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

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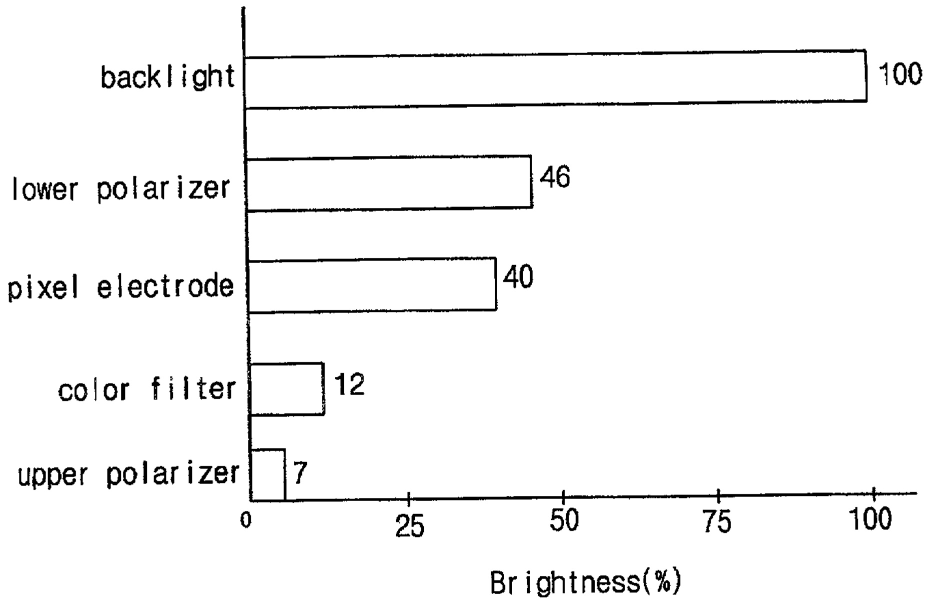
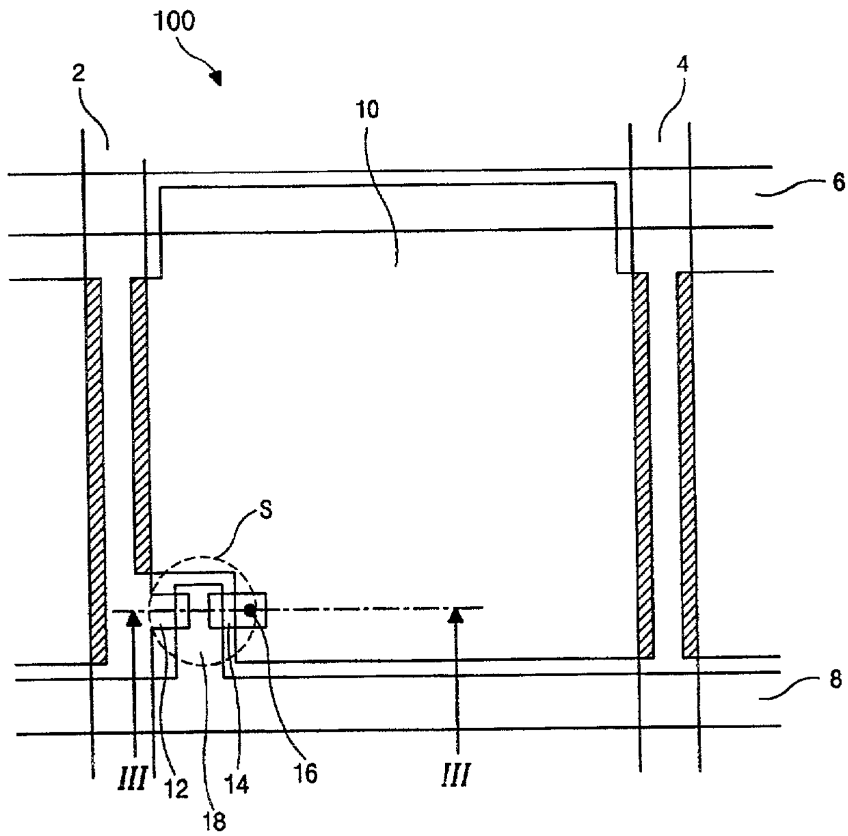
(57) **ABSTRACT**

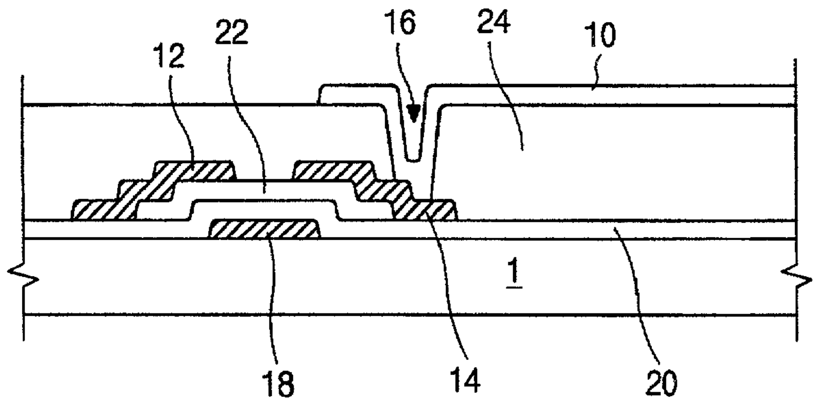
An array substrate of the transflective LCD device that includes forming a reflective plate on the substrate at first. An array substrate of transflective LCD device, including: a substrate having switching elements and a pixel region; a reflective plate formed on the substrate and having a light transmitting hole; a first insulating layer formed on the reflective plate while covering the light transmitting hole; a gate electrode formed on the first insulating layer over the reflective plate; a gate insulating layer formed on the first insulating layer while covering the gate electrode; an active layer formed on the gate insulating layer over the gate electrode and having a channel region; an ohmic contact layer formed on the active layer; source and drain electrodes formed on the ohmic contact layer and spaced apart from each other; a second insulating layer formed on the gate insulating layer while covering the source and drain electrode, the second insulating layer having a drain contact hole which exposes the predetermined portion of the drain electrode; and a pixel electrode formed on the second insulating layer and contacting the drain electrode through the drain contact hole.



