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Park et al.

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(54) **IN-CELL TOUCH LIQUID CRYSTAL DISPLAY APPARATUS, METHOD OF MANUFACTURING THE SAME, METHOD OF MANUFACTURING THIN FILM TRANSISTOR ARRAY SUBSTRATE, AND METHOD OF MANUFACTURING COLOR FILTER ARRAY SUBSTRATE**

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G02F 1/1362 (2006.01)

G02F 1/1339 (2006.01)

G02F 1/1333 (2006.01)

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(58) **Field of Classification Search**

CPC G02F 1/136286; G02F 1/13338; G02F 1/133512; G02F 1/133514; G02F 1/13394; G02F 1/1368

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0007632 A1* 1/2010 Yamazaki H01L 27/3234 345/175
2010/0156827 A1* 6/2010 Joo G02F 1/13338 345/173
2011/0102698 A1* 5/2011 Wang G02F 1/13338 349/54
2013/0162570 A1* 6/2013 Shin G06F 3/041 345/173

* cited by examiner

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(57) **ABSTRACT**

Disclosed are an in-cell touch liquid crystal display (LCD) device based on a twisted nematic (TN) mode, a method of manufacturing the same, a method of manufacturing a thin film transistor (TFT) array substrate, and a method of manufacturing a color filter array substrate. The TFT array substrate includes a TFT disposed in a pixel area defined by an intersecting gate line and data line, a conductive line disposed on the TFT, and a transparent conductive layer in electrical contact with the conductive line. The color filter array substrate includes a light shield layer, a color filter, an overcoat layer covering the light shield layer and the color filter, a column spacer disposed on the overcoat layer, and a common electrode disposed on the overcoat layer and the column spacer, where the conductive line supplies the common electrode with a common voltage or a touch driving signal.

7 Claims, 10 Drawing Sheets

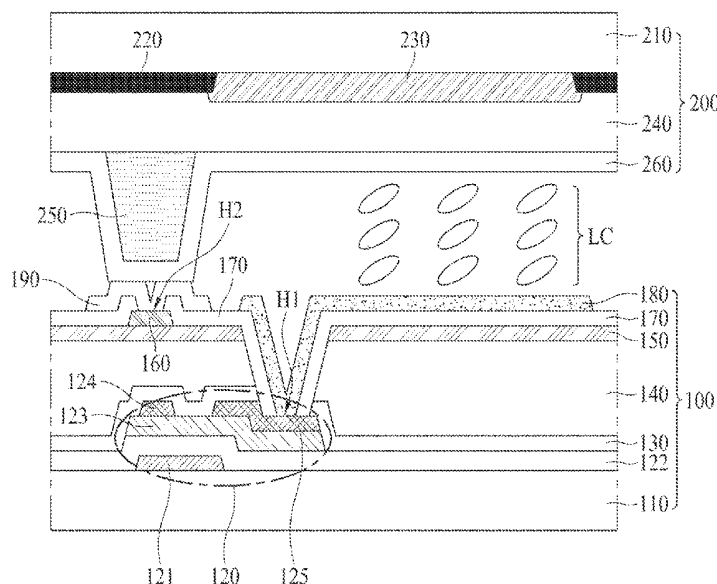


FIG. 1
(RELATED ART)

