metal layer, the impurity-doped amorphous silicon layer and the intrinsic amorphous silicon layer. A portion of the gate line 113 overlapping the second storage electrode 146 in

the storage area "StgA" functions as a first storage electrode 114. Here, a storage impurity-doped amorphous silicon pattern 127a and a storage intrinsic amorphous silicon pattern 127b having the same shape as the second storage electrode 146 are formed under the second storage electrode 146. Similarly, a data impurity-doped amorphous silicon pattern and a data intrinsic amorphous silicon pattern having the same shape as the data line 135 are formed under the data line 135.

In FIGS. 7C, 8C and 9C, the second portion 191b (of FIG. 7B) of the second PR pattern 191 are removed by an ashing step to expose a portion of the source-drain pattern 138 (of FIG. 7B). Since the first portion 191a (of FIGS. 7B and 9B) of the second PR pattern 191 has the first thickness greater than the second thickness, the first portion 191a of the second PR pattern 191 remains even after the second portion 191b of the second PR pattern 191 is removed. The remaining first portion (not shown) of the second PR pattern can have a thickness corresponding to a difference between the first and second thicknesses.

The portion of the source-drain pattern 138 (of FIG. 7B) exposed through the remaining first portion of the second PR pattern 191 and the impurity-doped amorphous silicon pattern 123 (of FIG. 7B) under the exposed portion of the source-drain electrode 138 are etched using the remaining first portion of the second PR pattern 191 as an etch mask to form a source electrode 140, a drain electrode 143 and an ohmic contact layer 125b under the source and drain electrodes 140 and 143. The source and drain electrodes 140 and 143 are spaced apart from each other and on opposite sides of the gate electrode 115 in the transistor area "TrA," and the ohmic contact layer 125b has the same shape as the source and drain electrodes 140 and 143. After the source electrode 140, the drain electrode 143 and the ohmic contact layer 125b are formed, the remaining first portion of the second PR pattern 191 is removed by a stripping step.

As shown in FIGS. 7D, 8D and 9D, a first passivation layer 150 of an inorganic insulating material, such as silicon oxide (SiO_2) or silicon nitride (SiN_x), is formed on the data line 135, the source electrode 140, the drain electrode 143 and the second storage electrode 146. When the active layer 125a contacts a second passivation layer 155 of an organic material in a subsequent process, the active layer 125a can be degraded by contamination that causes deterioration of the TFT "Tr." To prevent such contamination, the first passivation layer 150 prevents a contact between the active layer 125a and the second passivation layer 155. In an alternative embodiment, the first passivation layer 150 can be omitted when possible degradation of the active layer 125a is negligible.

The second passivation layer 155 is formed on the first passivation layer 150 through a third mask process. An organic insulating material layer having a photosensitivity is formed on the first passivation layer 150, and is exposed through a third mask (not shown) having a transmissive region, a blocking region and a half-transmissive region such that a transmittance of the half-transmissive region is greater than a transmittance of the blocking region and smaller than a transmittance of the transmissive region. For example, when the organic insulating material layer has a positive type photosensitivity, the third mask can be aligned such that transmissive regions correspond to the transmissive area "TA," the gate pad area "GPA," the data pad area "DPA," the drain contact hole 158 and the storage contact hole 160, and alternating blocking and half-transmissive regions correspond to the reflective area "RA." In the alternative, when the organic insulating material layer has a negative type photosensitivity, the third mask can be aligned such that blocking regions correspond to the transmissive area "TA," the gate pad area

“GPA,” the data pad area “DPA,” the drain contact hole 158 and the storage contact hole 160, and alternating transmissive region and the half-transmissive region correspond to the reflective area “RA.”

The organic insulating material layer is exposed through the third mask and the exposed organic insulating material layer is developed to form the through hole “TH” exposing the first passivation layer 150 in the transmissive area “TA,” the drain contact hole 158 exposing the first passivation layer 150 on the drain electrode 143, and the storage contact hole 160 exposing the first passivation layer 150 on the second storage electrode 146. The second passivation layer can have an uneven top surface due to the half-transmissive region of the third mask. The round shape of the uneven top surface of the second passivation layer 155 can be obtained by an additional heat treatment step.

As shown in FIGS. 7E, 8E and 9E, a third passivation layer 170 of an inorganic insulating material, such as silicon oxide (SiO₂) or silicon nitride (SiN_x), is formed on the second passivation layer 155 through a fourth mask process. A third PR layer (not shown) is formed on the third passivation layer 170 and is exposed through a fourth mask (not shown) having a transmissive region and a blocking region. The exposed third PR layer is developed to form a third PR pattern 193 exposing portions corresponding to the drain contact hole 158, the storage contact hole 160, the through hole “TH,” the gate pad area “GPA” and the data pad area “DPA.” In the alternative, the third passivation layer 170 can be omitted.