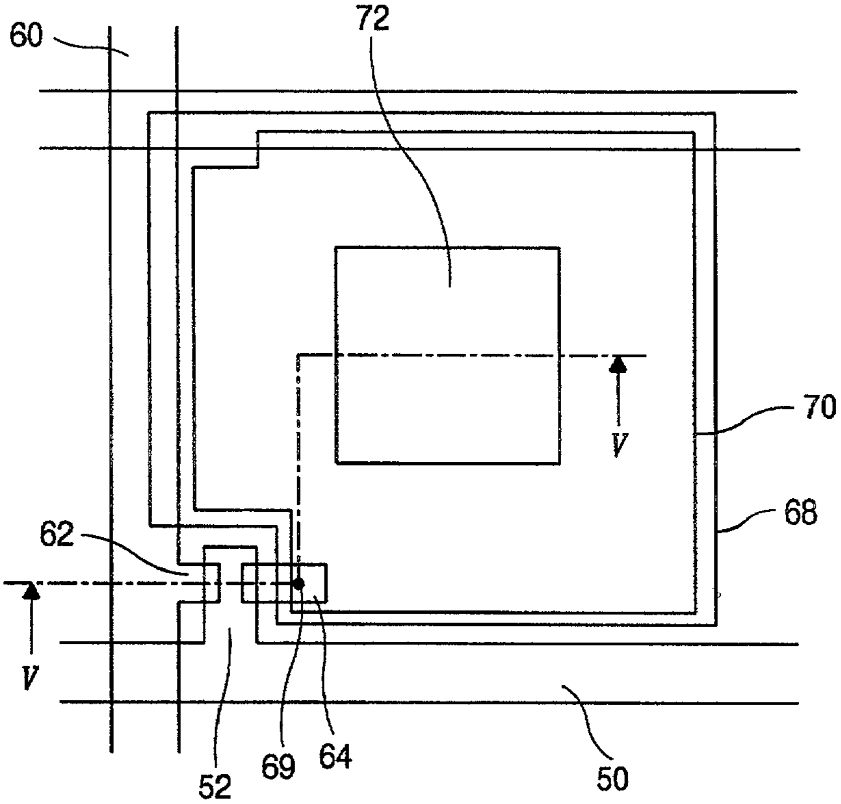
(RELATED ART)
FIG. 1



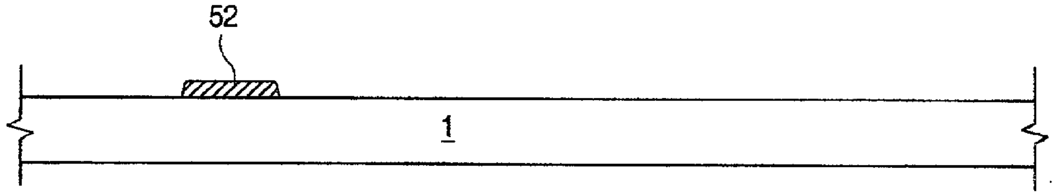
(RELATED ART)
FIG. 2



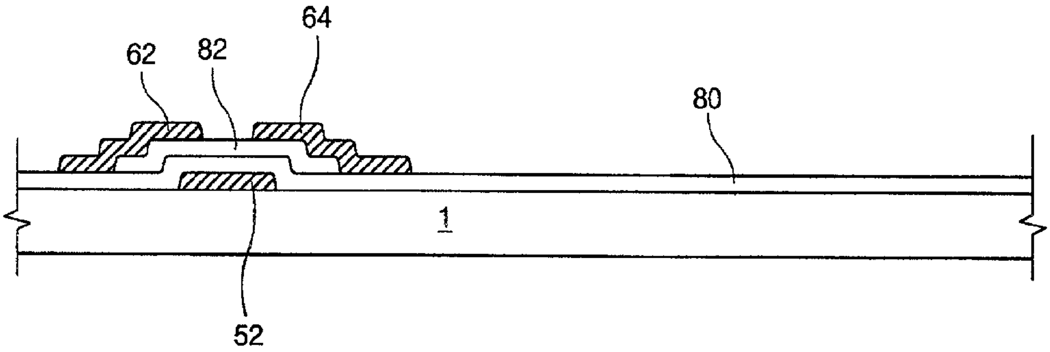
(RELATED ART)
FIG. 3



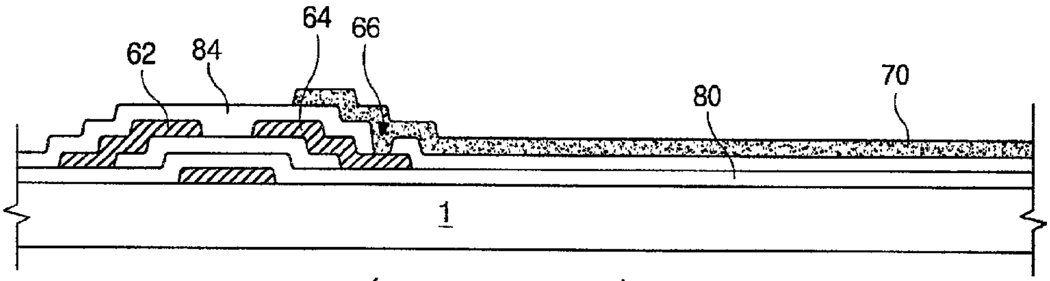
(RELATED ART)
FIG. 4



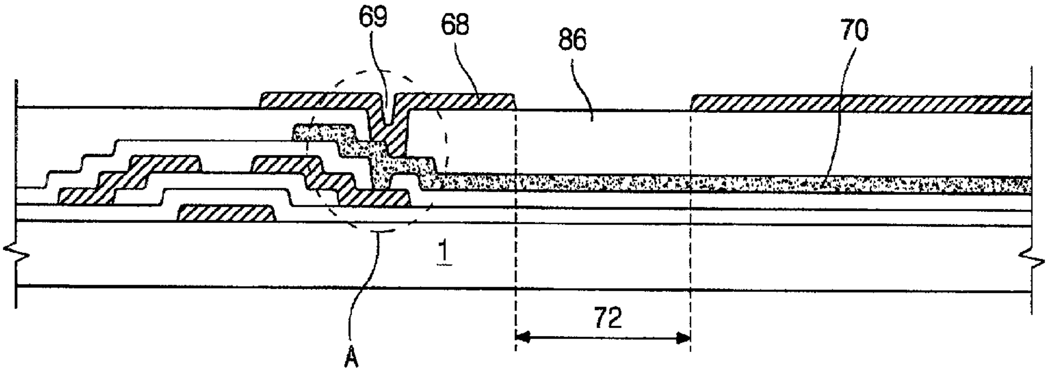
(RELATED ART)
FIG. 5A



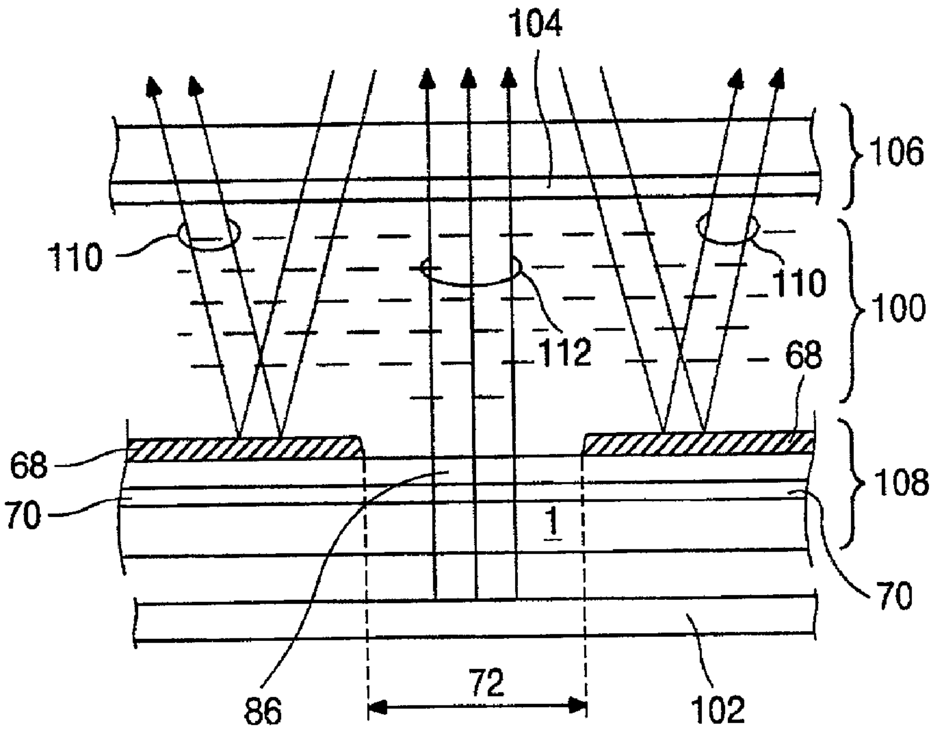