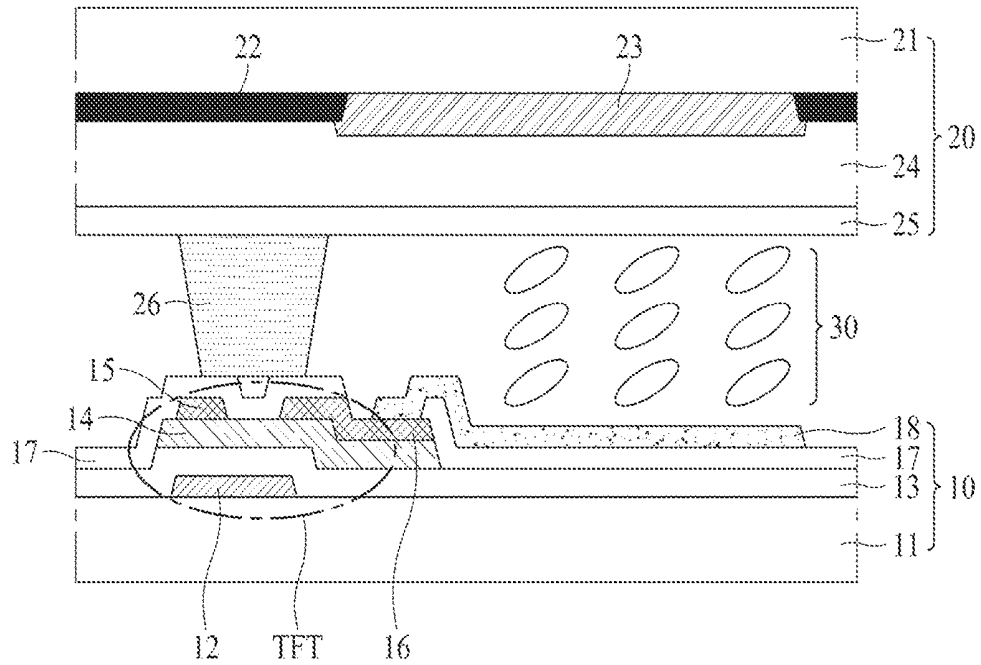


FIG. 2

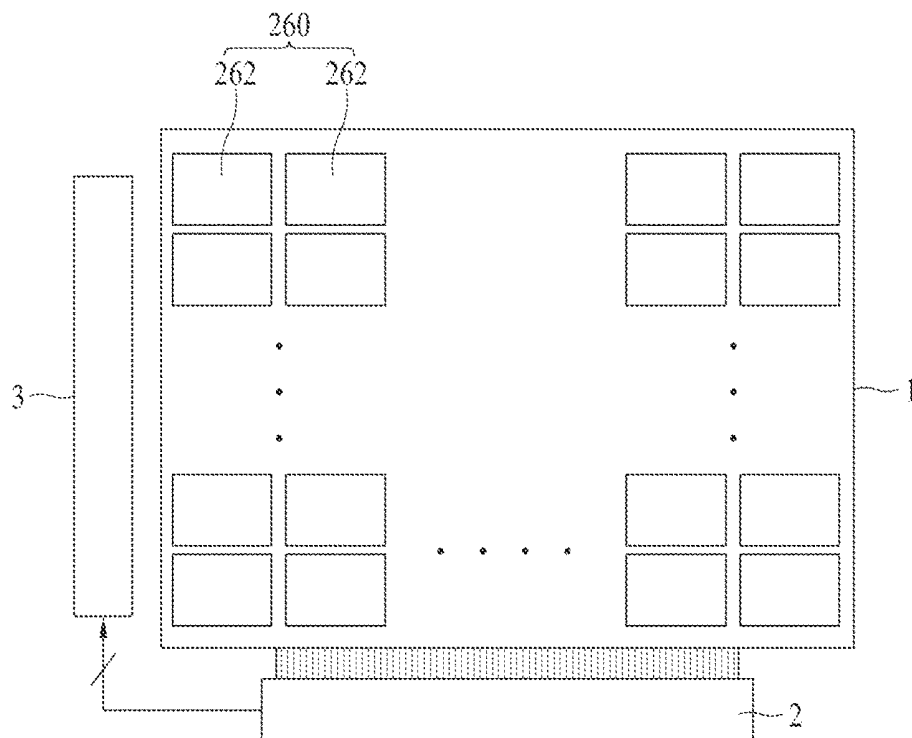


FIG. 3

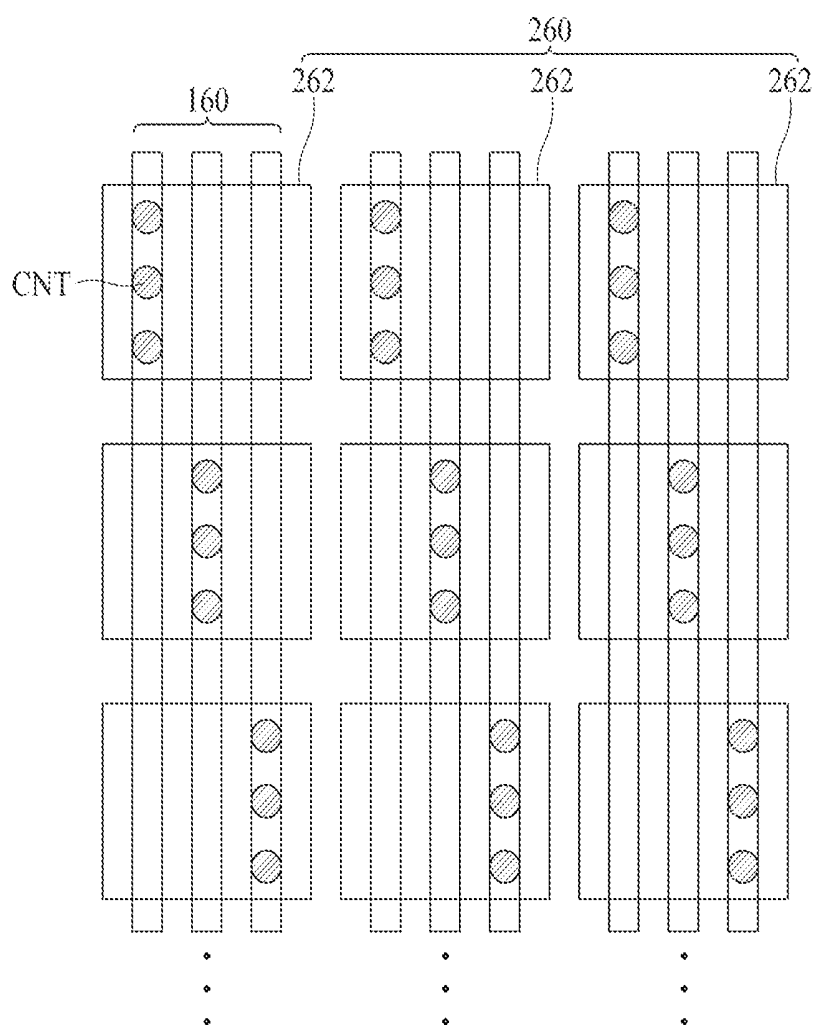
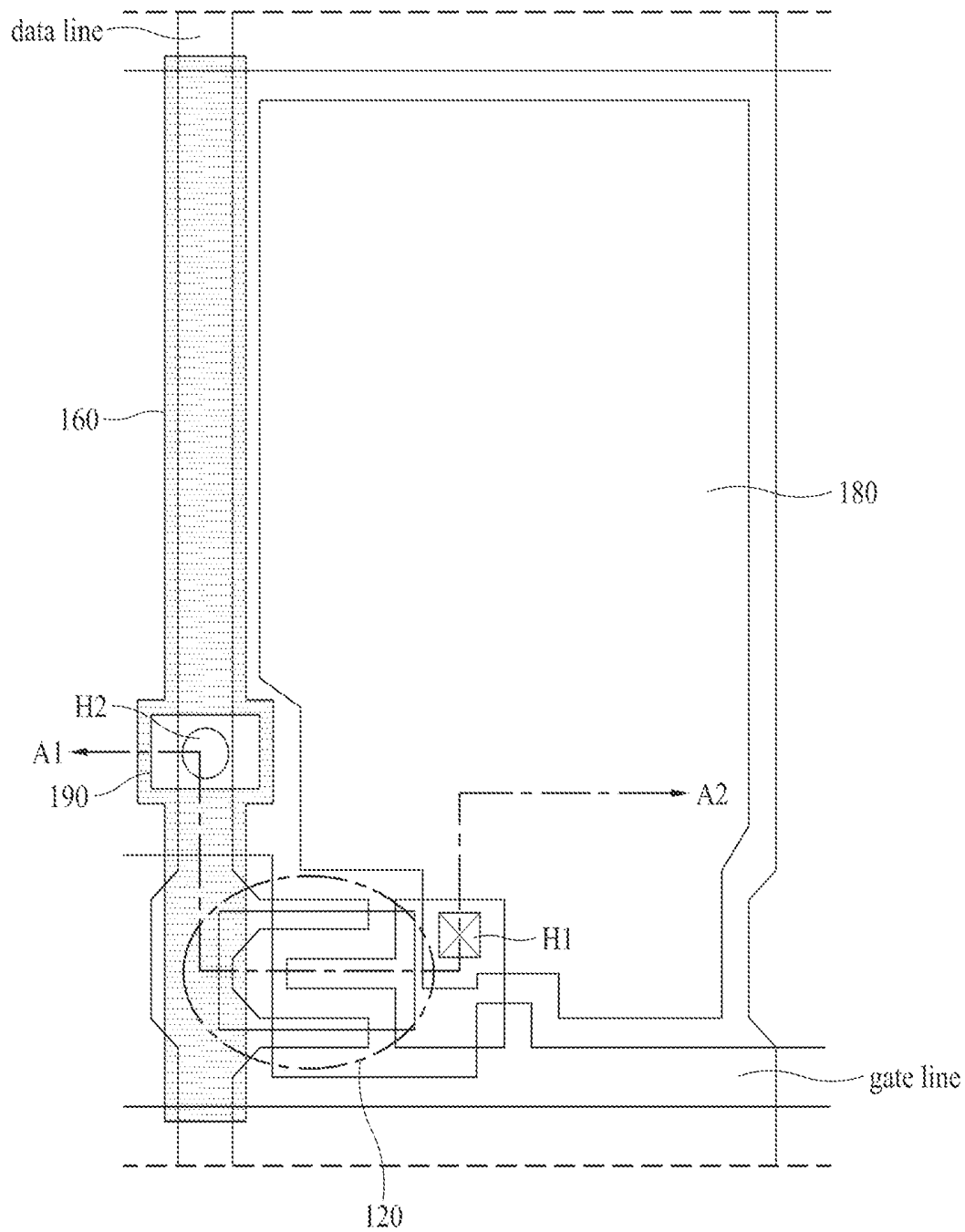


FIG. 4



Mask	Layer
1	gate
2	source / drain & active layer
3	buffer layer 1 & PAS 1
4	buffer layer 2 & conductive line
5	PAS 2
6	pixel electrode