The third passivation layer 170, the first passivation layer 150 and the gate insulating layer 120 are sequentially etched using the third PR pattern 193 as an etch mask to complete the drain contact hole 158 exposing the drain electrode 143, the storage contact hole 160 exposing the second storage electrode 146, the through hole “TH” exposing the substrate 110, the gate pad contact hole 162 exposing the gate pad 117 and the data pad contact hole exposing the data pad 148. As a result, the through hole “TH” is formed through the gate insulating layer 120, the first passivation layer 150, the second passivation layer 155 and the third passivation layer 170, and the gate pad contact hole 162 is formed through the gate insulating layer 120, the first passivation layer 150 and the third passivation layer 170. In addition, the drain contact hole 158 and the storage contact hole 160 are formed through the first, second and third passivation layers 150, 155 and 170. The data pad contact hole 164 is formed through the first passivation layer 150 and third passivation layer 170.

As shown in FIGS. 7F, 8F and 9F, a transparent conductive material layer 172 is formed on the third PR pattern 193. Accordingly, the transparent conductive material layer 172 is formed on bottoms and sidewalls of the drain contact hole 158, the storage contact hole 160, the through hole “TH,” the gate pad contact hole 162 and the data pad contact hole 164. A fourth PR layer 195 is formed on the transparent conductive material layer 172. Since the fourth PR layer 195 is formed by coating method having an excellent step coverage property, the drain contact hole 158, the storage contact hole 160, the through hole “TH,” the gate pad contact hole 162 and the data pad contact hole 164 are filled up with the fourth PR layer 195 having a flat top surface.

As shown in FIGS. 7G, 8G and 9G, the fourth PR layer 195 is removed by an ashing method having an anisotropic property. Accordingly, the fourth PR layer 195 is equally removed along a downward direction to expose the transparent conductive material layer 172 except on the bottoms and the sidewalls of the drain contact hole 158, the storage contact hole 160, the through hole “TH,” the gate pad contact hole 162 and the data pad contact hole 164. Since the transparent

conductive material layer 172 is not removed by the ashing method, the ashing method for the fourth PR layer 195 can be continuously performed even after the fourth PR layer 195 in the reflective area “RA” is removed. As a result, a fourth PR pattern 195a remains on the bottoms and the sidewalls of the drain contact hole 158, the storage contact hole 160, the through hole “TH,” the gate pad contact hole 162 and the data pad contact hole 164. The fourth PR pattern 195a can have a top surface height smaller than a top surface height of the second passivation layer 155 by controlling time period, or type and amount of gas for the ashing method. Since a thickness of the fourth PR layer 195 in the reflective area “RA” is much smaller than a thickness of the fourth PR layer 195 in each holes 158, 160, “TH,” 162 and 164 due to the third PR pattern 193 and the second passivation layer 155, the fourth PR pattern 195a remains more stably.

As shown in FIG. 7H, 8H and 9H, the transparent conductive material layer 172 (of FIGS. 7G, 8G and 9G) is etched using the fourth PR pattern 195a as an etch mask to form a pixel electrode 173, a drain terminal 175, a storage terminal 177, a gate pad terminal 180 and a data pad terminal 182. More particularly, the transparent conductive material layer 172 can be selectively etched leaving the pixel electrode 173 based upon the transparent conductive layer 172 on the third PR pattern 193 having a different crystalline state than the pixel electrode 173. The difference in crystalline states can be done by a laser process or ultraviolet treatment after forming the transparent conductive layer 172 or, in the alternative, by a laser or thermal process after forming the fourth PR pattern 195a.

The pixel electrode 173 contacts the substrate in the through hole “TH.” In addition, the drain terminal 175 and the storage terminal contact the drain electrode 143 in the drain contact hole 158 and the second storage electrode 146 in the storage contact hole 160, respectively. Further, the gate pad terminal 180 and the data pad terminal 182 contact the gate pad 117 in the gate pad contact hole 162 and the data pad 148 in the data pad contact hole 164, respectively.

As shown in FIGS. 7I, 8I and 9I, the third and fourth PR patterns 193 and 195a (of FIGS. 7H, 8H and 9H) are removed by a stripping method to expose the third passivation layer 170, the pixel electrode 173, the drain terminal 175, the storage terminal 177, the gate pad terminal 180 and the data pad terminal 182.