(RELATED ART)
FIG. 5B



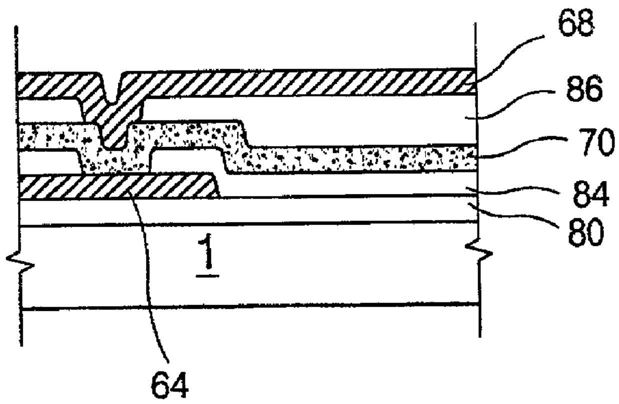
(RELATED ART)
FIG. 5C



(RELATED ART)
FIG. 5D



(RELATED ART)
FIG. 6



(RELATED ART)
FIG. 7

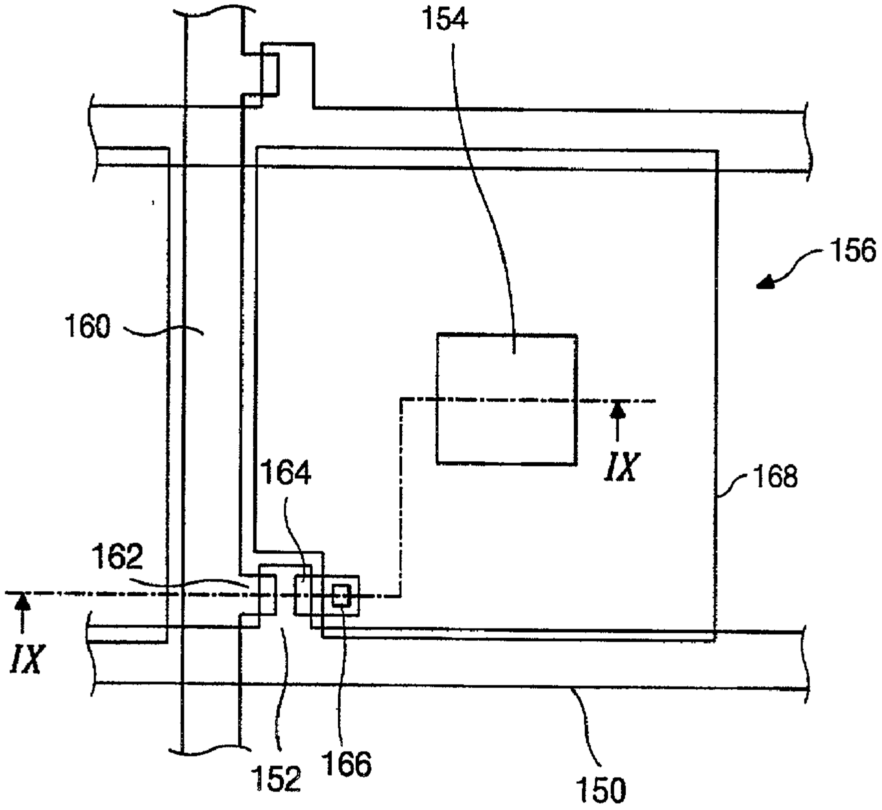


FIG. 8

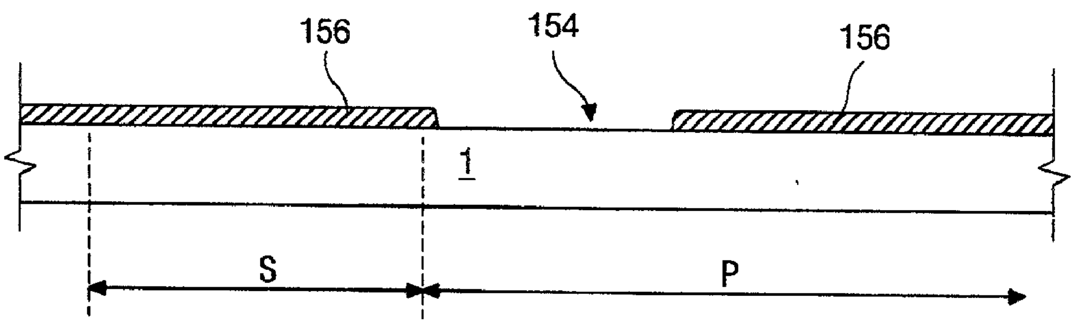


FIG. 9A

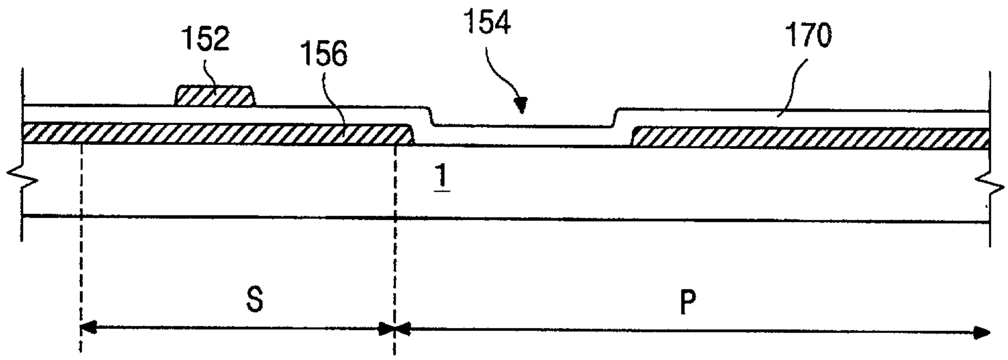


FIG. 9B

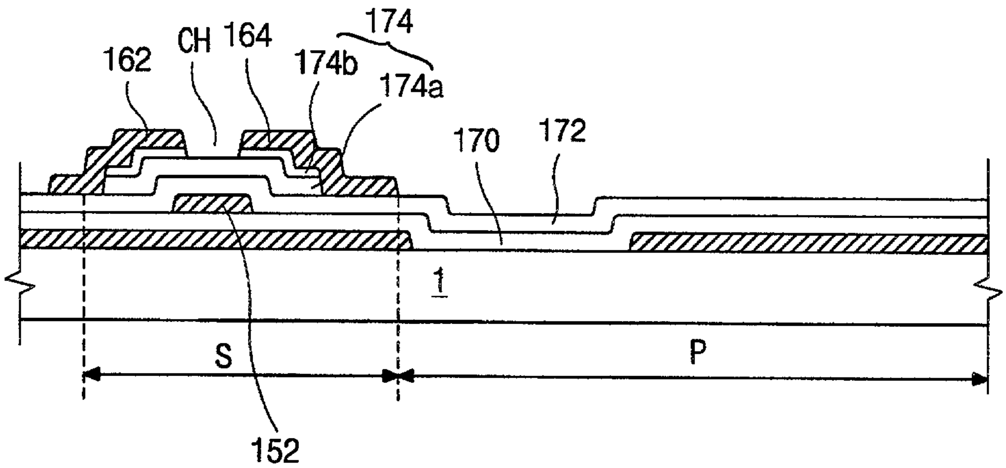