FIG. 7

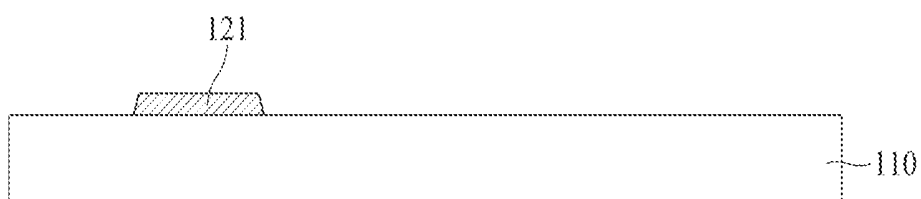


FIG. 8

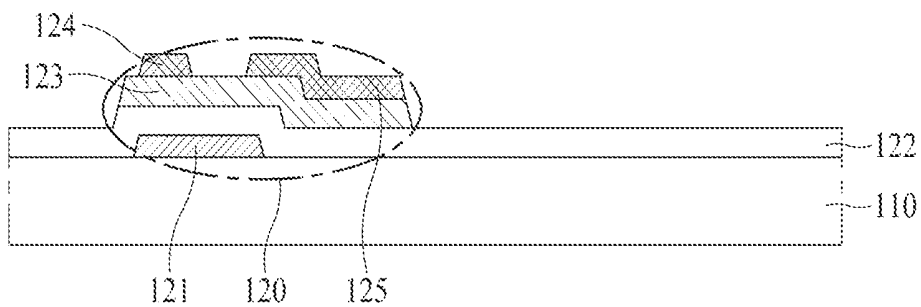


FIG. 9

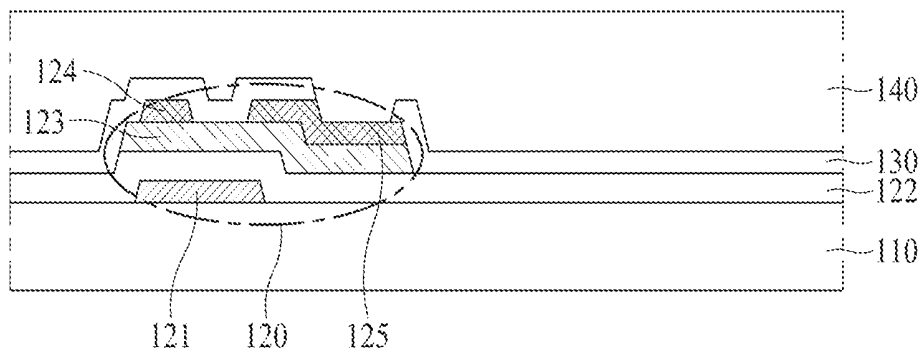


FIG. 10

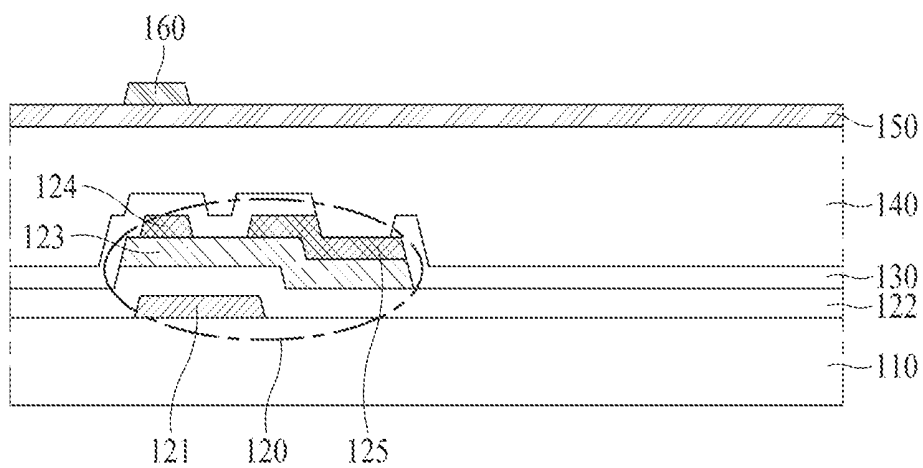


FIG. 13

Mask	Layer
1	black matrix
2	color filter
3	overcoat
4	column spacer
5	common electrode
6	touch electrode

FIG. 14

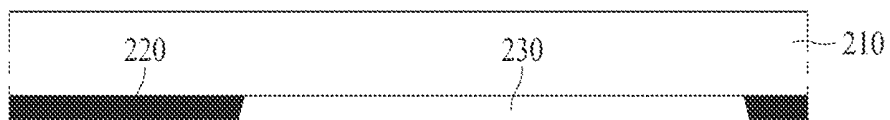


FIG. 15

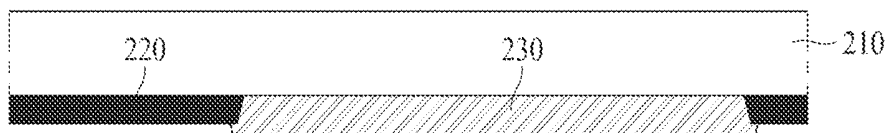


FIG. 16

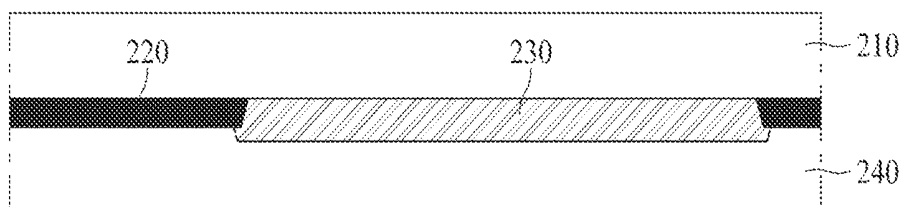


FIG. 17

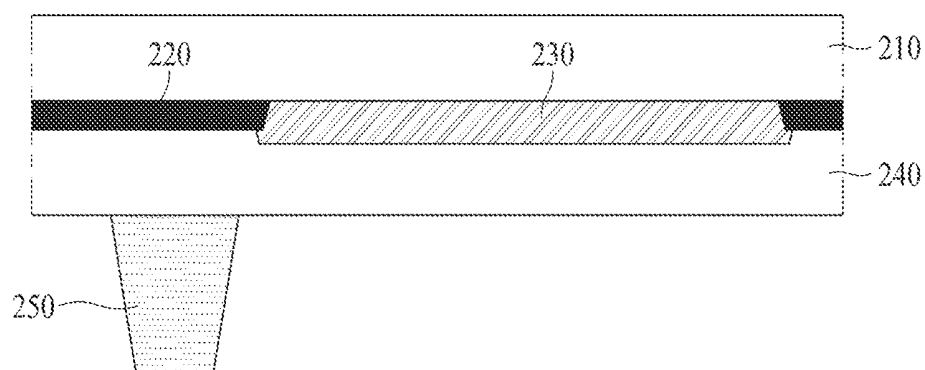
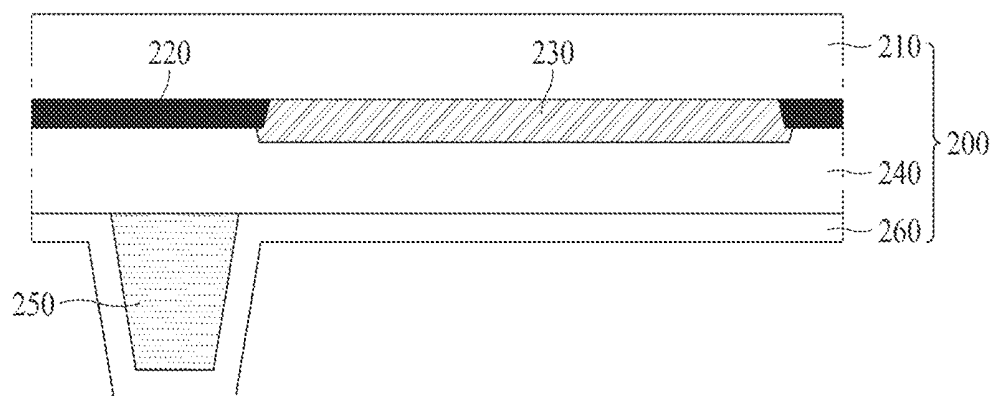


FIG. 18



**IN-CELL TOUCH LIQUID CRYSTAL
DISPLAY APPARATUS, METHOD OF
MANUFACTURING THE SAME, METHOD
OF MANUFACTURING THIN FILM
TRANSISTOR ARRAY SUBSTRATE, AND
METHOD OF MANUFACTURING COLOR
FILTER ARRAY SUBSTRATE**

CROSS-REFERENCE TO RELATED
APPLICATIONS

This application claims the benefit of the Korean Patent Application No. 10-2014-0150667 filed on Oct. 31, 2014, which is hereby incorporated by reference as if fully set forth herein.

BACKGROUND

Field of the Invention

The disclosed embodiments relate to an in-cell touch liquid crystal display (LCD) device based on a twisted nematic (TN) mode, a method of manufacturing the same, a method of manufacturing a thin film transistor (TFT) array substrate, and a method of manufacturing a color filter array substrate.

Discussion of the Related Art

As portable electronic devices (e.g., mobile phones, tablet personal computers (PCs), notebook computers) and display devices (e.g., monitors, televisions (TVs)) advance, the demand for applicable flat panel display (FPD) devices is increasing.

FPD devices include liquid crystal display (LCD) devices, plasma display panels (PDPs), field emission display (FED) devices, and organic light emitting display devices, for example.

Among FPD devices, LCD devices are increasing in popularity because the LCD devices are easily manufactured due to the advance of manufacturing technology and because LCD devices have an easily-driven driver, low power consumption, high image quality, and a large screen.

FIG. 1 is a diagram schematically illustrating a related art LCD device based on a twisted nematic (TN) mode. In FIG. 1, a backlight unit and a driving circuit unit are not illustrated.

Referring to FIG. 1, the related art LCD device based on the TN mode includes a thin film transistor (TFT) array substrate 10, a color filter array substrate 20, and a TN liquid crystal layer 30 disposed between the TFT array substrate 10 and the color filter array substrate 20.