As shown in FIGS. 7J, 8J and 9J, a reflective plate 186 is formed on the third passivation layer 170 through a fifth mask process. In the fifth mask process, a third metal layer (not shown) is formed on the third passivation layer 170, the pixel electrode 173, the drain terminal 175, the storage terminal 177, the gate pad terminal 180 and the data pad terminal 182, and a fifth PR layer (not shown) is formed on the third metal layer. A metallic material, such as aluminum (Al) or aluminum (Al) alloy, having a high reflectance can be used for the third metal layer. The fifth PR layer is exposed through a fifth mask (not shown) having a transmissive region and a blocking region to form a fifth PR pattern (not shown). The third metal layer is etched using the fifth PR pattern as an etch mask to form the reflective plate 186. The reflective plate 186 contacts the pixel electrode 173 on the sidewall of the through hole “TH,” and contacts the drain terminal 175 on the bottoms and the sidewalls of the drain contact hole 158 and the storage terminal 177 on the bottoms and the sidewalls of the storage contact hole 160. As a result, the reflective plate 186 is electrically connected to the drain electrode 143, the second storage electrode 146 and the pixel electrode 173. Thus, the reflective plate 186 functions as an electrode for driving a liquid crystal layer of a transmissive LCD device in a subse-

quent process. Since the reflective plate **186** and the pixel electrode **173** contact each other on the sidewall of the through hole “TH,” it is preferable that the through hole “TH” has a slanted sidewall for more reliable contact.

In embodiments of the present invention, since an array substrate for a transreflective LCD device is fabricated through a five-mask process, production yield is improved and fabrication cost is reduced. In addition, since a reflective plate having an uneven top surface is formed at a top of the array substrate, a mirror reflection is prevented and a reflection efficiency is maximized.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A method of fabricating an array substrate for a transreflective liquid crystal display device, comprising: forming a gate line and a data line on a substrate, the gate line and the data line crossing each other to define a pixel region including a transmissive area and a reflective area surrounding the transmissive area; forming a gate insulating layer between the gate line and the data line; forming a thin film transistor connected to the gate line and the data line; forming a first passivation layer on the thin film transistor, the first passivation layer having a drain contact hole exposing a drain electrode of the thin film transistor and a through hole exposing the gate insulating layer on the substrate in the transmissive area;

forming a second passivation layer on the first passivation layer; forming a first photoresist pattern on the second passivation layer, the first photoresist pattern exposing the drain contact hole and the through hole; etching the second passivation layer and the gate insulating layer using the first photoresist pattern as an etch mask such that the drain electrode is exposed through the drain contact hole and the substrate is exposed through the through hole; forming a transparent conductive material layer on the first photoresist pattern and on the second passivation layer; changing the crystalline state of the transparent conductive material layer such that the crystalline state of first portions of the transparent conductive material layer on the first passivation layer are different than second portions of the transparent conductive material layer over the first passivation layer; forming a first photoresist layer on the transparent conductive material layer; anisotropically removing the first photoresist layer to form a second photoresist pattern on the transparent conductive material layer in the drain contact hole and the through hole; selectively etching the second portions of the transparent conductive material layer to form a drain terminal in the drain contact hole and a pixel electrode in the through hole; removing the first and second photoresist patterns; and forming a reflective plate on the drain terminal and the pixel electrode, the reflective plate contacting the drain terminal and the pixel electrode.

2. The method according to claim **1**, wherein changing the crystalline state includes one of a laser process or ultraviolet treatment after forming the transparent conductive layer.

* * * * *

专利名称(译)	透反液晶显示装置及其制造方法		
公开(公告)号	US8368856	公开(公告)日	2013-02-05
申请号	US13/114033	申请日	2011-05-23
[标]申请(专利权)人(译)	李正II 杨JOONG YOUNG		
申请(专利权)人(译)	李正II 杨JOONG-YOUNG		
当前申请(专利权)人(译)	LG DISPLAY CO. , LTD.		
[标]发明人	LEE JUNG IL YANG JOONG YOUNG		
发明人	LEE, JUNG IL YANG, JOONG-YOUNG		
IPC分类号	G02F1/1335		
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摘要(译)

一种半透半反液晶显示装置用阵列基板，包括：基板；栅极线和数据线在基板上，栅极线和数据线彼此交叉以限定像素区域，该像素区域包括透射区域和围绕透射区域的反射区域；薄膜晶体管，具有栅极绝缘层，薄膜晶体管电连接到栅极线和数据线；第一钝化层，具有暴露薄膜晶体管的漏极的漏极接触孔和在透射区域中暴露衬底的通孔；第一钝化层上的像素电极，像素电极通过通孔与透射区域中的基板接触；在像素电极上的反射板上，反射板通过漏极接触孔与像素电极电连接到漏极。