FIG. 9C

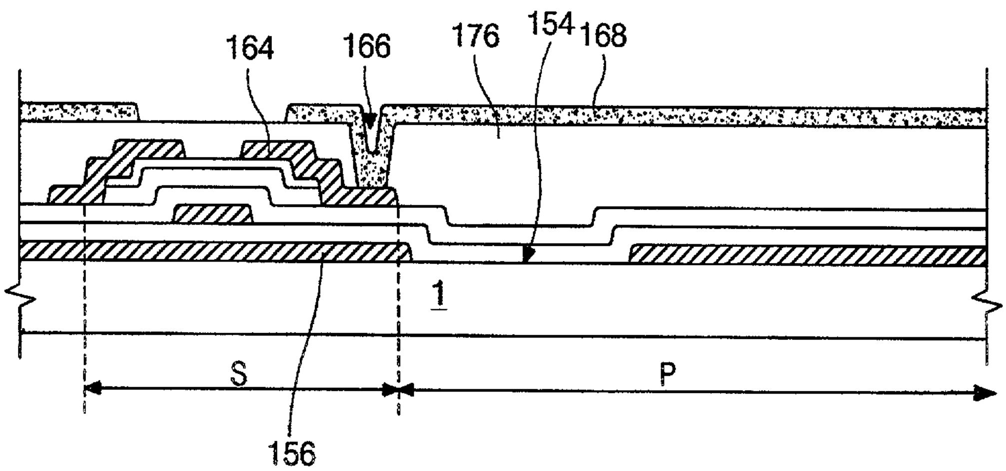


FIG. 9D

TRANSFLECTIVE LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME

CROSS REFERENCE

[0001] This application claims the benefit of Korean Patent Application No. 1999-63250, filed on Dec. 28, 1999, under 35 U.S.C. § 119, the entirety of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the invention