The TFT array substrate 10 includes a TFT and a pixel 18, which are disposed over a first glass substrate 11. The TFT includes a gate electrode 12, a gate insulation layer 13, an active layer 14, a source electrode 15, and a drain electrode 16. The pixel electrode 18 is electrically connected to the drain electrode 16 and is disposed on a passivation layer 17.

The color filter array substrate 20 includes a second glass substrate 21, a light shield layer (a black matrix) 22 defining a pixel area, red, green, and blue color filters 23, an overcoat layer 24, a common electrode 25, and a color spacer 26.

The color spacer 26 is formed on the common electrode 25 to protrude toward the TFT array substrate 10 and contacts an upper surface of the TFT. A cell gap between the TFT array substrate 10 and the color filter array substrate 20 is formed by the color spacer 26. The liquid crystal layer 30 is disposed between the TFT array substrate 10 and the color filter array substrate 20, and the TFT array substrate 10 is bonded to the color filter array substrate 20.

Instead of using an input device such as a mouse, a keyboard, a keypad, or the like that is conventionally used with an LCD device or a portable electronic device, display devices may include a touch screen that enables a user to directly input information to the screen with a finger, pen, or other utensil.

A touch screen is applied to monitors of devices such as navigation devices, industrial terminals, notebook computers, automated teller machines (ATMs), game machines, portable devices (e.g., portable phones, MP3 players, personal digital assistants (PDAs), portable media players (PMPs), programmable signal processors (PSPs), portable game machines, digital media broadcasting (DMB) receivers, and tablet personal computers (PCs)), and home appliances (e.g., refrigerators, microwave ovens, and washing machines). Since all users can easily manipulate the touch screen, touch screens are increasing in popularity.

A touch screen may be classified based on the structure where the touch screen is coupled to a liquid crystal panel. The touch screen may be an in-cell touch type in which the touch screen is built in a cell of a liquid crystal panel, an on-cell touch type in which the touch screen is disposed on a cell of a liquid crystal panel, an add-on type in which the touch screen is coupled to an outer portion of a display panel, or a one glass solution type in which a touch sensor is disposed on a window glass (or a cover glass) of a display device. Recently, because of its superior aesthetic appearance and reduced thickness, the in-cell touch type touch screen is increasing in popularity.

The in-cell touch type touch screen is used in LCD devices in an in-plane switching (IPS) mode or a fringe field switching (FFS) mode. However, there are many limitations in applying the in-cell touch type to LCD devices based on the TN mode.

Since the related art LCD device based on the TN mode has a structure where a common electrode is spread all over a color filter array substrate, it is difficult to apply the in-cell touch type to the LCD device based on the TN mode. LCD devices using TN mode are typically notebook PCs and PC monitors, but an in-cell touch LCD device based on the TN mode has not been developed.

SUMMARY

Accordingly, the disclosed embodiments describe an in-cell touch liquid crystal display (LCD) device based on a twisted nematic (TN) mode, a method of manufacturing the same, a method of manufacturing a thin film transistor (TFT) array substrate, and a method of manufacturing a color filter array substrate that substantially obviate one or more problems due to limitations and disadvantages of the related art.

The disclosed embodiments include an in-cell touch LCD device based on a TN mode.

The disclosed embodiments include a TFT array substrate configuring an in-cell touch LCD device based on a TN mode and a method of manufacturing the same.

The disclosed embodiments include a color filter array substrate configuring an in-cell touch LCD device based on a TN mode and a method of manufacturing the same.

Additional advantages and features of the invention will be set forth in part in the description which follows, in part will become apparent to those having ordinary skill in the art upon examination of the following, and may be learned in part from practice of the invention. The objectives and other advantages of the invention may 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, as embodied and broadly described herein, an in-cell touch liquid crystal display (LCD) device includes: a thin film transistor (TFT) array substrate including a gate line and a data line that intersect each other to define a pixel area on a first glass substrate, a TFT disposed in the pixel area, a conductive line disposed on the TFT, and a transparent conductive layer disposed above the conductive line and in electrical contact with the conductive line; a color filter array substrate including: a light shield layer and a color filter disposed on a second glass substrate, an overcoat layer covering the light shield layer and the color filter, a column spacer disposed on the overcoat layer to horizontally overlap with the light shield layer, and a common electrode disposed on the overcoat layer and the column spacer, the conductive line configured to supply the common electrode with a common voltage or a touch driving signal through the transparent conductive layer in electrical contact with the common electrode; and a liquid crystal layer disposed between the TFT array substrate and the color filter array substrate.

In another aspect, a method of manufacturing a thin film transistor (TFT) array substrate includes: forming a data line and a TFT on a first glass substrate; forming a first passivation layer to cover the TFT; forming a conductive line above the first passivation layer in a region horizontally overlapping with the data line; forming a second passivation layer on the conductive line; forming a pixel electrode above the first passivation layer and in electrical contact with the TFT; and forming a transparent conductive layer on the conductive line and in electrical contact with the conductive line.

In another aspect, a method of manufacturing a color filter array substrate includes: forming a light shield layer and a color filter on a second glass substrate; forming an overcoat layer to cover the light shield layer and the color filter; forming a column spacer on the overcoat layer to horizontally overlap with the light shield layer; forming a common electrode on the overcoat layer and the column spacer; and patterning the common electrode as a plurality of blocks to form a plurality of touch electrodes.

In another aspect, a method of manufacturing an in-cell touch liquid crystal display device includes: providing a liquid crystal layer between the TFT array substrate and the color filter array substrate; and bonding the thin film transistor array substrate to the color filter array substrate to bring the conductive line formed on the TFT array substrate into electrical contact with the touch electrode formed on the color filter array substrate.

It is to be understood that both the foregoing general description and the following detailed description provide examples embodiments that 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 disclosed embodiments and are incorporated in and constitute a part of this application, illustrate the disclosed embodiments and together with the description serve to explain the principles of the disclosed embodiments. In the drawings:

FIG. 1 is a diagram schematically illustrating a related art LCD device based on a TN mode;

FIG. 2 is a diagram illustrating an in-cell touch LCD device according to an embodiment;

FIG. 3 is a diagram illustrating a touch electrode provided by patterning a common electrode of a color filter array substrate according to an embodiment;

FIG. 4 is a diagram illustrating a plan layout of a TFT array substrate according to an embodiment;

FIG. 5 is a cross-sectional view illustrating a cross-sectional structure of a liquid crystal panel configured as an in-cell touch LCD device according to an embodiment and illustrates a view of a TFT array substrate and a color filter array substrate along path A1-A2 of FIG. 4;

FIG. 6 is a table describing six masks used to manufacture a TFT array substrate and a layer formed by a mask process corresponding to each mask according to an embodiment;

FIGS. 7 to 12 are diagrams illustrating a method of manufacturing a TFT array substrate according to an embodiment;

FIG. 13 is a table describing six masks used to manufacture a color filter array substrate according to an embodiment and a layer formed by a mask process corresponding to each mask;

FIGS. 14 to 19 are diagrams illustrating a method of manufacturing a color filter array substrate according to an embodiment; and

FIG. 20 is a diagram illustrating that a conductive line is electrically connected to a touch electrode by bonding a TFT array substrate to a color filter array substrate according to an embodiment.

DETAILED DESCRIPTION

Reference will now be made in detail to the example embodiments that are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Advantages and features of the present invention, and implementation methods thereof will be clarified through the following embodiments described with reference to the accompanying drawings. The present invention may, however, be embodied in different forms and should not be construed as being limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough, and will fully convey the scope of the present invention to those skilled in the art. Furthermore, the present invention is defined by the scope of the claims.

Any shape, size, ratio, angle, or number disclosed in the drawings for describing an embodiment is merely an example, and thus, the present invention is not limited to the illustrated details. Like reference numerals refer to like elements throughout. In the following description, when the detailed description of the relevant known function or configuration unnecessarily obscures the features of the disclosed embodiment, such detailed description is omitted. Where the present specification uses "comprise," "have," or "include," another part may be added unless "only" is used. A reference to an element in singular form includes a plurality of that element unless otherwise stated.