[0003] The present invention relates to a liquid crystal display (LCD) device, and more particularly, to a transflective LCD device and a method of manufacturing the same.

[0004] 2. Description of Related Art

[0005] Until now, the cathode-ray tube (CRT) has been developed for and is mainly used for the display systems. However, the flat panel display is beginning to make its appearance due to the requirement of the small depth dimensions, undesirably low weight and low voltage power supply. At this point, the thin film transistor-liquid crystal display (TFT-LCD) having a high resolution and small depth dimension has been developed.

[0006] In a point of the operating principles of the TFT-LCD, when the pixel is turned ON by the switching elements, the pixel transmits the light generated from the backlight device. The switching elements are generally the amorphous silicon thin film transistor (a-Si:H TFT) which have the semiconductor layer because the amorphous silicon TFT can be formed on the low cost glass substrate in a low temperature.

[0007] In general, the TFT-LCD demonstrates the image using the light from the back light device that is positioned under the TFT-LCD panel. However, the TFT-LCD only employs 3~8% of the incident light generated from the backlight device, i.e., the inefficient optical modulation.

[0008] Referring to the attached drawings, an array substrate of an LCD device that is manufactured by a conventional method will now be explained in some detail.

[0009] **FIG. 1** is a graph illustrating a transmittance respectively measured after light passes through each layers of a conventional liquid crystal display device.

[0010] The two polarizers have a transmittance of 45% and, the two substrates have a transmittance of 94%. The TFT array and the pixel electrode have a transmittance of 65%, and the color filter has a transmittance of 27%. Therefore, the typical transmissive LCD device has a transmittance of about 7.4% as seen in **FIG. 1**, which shows a transmittance (in brightness %) after light passes through each layer of the device. For this reason, the transmissive LCD device requires a high, initial brightness, and thus electric power consumption by the backlight device increases. A relatively heavy battery is needed to supply a sufficient power to the backlight of such a device. Moreover, there still exists a problem that the battery can not be used for a long time.

[0011] In order to overcome the problem described above, the reflective LCD has been developed. Since the reflective LCD device uses ambient light, it is light and easy to carry. Also, the reflective LCD device is superior in aperture ratio compared to the transmissive LCD device.

[0012] **FIG. 2** is a plan view illustrating a typical reflective LCD device. As shown in **FIG. 2**, the reflective LCD device **100** includes gate lines **6** and **8** arranged in a transverse direction, data lines **2** and **4** arranged in a longitudinal direction perpendicular to the gate lines **6** and **8**, and thin film transistors (TFTs), for example, the thin film transistor "S" near a cross point of the gate line **8** and the data line **2**. Each of the TFTs "S" has a gate electrode **18**, a source electrode **12** and a drain electrode **14**. The gate electrode **18** extends from the data line **2**, and the gate electrode **18** extends from the gate line **8**. The reflective LCD device **100** further includes reflective electrodes **10**. The reflective electrode **10** is electrically connected with the drain electrode **14** through a contact hole **16** and is made of a metal having a good reflectance.

[0013] **FIG. 3** is a cross sectional view taken along the line III-III of **FIG. 2**. As shown in **FIG. 3**, the gate electrode **18** is formed on the substrate **1**, and a gate insulating layer **20** is formed on the exposed surface of the substrate **1** while covering the gate electrode **18**. A semiconductor layer **22** as an active area of the TFT "S" (see **FIG. 2**) is formed over the gate electrode **18**. The source and drain electrodes **12** and **14** are spaced apart from each other. The source electrode **12** overlaps one end portion of the semiconductor layer **22**, and the drain electrode **14** overlaps the other end portion of the semiconductor layer **22**. A passivation film **24** is formed over the whole surface of the substrate **1** while covering the TFT "S". The passivation film **24** has the contact hole **16** on the predetermined portion of the drain electrode **14**. The reflective electrode **10** is formed on the passivation film **24** and is electrically connected with the drain electrode **14** through the contact hole **16**.

[0014] As mentioned above, since the reflective LCD device uses ambient light, the battery is not necessary. By the way, the reflective LCD device has a problem that it is affected by its surroundings. For example, the brightness of indoors-ambient light differs largely from that of outdoors. Also, even in the same location, the brightness of ambient light depends on the time of day (e.g., noon or dusk). Therefore, the reflective LCD device cannot be used at night without ambient light.

[0015] For the foregoing reasons, there is a need for a transflective LCD device that can be used on the time of day as well as night.