In construing an element, the element should be construed as including an error range even when there is no explicit description of an error range.

In describing a positional relationship, for example, when a positional relation between two parts is described as "on," "over," "under," or "next to," one or more other parts may be disposed between the two parts unless "just" or "directly" is used.

In describing a time relationship, for example, when the temporal order of a step is described as “after,” “subsequent,” “next,” or “before,” another step, one or more further steps may be included between the step and the other step unless “just” or “direct” is used.

The term “at least one” should be understood as including any and all combinations of one or more of the associated listed items. For example, the meaning of “at least one of a first item, a second item, and a third item” denotes any combination or subset of the items, such as two or more of the first item, the second item, and the third item as well as the first item, the second item, or the third item.

It will be understood that, although the terms “first,” “second,” and other ordinal terms may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element, without departing from the scope of the present invention.

Features of various embodiments may be partially or completely coupled to or combined with each other, and may be variously inter-operated with each other and driven technically as those skilled in the art may understand. The embodiments of the present invention may be carried out independently from each other, or may be carried out together in co-dependent relationship.

Before providing a detailed description with reference to the drawings, LCD devices have been variously developed in a twisted nematic (TN) mode, a vertical alignment (VA) mode, an in-plane switching (IPS) mode, and a fringe field switching (FFS) mode according to a scheme of adjusting the alignment of liquid crystals. An LCD device including a TFT array substrate and a color filter array substrate according to an embodiment may be applied to the VA mode as well as the TN mode.

Hereinafter, an in-cell touch LCD device based on a TN mode, a method of manufacturing the same, a method of manufacturing a thin film transistor (TFT) array substrate, and a method of manufacturing a color filter array substrate, according to various embodiments will be described in detail with reference to the accompanying drawings.

FIG. 2 is a diagram illustrating an in-cell touch LCD device according to an embodiment.

Referring to FIG. 2, the in-cell touch LCD device according to an embodiment may include a liquid crystal panel 1, a driving circuit unit 2, a backlight unit 3, and a power supply (not shown). The driving circuit unit 2 may include a timing controller, a data driver, a gate driver, a touch driver, and a backlight driver.

The gate driver may be integrated on a TFT array substrate of the liquid crystal panel 1 in an amorphous silicon gate (ASG) type or a gate-in panel (GIP) type. Also, the gate driver, the timing controller, the data driver, and the touch driver may each be manufactured as a separate integrated circuit (IC) chip or may all be implemented as one IC chip. A method of driving each of the timing controller, the data driver, the gate driver, the touch driver, and the backlight driver is irrelevant to the disclosed embodiments, and thus, the elements of the driving circuit unit 2 and a method of driving the driving circuit unit 2 are not described.

The liquid crystal panel 1 may include a color filter array substrate (an upper substrate), a TFT array substrate (a lower substrate), and a liquid crystal layer disposed between two the substrates. The liquid crystal panel 1 may be configured to operate in the TN mode, a pixel electrode may be formed in each of a plurality of pixel areas in the TFT array substrate

of the liquid crystal panel 1, and a common electrode 260 may be formed on the color filter array substrate. Hereinafter, it has been described above that the liquid crystal panel 1 is configured to operate in the TN mode, but the liquid crystal panel 1 is not limited thereto. In other embodiments, the liquid crystal panel 1 may be configured to operate in the VA mode.

An alignment of the liquid crystal layer may be adjusted according to a vertical electric field generated between the pixel electrode formed on the TFT array substrate and the common electrode 260 formed on the color filter array substrate, and a transmittance of light emitted from the backlight unit 3 may be adjusted according to an alignment of liquid crystal, thereby displaying an image.

In the liquid crystal panel 1, a plurality of pixels for displaying an image and a plurality of touch sensors for detecting a touch may be implemented in one body. By temporally dividing display driving and touch sensing driving, an image may be displayed, and touch may be sensed.

In a display period, a data voltage based on image data may be supplied to the pixel electrode of each of the plurality of pixels, and a common voltage (Vcom) may be supplied to the common electrode, thereby displaying an image. In a non-display period (a touch period), a touch driving signal may be supplied to the common electrode (i.e., a plurality of touch electrodes), and then, capacitances of the touch electrodes may be sensed, thereby determining whether there is a touch and detecting a touched position.

FIG. 3 is a diagram illustrating a touch electrode provided by patterning a common electrode of a color filter array substrate according to an embodiment.

Referring to FIG. 3, the common electrode 260 formed on the color filter array substrate may be patterned as a plurality of touch blocks, and each of the plurality of touch blocks may become a touch electrode 262. One touch block 262 may be formed to correspond to a plurality of pixels. The number of pixels corresponding to each touch block 262 may be changed depending on a size of the liquid crystal panel 1 and a size of each pixel, but for example, each of the plurality of touch blocks 262 may be configured to correspond to twenty horizontal pixels and twelve vertical pixels (20×12).

Here, a plurality of conductive lines 160 and each of the touch electrodes 262 formed on the TFT array substrate may be selectively connected to each other, and thus, the common voltage and the touch driving signal may be applied to the connected touch electrode 262. Each of the touch blocks 262 may operate separately, and thus is not short-circuited when a touch driving signal is applied to another touch block 262. To this end, one conductive line 160 may be connected to one touch block 262. A minimum of one contact part CNT connects a touch block 262 to a corresponding conductive line 160. A contact part CNT may connect a conductive line 160 to the corresponding touch block 262 at every pixel corresponding to the touch block 262 or to only a subset of the pixels corresponding to the touch block 262. FIG. 3 illustrates an example where one touch block 262 is connected to one conductive line 160 by three contact parts CNT. A structure where the touch blocks 262 are connected to the conductive lines 160 will be described in detail with reference to FIGS. 4 and 5.

FIG. 4 is a diagram illustrating a plan layout of a TFT array substrate according to an embodiment. In FIG. 4, a plan layout and a cross-sectional structure of one of a plurality of pixels are illustrated.

Referring to FIG. 4, a gate line may be disposed in a first direction (for example, a horizontal direction) on a substrate,

and a data line may be disposed in a second direction (for example, a vertical direction) to intersect the gate line. A pixel area may be defined around an intersection of the gate line and the data line. A TFT **120**, a pixel electrode **180**, and a storage capacitor which are switching elements may be included in the pixel area. The pixel electrode **180** is formed in a display area of the pixel area.

A conductive line **160** may be disposed on the data line, and a transparent conductive layer **190** may be disposed on the conductive line **160** to horizontally overlap with the conductive line **160** with a passivation layer of an insulating material therebetween. A contact hole **H2** may be formed by removing the passivation layer in order for the conductive line **160** to be exposed, and the conductive line **160** may be electrically connected to the transparent conductive layer **190** through the contact hole **H2**. A column spacer may be disposed on a color filter array substrate to horizontally overlap with the transparent conductive layer **190**, and a common electrode (a touch electrode) disposed on the color filter array substrate may be electrically connected to the transparent conductive layer **190**.

Although not shown, a black light shield pattern (BLSP) for blocking light emitted from a backlight unit may be included in each of a plurality of pixel areas. The black light shield pattern may surround an opening of each of the pixel areas and may be disposed on the same layer as the gate line.

FIG. 5 is a cross-sectional view illustrating a cross-sectional structure of a liquid crystal panel configured as an in-cell touch LCD device according to an embodiment and illustrates a view of a TFT array substrate and a color filter array substrate along path A1-A2 of FIG. 4. In FIG. 5, a plan layout and a cross-sectional structure of one of a plurality of pixels are illustrated.

Referring to FIG. 5, the in-cell touch LCD device according to an embodiment may include a TFT array substrate **100**, a color filter array substrate **200**, and a liquid crystal layer **LC** disposed between the TFT array substrate **100** and the color filter array substrate **200**. The TFT array substrate **100** and the color filter array substrate **200** may be bonded to each other and may be sealed by a sealant. A lower polarizing film **POL1** may be disposed under the TFT array substrate **100**, and an upper polarizing film **POL2** may be disposed on the color filter array substrate **200**.

First, elements and a structure of the TFT array substrate **100** will now be described.

The TFT array substrate **100** may include a first glass substrate **110**, a TFT **120**, a first buffer layer **130**, a first passivation layer (PAS1) **140**, a second buffer layer **150**, a conductive line **160**, a second passivation layer (PAS2) **170**, a pixel electrode **180**, and a transparent conductive layer **190**.

The TFT **120** may be disposed in each of a plurality of pixel areas included on the TFT array substrate **100**, and may have a bottom gate structure. The TFT **120** may include a gate electrode **121** disposed under a gate insulation layer **122**, an active layer **123**, a source electrode **124**, and a drain electrode **125**. The active layer **123**, the source electrode **124**, and the drain electrode **125** may be disposed on the gate insulation layer **122**. Although not shown, a storage capacitor may be formed in each of the pixel areas. In FIG. 5, the TFT **120** is illustrated as having a bottom gate structure, but it is not limited thereto. In other embodiments, the TFT **120** may have a top gate structure.

The gate electrode **121** may be formed on the first glass substrate **110**. The gate electrode **121** may branch from the gate line illustrated in FIG. 4, and metal of a gate electrode in a TFT area may be the gate electrode **121**. In this case, the

gate electrode **121** may be formed of copper (Cu), aluminum (Al), molybdenum (Mo), titanium (Ti), Mo—Ti, other metals, other alloys, or other conductors and may have a thickness of 2,000 Å to 3,000 Å.

The gate insulation layer **122** may be formed to cover the gate line and the gate electrode **121**. The gate insulation layer **122** may be formed of silicon oxide (SiO₂) or nitride silicon (SiN_x) and may have a thickness of 1,000 Å to 3,000 Å. As another example, the gate insulation layer **122** may be formed in a multi-layer structure where a SiO₂ layer and a SiN_x layer are stacked. The gate insulation layer **122** may be formed by depositing tetra ethyl ortho silicate (TEOS) or middle temperature oxide (MTO) in a chemical vapor deposition (CVD) process.

The active layer **123** may be formed on the gate insulation layer **122** to horizontally overlap with the gate electrode **121**. The active layer **123** may have a thickness of 500 Å to 1,500 Å. The active layer **123** may be formed of amorphous silicon, poly silicon, low temperature poly silicon (LTPS), oxide, and/or the like.

The source electrode **124** may be formed on one side of an upper surface of the active layer **123**, and the drain electrode **125** may be formed on the other side. Each of the source electrode **124** and the drain electrode **125** may be formed of copper (Cu), aluminum (Al), molybdenum (Mo), titanium (Ti), Mo—Ti, other metals, other alloys, or other conductors and may have a thickness of 2,000 Å to 3,000 Å. The TFT **120** may be configured with the gate electrode **121**, the gate insulation layer **122**, the active layer **123**, the source electrode **124**, and the drain electrode **125**.

The first buffer layer **130** may be formed over the first glass substrate **110** to cover the TFT **120**. The first buffer layer **130** may be formed of SiO₂, SiN_x, and/or the like and may have a thickness of 1,000 Å to 2,000 Å.

The first passivation layer **140** may be formed to cover the first buffer layer **130**. The first passivation layer **140** may be formed of photo acryl and may have a thickness of 2.0 μm to 3.0 μm. Accordingly, the first passivation layer **140** is thicker than the TFT **120** (between about 1.9 and 5.5 times thicker). The first passivation layer **140** may be thickly formed for reducing a parasitic capacitance between the conductive line **160** and the TFT **120** and a parasitic capacitance between lower metal layers.

The second buffer layer **150** may be formed to cover the first passivation layer **140**. The second buffer layer **150** may be formed of SiO₂, SiN_x, and/or the like and may have a thickness of 1,000 Å to 2,000 Å.

The conductive line **160** may be formed on a portion of an upper surface of the second buffer layer **150** horizontally overlapping the data line. In FIG. 4, a position at which the conductive line **160** is formed is illustrated. The conductive line **160** may transfer a common voltage (Vcom) and a touch driving signal to a common electrode (a touch electrode) and may be connected to an output channel of a driving circuit unit. In a display period, the common voltage (Vcom) may be supplied to the common electrode through the conductive line **160**, thereby displaying an image. In a non-display period, the touch driving signal may be supplied to the conductive line **160**, and thus, a touch may be sensed.

The conductive line **160** may have a line width which is the same as or broader than that of the data line. The conductive line **160** may be formed of copper (Cu), aluminum (Al), molybdenum (Mo), titanium (Ti), Mo—Ti, other metals, other alloys, or other conductors and may have a thickness of 1,000 Å to 2,000 Å. The conductive line **160** may be formed in a multi-layer structure where a Cu layer, a Mo layer, an Al layer, and a Mo layer are stacked.

The second passivation layer **170** may be formed to cover a portion of the conductive line **160** and the second buffer layer **150**. The second passivation layer **170** may be formed of SiO_2 , SiNx , and/or the like and may have a thickness of 1,000 Å to 2,000 Å.

A first contact hole **H1** exposing a top of the drain electrode **125** of the TFT **120** may be formed by removing a portion of each of the first buffer layer **130**, the first passivation layer **140**, the second buffer layer **150**, and the second passivation layer **170** corresponding to a portion which horizontally overlaps with the drain electrode **125** of the TFT **120**. Also, a second contact hole **H2** exposing a top of the conductive line **160** may be formed by removing a portion of the second passivation layer **170** corresponding to a portion which horizontally overlaps with the conductive line **160**.

The pixel electrode **180** may be formed on a portion of an upper surface of the second passivation layer **170** around the opening of the first contact hole **180**. The pixel electrode **180** may be formed in the first contact hole **H1** and may be electrically connected to the drain electrode **125** of the TFT **120**. The pixel electrode **180** may be formed of a transparent conductive material such as indium-tin-oxide (ITO), indium-zinc-oxide (IZO), indium tin zinc oxide (ITZO), and/or the like and may have a thickness of 700 Å to 1,500 Å.

The transparent conductive layer **190** may be formed on a portion of an upper surface of the second passivation layer **170** horizontally overlapping with the conductive line **160**. An upper surface of the conductive line **160** may be exposed by the second contact hole **H2**, and thus, the conductive line **160** may be electrically connected to the transparent conductive layer **190**. The transparent conductive layer **190** may be formed of a transparent conductive material such as indium-tin-oxide (ITO), indium-zinc-oxide (IZO), indium tin zinc oxide (ITZO), and/or the like and may have a thickness of 700 Å to 1,500 Å.

Here, the pixel electrode **180** and the transparent conductive layer **190** may be formed of the same material through the same manufacturing process. In FIGS. 4 and 5, the pixel electrode **180** is formed in a plate shape in a pixel area, but the present embodiment is not limited thereto. In other embodiments, the pixel electrode **180** may be patterned and formed in a finger shape.

The TFT array substrate **100** according to an embodiment may be configured with the above-described elements.

Hereinafter, elements and a structure of the color filter array substrate **200** will be described.

The color filter array substrate **200** may include a second glass substrate **210**, a light shield layer (a black matrix) **220**, red (R), green (G), and blue (B) color filters (hereinafter referred to as a color filter) **230**, an overcoat layer **240**, a column spacer **250**, and a common electrode **260**.

The light shield layer (the black matrix) **220** may be formed on the second glass substrate **210**. The light shield layer (the black matrix) **220** may be included an opaque material to define a plurality of pixel areas. The R, G, and B color filters **230** may be respectively formed in the plurality of pixel areas defined by the light shield layer (the black matrix) **220**. The light shield layer (the black matrix) **220** may be disposed to correspond to a light shield area, and the color filter **230** may be disposed to correspond to an opening area.

The overcoat layer **240** may be formed to cover the light shield layer (the black matrix) **220** and the color filter **230**. An upper surface of the second glass substrate **210** may be planarized by the overcoat layer **240**. In FIG. 5, one of the

plurality of pixel areas is illustrated, and the red color filter of the R, G, and B color filters **230** is illustrated as an example.