[0016] **FIG. 4** is a plan view illustrating an array substrate of a transflective liquid crystal display (LCD) device according to a conventional art. As shown in **FIG. 4**, the array substrate includes a gate line **50** arranged in a transverse direction, data line **60** arranged in a longitudinal direction perpendicular to the gate line **50**, and a thin film transistor (TFT) arranged near the cross portion of the gate and data lines **50** and **60**. The TFT has a gate electrode **52**, a source electrode **62** and a drain electrode **64**. The gate electrode **52** extends from the gate line **50**, and the source electrode **62** extends from the data line **60**. The drain electrode **64** is spaced apart from the source electrode **62**. And the source electrode **62** overlaps one end portion of the gate electrode **52**, and the drain electrode **64** overlaps the other end portion of the gate electrode **52**. The array substrate further includes a reflective electrode **68** and a pixel electrode **70**, which are formed on a region defined by the gate and data lines **50** and **60**. The reflective electrode **68** and the pixel electrode **70** are electrically connected with the drain electrode **64** through contact hole **69** and **66** (see **FIG. 5C**). The reflective electrode **68** is made of an opaque conductive metal, and the pixel electrode **70** is made of a transparent conductive material. The reflective electrode **68** has a light transmitting hole **72** formed on a central portion thereof. The light transmitting hole **72** serves to transmit light and has a substantially rectangular shape. The pixel electrode **70** has a sufficient size to cover the light transmitting hole **72**. In other words, the pixel electrode **70** covers the light transmitting hole **72**.

[**0017**] **FIGS. 5A** to **5**D are cross sectional views taken along the line V-V of **FIG. 4**, illustrating a process of manufacturing the array substrate of the transflective LCD device according to the conventional art.

[**0018**] First, as shown in **FIG. 5A, a** first metal layer is deposited on a substrate **1** and patterned into the gate electrode **52**. The first metal layer is made of a metal having a high corrosion resistance such as Chrome or Tungsten or having a low resistance such as Aluminum alloy.

[**0019**] Then, as shown in **FIG. 5B, a** gate insulating layer **80**, a semiconductor layer **82** and the source and drain electrodes **62** and **64** are sequentially formed. The gate insulating layer **80** is formed on the exposed surface of the substrate **1** while covering the gate electrode **52**. The semiconductor layer **82** is formed on the gate insulating layer **80** and over the gate electrode **52**. The source electrode **62** overlaps one end portion of the semiconductor layer **82**, and the drain electrode **64** overlaps the other end portion of the semiconductor layer **82**. The source and drain electrodes **62** and **64** are spaced apart from each other.

[**0020**] Sequentially, as shown in **FIG. 5C, a** passivation film **84** is formed on the exposed surface of the gate insulating layer **80** while covering the source and drain electrodes **62** and **64**. A portion of the passivation film **84** on the drain electrode **54** is etched to form a first contact hole **66**. The passivation film **84** is made of an insulating material having a good moisture resistance and a good transmittance and preferably Silicon Nitride (SiN_x) or Silicon Oxide (SiO_x). Next, the pixel electrode **70** is formed on the passivation film **84** and is electrically connected with the drain electrode **64** through the first contact hole **66**. The pixel electrode **70** is made of a transparent conductive metal having a good transmittance and preferably one of Indium Tin Oxide (ITO) and Indium Zinc Oxide (IZO).

[**0021**] After that, as shown in **FIG. 5**D, an inter-layer insulating film **86** is formed over the entire surface of the substrate **1** while covering the pixel electrode **70**. The interlayer insulating film **86** is made of made of one of Benzocyclobutene (BCB) that has a good transmittance. A portion of the inter-layer insulating film **86** over the first contact hole **66** is etched to form a second contact hole **69**. Then, the reflective electrode **68** is formed on the inter-layer insulating film **86** and is electrically connected with the pixel electrode **70**. A portion of the reflective electrode **68** is etched to form the light transmitting hole **72**.

[**0022**] **FIG. 6** is a schematic cross-sectional view illustrating the operating principle of the transflective LCD device according to the conventional art. As shown in **FIG. 6**, the transflective LCD device includes a liquid crystal panel and a backlight device **102**. The liquid crystal display panel includes lower and upper substrates **108** and **106** with an interposed liquid crystal layer **100**. The upper substrate **106** has a color filter **104**, and the lower substrate **108** as the array substrate has the TFT, the pixel electrode **70** and the reflective electrode **68**. The reflective electrode **68** includes the light transmitting hole **72** formed therein. The inter-layer insulating film **86** is interposed between the reflective electrode **68** and the pixel electrode **70**. The pixel electrode **70** covers a region corresponding to the light transmitting hole **72**. The transflective LCD device further includes an upper polarizer (not shown) on the upper substrate **106** and a lower polarizer (not shown) located between the lower substrate **108** and the backlight device **102**.

[**0023**] The transflective LCD device according to the conventional art is operated as follows.

[**0024**] First, in the reflective mode, the incident light **110** from the outside is reflected on the reflective electrode **68** and directs toward the upper substrate **106** again. At this time, when the electrical signals are applied to the reflective electrode **68** by the switching element (not shown), phase of the liquid crystal layer **100** varies and thus the reflected light of the incident light **110** is colored by the color filter **104** and displayed in the form of colored light. In the transmissive mode, light **112** emitted from the backlight device **102** passes through the transmitting holes **72**. At this time, when the electrical signals are applied to the pixel electrode **70** by the switching element (not shown), phase of the liquid crystal layer **100** varies. Thus, the light **112** passing through the liquid crystal layer **100** is colored by the color filter **104** and displayed in the form of images with other colored lights.

[**0025**] **FIG. 7** is an enlarged view illustrating the portion "A" of **FIG. 5**D, focused on the first and second contact holes. In the conventional art, as shown in **FIG. 7**, the passivation layer **84** is etched by using a photolithography process to form the first contact hole **66** through which the pixel electrode **70** contacts the drain electrode **64**. And then the inter-layer insulating layer **86** is also etched to form the second contact hole **69** through which the reflective electrode **68** contacts the pixel electrode **70**. Thus, the reflective electrode **68** is electrically connected to the drain electrode **64**.

[**0026**] However, the above-mentioned process has some problems that the photolithography process performs twice to form the first and second contact holes and to electrically connect the reflective electrode to the drain electrode. And the photolithography process includes a lot of processes such as a cleaning process, an exposure process, a baking process, a developing process etc.

[**0027**] Therefore, if one photolithography process is omitted, the manufacturing yields will increase and the defects caused by misalignment will decrease.