A plurality of column spacers **250** may be formed in a region of an upper surface of the overcoat layer **240** corresponding to the light shield layer (the black matrix) **220**. To describe a position of the column spacer **250** with reference to FIGS. 4 and 5, the column spacers **250** may be formed on the overcoat layer **240** to horizontally overlap with the conductive line **160** and the transparent conductive layer **190** which are formed on the TFT array substrate **100**. Since the conductive line **160** and the column spacers **250** are formed to horizontally overlap with the data line, an aperture ratio of each of a plurality of pixels is preserved when an in-cell touch structure is applied to a display device. That is, the conductive line **160** and the column spacers **250** may be aligned in one row on a cross-sectional surface, and thus, a separate structure for electrically connecting the conductive line **160** to the touch electrode **262** is not formed, which would reduce the aperture ratio.

The plurality of column spacers **250** may maintain a cell gap between the TFT array substrate **100** and the color filter array substrate **200**. Each of the column spacers **250** may be formed in, for example, a circular shape or a bar shape when seen from above.

In FIG. 5, one of the plurality of pixel areas is illustrated, and one of the plurality of column spacers **250** is illustrated. Although not shown, a plurality of push spacers may be formed in order for a certain portion of the color filter array substrate **200** to be pressed when pressure is applied to the color filter array substrate **200**.

The common electrode **260** may be formed to cover the overcoat layer **240** and the column spacers **250**. The common electrode **260** may be formed of a transparent conductive material such as indium-tin-oxide (ITO), indium-zinc-oxide (IZO), indium tin zinc oxide (ITZO), and/or the like and may have a thickness of 700 Å to 1,500 Å.

To provide a description with reference to FIGS. 3 and 5, the in-cell touch LCD device according to an embodiment may use the common electrode **260**, formed on the color filter array substrate **200**, as the touch electrode. To this end, the common electrode **260** may be patterned as a plurality of blocks, and each of the blocks of the patterned common electrode **260** may be a separate touch electrode **262**.

The color filter array substrate **200** according to an embodiment may be configured with the above-described elements.

When the TFT array substrate **100** is bonded to the color filter array substrate **200**, the common electrode (the touch electrode) **260** formed on the column spacer **250** may electrically contact the transparent conductive layer **190** formed on the TFT array substrate **100**.

Here, since the transparent conductive layer **190** electrically contacts the conductive line **160** through the second contact hole **H2**, the touch electrode **262** formed on the color filter array substrate **200** may electrically contact the conductive line **160** formed on the TFT array substrate **100** by using a protruding form of the column spacer **250**. The in-cell touch LCD device including the above-described elements according to an embodiment enables an in-cell touch type to be applied to the TN mode.

In the display period, the data driver may supply the common voltage to the conductive line **160** to allow all touch electrodes **262** to act as the common electrode **260**, thereby displaying an image. Also, in the non-display period, the touch driver may supply the touch driving signal to the conductive line **160** in a self-touch sensing type and

then may sense a capacitance of each of the touch electrodes **262**, thereby allowing a touch to be sensed.

FIG. 6 is a table describing six masks used to manufacture a TFT array substrate according to an embodiment and a layer formed by a mask process corresponding to each mask, and FIGS. 7 to 12 are diagrams illustrating a method of manufacturing a TFT array substrate according to an embodiment.

Hereinafter, a method of manufacturing the TFT array substrate **100** according to an embodiment will be described with reference to FIGS. 6 to 12.

As illustrated in FIG. 6, the TFT array substrate **100** according to an embodiment may be manufactured through a 6-mask manufacturing process.

Referring to FIG. 7, a gate metal layer may be formed by coating a conductor such as Cu, Al, Mo, Ti, Mo/Ti, and/or the like on the first glass substrate **110**. Subsequently, the gate line (not shown) and the gate electrode **121** may be formed by performing a photolithography process and an etching process using a first mask. In this case, the gate line and the gate electrode **121** may have a thickness of 2,000 Å to 3,000 Å.

Referring to FIG. 8, the gate insulation layer **122** may be formed by coating SiO₂, SiNx, and/or the like on a whole surface of the first glass substrate to cover the gate line and the gate electrode **121**. The gate insulation layer **122** may have a thickness of 1,000 Å to 3,000 Å.

As another example, the gate insulation layer **122** may be formed in a multi-layer structure where a SiO₂ layer and a SiNx layer are stacked. The gate insulation layer **122** may be formed by depositing tetra ethyl ortho silicate (TEOS) or middle temperature oxide (MTO) in a chemical vapor deposition (CVD) process.

Subsequently, a semiconductor layer may be formed by coating amorphous silicon, poly silicon, low temperature poly silicon (LTPS), oxide, and/or the like to cover the gate electrode **121**.

Subsequently, a source/drain metal layer may be formed by coating a conductor such as Cu, Al, Mo, Ti, Mo/Ti, and/or the like on the semiconductor layer.

Subsequently, the semiconductor layer and the source/drain metal layer may be patterned by performing a photolithography process and an etching process using a second mask (a halftone mask).

Therefore, the active layer **123** may be formed to horizontally overlap with the gate electrode **121**, and the data line intersecting the gate line may be formed. Also, the source electrode **124** may be formed on one side of an upper surface of the active layer **123**, and the drain electrode **125** may be formed on the other side. The active layer **123** may have a thickness of 500 Å to 1,500 Å, and the source electrode **124** and the drain electrode **125** may each have a thickness of 2,000 Å to 3,000 Å.

The TFT **120** having the bottom gate structure may be configured with the gate electrode **121**, the gate insulation layer **122**, the active layer **123**, the source electrode **124**, and the drain electrode **125**. In FIG. 8, the TFT **120** is illustrated as having the bottom gate structure, but is not limited thereto. In other embodiments, the TFT **120** may be formed in the top gate structure.

Referring to FIG. 9, by performing a photolithography process and an etching process using a third mask, the first buffer layer **130** may be formed by coating SiO₂, SiNx, and/or the like on a whole surface of the first glass substrate **110** to cover the TFT **120**. The first buffer layer **130** may have a thickness of 1,000 Å to 2,000 Å.

Subsequently, the first passivation layer **140** may be formed by coating photo acryl to cover the first buffer layer **130**. The first passivation layer **140** may have a thickness of 2.0 μm to 3.0 μm.

Referring to FIG. 10, the second buffer layer **150** may be formed by coating SiO₂, SiNx, and/or the like to cover the first passivation layer **140**. The second buffer layer **150** may have a thickness of 1,000 Å to 2,000 Å.

Subsequently, a conductive metal layer may be formed by coating a conductor such as Cu, Al, Mo, Ti, M—Ti, and/or the like on the second glass substrate **110**.

Subsequently, by performing a photolithography process and an etching process using a fourth mask, the conductive line **160** may be formed on a portion of an upper surface of the second buffer layer **150** which horizontally overlaps with the data line and the source electrode **124**. The conductive line **160** may have a line width which is the same as or broader than that of the data line, and may have a thickness of 1,000 Å to 2,000 Å. The conductive line **160** may be formed in a multi-layer structure where a Cu layer, a Mo layer, an Al layer, and a Mo layer are stacked.

The conductive line **160** may transfer the common voltage (Vcom) and the touch driving signal to the common electrode (the touch electrode) and may be connected to an output channel of a driving circuit unit. In the display period, the common voltage (Vcom) may be supplied to the common electrode through the conductive line **160**, thereby displaying an image. In the non-display period, the touch driving signal may be supplied to the conductive line **160**, and thus, a touch may be sensed.

Referring to FIG. 11, the second passivation layer **170** may be formed by coating SiO₂, SiNx, and/or the like to cover the second buffer layer **150** and the conductive line **160**. The second passivation layer **170** may have a thickness of 1,000 Å to 2,000 Å.

Subsequently, a portion of each of the first buffer layer **130**, the first passivation layer **140**, the second buffer layer **150**, and the second passivation layer **170** corresponding to the drain electrode **125** may be removed by performing a photolithography process and an etching process using a fifth mask. Since the portion of each of the first buffer layer **130**, the first passivation layer **140**, the second buffer layer **150**, and the second passivation layer **170** is removed, the first contact hole H1 exposing the top of the drain electrode **125** may be formed.

Simultaneously, a portion of the second passivation layer **170** horizontally overlapping with the conductive line **160** may be removed. Since the portion of the second passivation layer **170** is removed, the second contact hole H2 exposing the top of the conductive line **160** may be formed. The first contact hole H1 and the second contact hole H2 may be simultaneously formed through the same mask process, and thus, the number of detailed processes is reduced, and manufacturing efficiency is enhanced.