[**0028**] Meanwhile, due to the fact that the reflective electrode made of opaque metal is formed in the latest process step and that the reflective electrode reflects an alignment signal very well, the align key is not easily recognized during the photolithography process, i.e., misalignment occurs.

SUMMARY OF THE INVENTION

[0029] Accordingly, the present invention is directed to an array substrate of the LCD device that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

[0030] To overcome the problems described above, a preferred embodiment of the present invention provides a transflective LCD device manufactured by a simplified process.

[0031] Additional features and advantages of the invention will be set forth in the description that follows, and in part will be apparent from that description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0032] In order to achieve the above object, the preferred embodiment of the present invention provides an array substrate of transflective liquid crystal display (LCD) device, including: a substrate having switching elements and a pixel region; a reflective plate formed on the substrate and having a light transmitting hole; a first insulating layer formed on the reflective plate while covering the light transmitting hole; a gate electrode formed on the first insulating layer over the reflective plate; a gate insulating layer formed on the first insulating layer while covering the gate electrode; an active layer formed on the gate insulating layer over the gate electrode and having a channel region; an ohmic contact layer formed on the active layer; source and drain electrodes formed on the ohmic contact layer and spaced apart from each other; a second insulating layer formed on the gate insulating layer while covering the source and drain electrode, the second insulating layer having a drain contact hole which exposes the predetermined portion of the drain electrode; and a pixel electrode formed on the second insulating layer and contacting the drain electrode through the drain contact hole.

[0033] The reflective electrode is beneficially made of a opaque conductive metal and the pixel electrode is beneficially made of the material selected from a group of consisting of Indium-Tin-Oxide (ITO) and Indium-Zinc-Oxide (IZO).

[0034] 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

[0035] For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which like reference numerals denote like parts, and in which:

[0036] **FIG. 1** is a graph illustrating a transmittance respectively measured after light passes through each layers of a conventional liquid crystal display device;

[0037] **FIG. 2** is a plan view illustrating a conventional reflective liquid crystal display device;

[0038] **FIG. 3** is a cross sectional view taken along the line III-III of **FIG. 2**, illustrating the conventional reflective liquid crystal display device;

[0039] **FIG. 4** is a plan view illustrating an array substrate of a transflective liquid crystal display device according to a conventional art;

[0040] **FIGS. 5A** to **5D** are cross sectional views taken along the line V-V of **FIG. 4**, illustrating a process for manufacturing the array substrate of the transflective liquid crystal display device according to the conventional art;

[0041] **FIG. 6** is a cross sectional view illustrating a modification of the array substrate of the transflective liquid crystal display device according to the conventional art;

[0042] **FIG. 7** is an enlarged view illustrating the portion "A" of **FIG. 5D** and focused on the first and second contact holes;

[0043] **FIG. 8** is a plan view illustrating an array substrate of a transflective liquid crystal display device according to a preferred embodiment of the present invention; and

[0044] **FIGS. 9A** to **9D** are cross sectional views taken along the line IX-IX of **FIG. 4**, illustrating a process for manufacturing the array substrate of the transflective liquid crystal display device according to the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFFERED EMBODIMENTS

[0045] Reference will now be made in detail to the preferred embodiment of the present invention, example of which is illustrated in the accompanying drawings.

[0046] **FIG. 8** is a plan view illustrating an array substrate of a transflective liquid crystal display (LCD) device according to a preferred embodiment of the present invention. As shown in **FIG. 8**, the array substrate includes a gate line **150** arranged in a transverse direction, a data line **160** arranged in a longitudinal direction perpendicular to the gate line **150**, and a thin film transistor (TFT) arranged near the cross portion of the gate and data lines **150** and **160**. The TFT has a gate electrode **152**, a source electrode **162** and a drain electrode **164**. The gate electrode **152** extends from the gate line **150**, and the source electrode **162** extends from the data line **160**. The drain electrode **164** is spaced apart from the source electrode **162**. And the source electrode **162** overlaps one end portion of the gate electrode **152**, and the drain electrode **164** overlaps the other end portion of the gate electrode **152**. The array substrate further includes a reflective plate **156** and a pixel electrode **168**, which are formed on a region defined by the gate and data lines **150** and **160**. The pixel electrode **168** is electrically connected with the drain electrode **164** through a contact hole **166**. The reflective plate **156** is made of an opaque conductive metal, and the pixel electrode **70** is made of a transparent conductive material such as Indium-Tin-Oxide (ITO) or Indium-Zinc-Oxide (IZO). The reflective plate **156** has a light transmitting hole **154** formed on a central portion thereof. The light transmitting hole **154** serves to transmit light and has a substantially rectangular shape. The pixel electrode **168** has a sufficient size to cover the light transmitting hole **154**. In other words, the pixel electrode **168** covers the light transmitting hole **154**.

[0047] **FIGS. 9A** to 9D are cross sectional views taken along the line IX-IX of **FIG. 8**, illustrating a process of manufacturing the array substrate of the transflective LCD device according to the preferred embodiment of the present invention.

[0048] First, as shown in **FIG. 9A, a** substrate divided into a switching potion "S" and a pixel region "P". And then a first metal layer is deposited on a substrate **1** and patterned into the reflective plate **156** that has a light transmitting hole **154** in the pixel region "P". Thus, the first metal layer beneficially covers the entire substrate **1** except the portion for the light transmitting hole **154**. The first metal layer is beneficially made of an opaque metal having the superior reflectance such as Aluminum-Neodymium (AlNd).

[0049] Then, as shown in **FIG. 5B, a** first insulating layer **170** is formed on the reflective plate **156** while covering the light transmitting hole **154**. As a material for the first insulating layer **170**, Silicon Nitride (SiN_x) or Silicon Oxide (SiO_x) is used. And a second metal layer is deposited on the first insulating layer **179** and patterned into a gate electrode **152** over the reflective plate **156** in the switching portion "S".

[0050] **FIG.** 9*c* is a cross-sectional view illustrating a process step of fabricating the thin film transistor (TFT) as a switching element. The TFT includes the gate electrode **152**, the semiconductor layer **174** and the source and drain electrodes **162** and **164**. The preferred embodiment of the present invention employs the inverted staggered type.

[0051] A gate insulating layer **172** is formed on the first insulating layer **170** while covering the gate electrode **152**. Then the intrinsic semiconductor (pure amorphous silicon) and the extrinsic semiconductor (impurity amorphous silicon) are sequentially deposited on the gate insulating layer **172**, and patterned into the active layer **174***a* and the ohmic contact layer **174***b*, respectively. The spaced apart source and drain electrodes **162** and **164** are formed on the ohmic contact layer **174***b*. The portion of the ohmic contact layer **174***b*, between the source electrode **162** and the drain electrode **164**, is removed to form a channel region "CH" on the active layer **174***a*. Thus, The source electrode **162** overlaps one of the ohmic contact layer **174***b*, and the drain electrode **164** overlaps the other ohmic contact layer **174***b*. And the source and drain electrodes **162** and **164** are spaced apart from each other.

[0052] After that, as shown in **FIG. 9D, a** second insulating film **176** is formed over the gate insulating layer **172** while covering the TFT portion "S". A portion of the second insulating film **176** over the drain electrode **164** is etched to form a drain contact hole **166** that exposes the predetermined portion of the drain electrode **164**. Then, the pixel electrode **168** is formed on the second insulating film **176** and is electrically connected with the pixel electrode **164** through the drain contact hole **166**. The pixel electrode **168** formed over the pixel region "P" and covers the light transmitting hole **154**. The pixel electrode **168** is made of a transparent conductive metal having a good transmittance and preferably one of Indium Tin Oxide (ITO) and Indium Zinc Oxide (IZO).

[0053] As described above, since the reflective palate is formed at first and do not contact the drain electrode through another contact hole in the preferred embodiment of the present invention, the contact hole through which the reflective plate contact the drain electrode is not required. Thus, the process of forming another contact hole can be omitted.

[0054] Moreover, since the reflective plate is formed at first on the substrate, the alignment defects, which are caused by the reflectivity of the reflective electrode in the conventional art, decrease. Meanwhile, since the reflective plate is formed on the entire surface of the substrate except the portion for the light transmitting hole, and since the reflective plate is overlapped by the gate electrodes and the gate lines, the aperture ratio increase in the reflective mode of the transflective LCD device.

[0055] Namely, the TFT array substrate of preferred embodiments has the following advantages.

[0056] First, since the pixel electrode only directly contact the drain electrode, another process of forming the contact hole through which the reflective electrode electrically contacts the drain electrode is omitted compared to the conventional transflective LCD device.

[0057] Second, since the reflective plate is formed at first, the alignment defects caused by the reflective electrode can decrease.

[0058] Third, since the reflective plate is formed on the entire surface of the substrate except the light transmitting hole, the aperture ratio increase in the reflective mode of the transflective LCD device.

[0059] While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An array substrate of transflective liquid crystal display (LCD) device comprising:

a substrate having switching elements and a pixel region;

a reflective plate formed on the substrate and having a light transmitting hole;

a first insulating layer formed on the reflective plate while covering the light transmitting hole;

a gate electrode formed on the first insulating layer over the reflective plate;

a gate insulating layer formed on the first insulating layer while covering the gate electrode;

an active layer formed on the gate insulating layer over the gate electrode and having a channel region;

an ohmic contact layer formed on the active layer; source and drain electrodes formed on the ohmic contact layer and spaced apart from each other;

a second insulating layer formed on the gate insulating layer while covering the source and drain electrode, the second insulating layer having a drain contact hole which exposes the predetermined portion of the drain electrode; and

a pixel electrode formed on the second insulating layer and contacting the drain electrode through the drain contact hole.

2. An array substrate of transflective liquid crystal display (LCD) device of claim 1, wherein the reflective electrode is beneficially made of a opaque conductive metal.

3. An array substrate of transflective liquid crystal display (LCD) device of claim 1, wherein the pixel electrode is beneficially made of the material selected from a group of consisting of Indium-Tin-Oxide (ITO) and Indium-Zinc-Oxide (IZO).

* * * * *

专利名称(译)	透反液晶显示装置及其制造方法		
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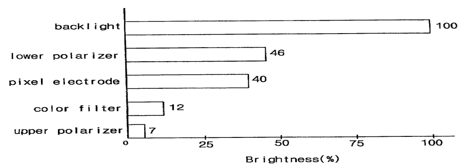
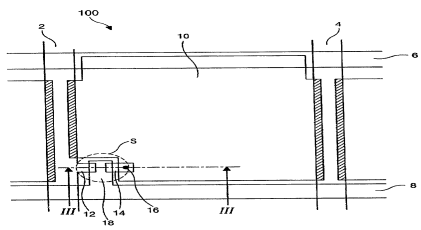
摘要(译)

透反射LCD装置的阵列基板包括首先在基板上形成反射板。一种透反射LCD装置的阵列基板，包括：具有开关元件和像素区域的基板;反射板，形成在基板上并具有透光孔;第一绝缘层，形成在反射板上，同时覆盖透光孔;栅电极形成在反射板上方的第一绝缘层上;栅极绝缘层形成在第一绝缘层上，同时覆盖栅极;栅极绝缘层上形成的有源层，具有沟道区;形成在有源层上的欧姆接触层;源极和漏极形成在欧姆接触层上并彼此间隔开;第二绝缘层形成在栅极绝缘层上，同时覆盖源极和漏极，第二绝缘层具有暴露漏极的预定部分的漏极接触孔;像素电极形成在第二绝缘层上并通过漏极接触孔与漏极接触。



(RELATED ART)
FIG. 1



(RELATED ART)
FIG. 2