Referring to FIG. 12, a transparent conductive material such as ITO, IZO, ITZO, and/or the like may be coated to cover the second passivation layer **170**.

Subsequently, by patterning a transparent conductive material layer through a photolithography process and an etching process using a sixth mask, the pixel electrode **180** may be formed on a portion of an upper surface of the second passivation layer **170** corresponding to an opening area. The pixel electrode **180** may have a thickness of 700 Å to 1,500 Å. In this case, the pixel electrode **180** may be formed in the first contact hole H1, and thus, the drain electrode **125** of the TFT **120** may electrically contact the

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pixel electrode **180**. The pixel electrode **180** is formed in a plate shape in a pixel area, or may be patterned and formed in a finger shape.

Simultaneously, the transparent conductive layer **190** may be formed of a transparent conductive material, such as ITO, IZO, ITZO, and/or the like, in a region of an upper surface of the second passivation layer **170** overlapping with the conductive line **160**. The transparent conductive layer **190** may have a thickness of 700 Å to 1,500 Å. The pixel electrode **180** and the transparent conductive layer **190** may be simultaneously formed through the same mask process, and thus, the number of detailed processes is reduced, and manufacturing efficiency is enhanced.

The transparent conductive layer **190** may be formed with an upper surface of the conductive line **160** being exposed by the second contact hole H2, and thus may electrically contact the conductive line **160**.

The TFT array substrate **100** according to an embodiment may be manufactured by the above-described manufacturing process.

FIG. **13** is a table describing six masks used to manufacture a color filter array substrate according to an embodiment and a layer formed by a mask process corresponding to each mask, and FIGS. **14** to **19** are diagrams illustrating a method of manufacturing a color filter array substrate according to an embodiment.

Hereinafter, a method of manufacturing the color filter array substrate **200** according to an embodiment will be described with reference to FIGS. **13** to **19**.

As illustrated in FIG. **13**, the color filter array substrate **200** according to an embodiment may be manufactured through a 6-mask manufacturing process.

Referring to FIG. **14**, a resin or a black resin containing a light blocking pigment may be coated on the second glass substrate **210**, and then, the light shield layer (the black matrix) **220** may be formed by performing a photolithography process and an etching process using a first mask. An opening of each of the plurality of pixel areas may be defined by the light shield layer (the black matrix) **220**. The light shield layer (the black matrix) **220** may be formed of a conductive metal material, such as Cr, Mo, Ti, Cr-Oxide, and/or the like, or a carbon-based organic material.

Although not shown, the light shield layer (the black matrix) **220** may be formed in a bezel area of a liquid crystal panel to cover a non-display area and a plurality of signal lines which are routed at an edge of the TFT array substrate **100**.

Referring to FIG. **15**, the R, G, and B color filters **230** may be sequentially disposed in a pixel area defined by the light shield layer (the black matrix) **220** by sequentially performing a photolithography process and an etching process using a second mask. In FIG. **15**, one of the plurality of pixel areas is illustrated, and the red color filter of the R, G, and B color filters **230** is illustrated as an example.

Referring to FIG. **16**, an overcoat material may be coated to cover the light shield layer (the black matrix) **220** and the color filter **230**. Subsequently, the overcoat layer **240** may be formed by performing a photolithography process and an etching process using a third mask. An upper surface of the second glass substrate **210** may be planarized by the overcoat layer **240**.

Referring to FIG. **17**, an organic layer or an inorganic layer may be formed by coating an organic material or an inorganic material on a region of an upper surface of the overcoat layer **240** corresponding to the light shield layer (the black matrix) **220**. Subsequently, the column spacer **250** may be formed by patterning the organic layer or the

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inorganic layer through a photolithography process and an etching process using a fourth mask.

To describe a position of the column spacer **250** with further reference to FIG. **4**, the column spacer **250** may be formed on the overcoat layer **240** to horizontally overlap with the conductive line **160** and the transparent conductive line **190** which are formed on the TFT array substrate **100**. The plurality of column spacers **250** may maintain a cell gap between the TFT array substrate **100** and the color filter array substrate **200**. Each of the column spacers **250** may be formed in a circular shape or a bar shape when seen from above.

Referring to FIG. **18**, a transparent conductive material such as ITO, IZO, ITZO, and/or the like may be coated to cover the overcoat layer **240** and the column spacer **250**.

Subsequently, the common electrode **260** may be formed on the overcoat layer **240** and the column spacer **250** by patterning a transparent conductive material layer through a photolithography process and an etching process using a fifth mask. The common electrode **260** may have a thickness of 700 Å to 1,500 Å.

Referring to FIG. **19**, the in-cell touch LCD device according to an embodiment may use the common electrode **260**, formed on the color filter array substrate **200**, as the touch electrode. To this end, the common electrode **260** may be patterned as a plurality of blocks by performing the photolithography process and the etching process using the sixth mask, and each of the blocks of the patterned common electrode **260** may be a separate touch electrode **262**.

The color filter array substrate **200** according to an embodiment may be manufactured by the above-described manufacturing process.

FIG. **20** is a diagram illustrating that a conductive line is electrically connected to a touch electrode by bonding a TFT array substrate to a color filter array substrate.

Referring to FIG. **20**, the liquid crystal layer LC may be disposed in the cell gap between the TFT array substrate **100** and the color filter array substrate **200**, and the TFT array substrate **100** may be bonded to the color filter array substrate **200** by the sealant.

When the TFT array substrate **100** is bonded to the color filter array substrate **200**, the common electrode (the touch electrode) **260** formed on the column spacer **250** may electrically contact the transparent conductive layer **190** formed on the TFT array substrate **100**. Here, since the transparent conductive layer **190** electrically contacts the conductive line **160** through the second contact hole H2, the touch electrode **262** formed on the color filter array substrate **200** may electrically contact the conductive line **160** formed on the TFT array substrate **100** by using a protruding form of the column spacer **250**.

The in-cell touch LCD device according to an embodiment may be manufactured by the above-described manufacturing process.

The above embodiments describe an in-cell touch LCD device based on the TN mode; a TFT array substrate configuring the in-cell touch LCD device based on the TN mode and the method of manufacturing the same; and a color filter array substrate configuring the in-cell touch LCD device based on the TN mode and the method of manufacturing the same.

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 its spirit or scope. Thus, it is intended that the present invention covers modifications and variations of this invention that come within the scope of the appended claims and their equivalents.

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What is claimed is:

1. An in-cell touch liquid crystal display (LCD) device comprising:

a thin film transistor (TFT) array substrate including:

a gate line and a data line that intersect each other to define a pixel area on a first glass substrate,

a TFT disposed in the pixel area,

a first passivation layer disposed above the TFT,

a conductive line disposed on the first passivation layer to horizontally overlap with the data line, and

a transparent conductive layer disposed above the conductive line and in electrical contact with the conductive line;

a pixel electrode disposed above the first passivation layer, the pixel electrode electrically connected to the TFT through a first contact hole in the first passivation layer, the pixel electrode being on a same layer as at least a part of the transparent conductive layer,

a color filter array substrate including:

a light shield layer and a color filter disposed on a second glass substrate,

an overcoat layer covering the light shield layer and the color filter,

a column spacer disposed on the overcoat layer to horizontally overlap with the light shield layer, and

a common electrode disposed on the overcoat layer and the column spacer, the conductive line configured to supply the common electrode with a common voltage or a touch driving signal through the transparent conductive layer in electrical contact with the common electrode; and

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a liquid crystal layer disposed between the TFT array substrate and the color filter array substrate.

2. The in-cell touch LCD device of claim 1, further comprising:

a first buffer layer disposed between the first passivation layer and the TFT; and

a second buffer layer disposed between the conductive line and the first passivation layer.

3. The in-cell touch LCD device of claim 1, further comprising a second passivation layer disposed on an upper surface of the conductive line, the transparent conductive layer electrically connected to the conductive line through a second contact hole in the second passivation layer.

4. The in-cell touch LCD device of claim 3, wherein the second passivation layer contacts the TFT through the first contact hole in the first passivation layer.

5. The in-cell touch LCD device of claim 3, wherein the transparent conductive layer and the pixel electrode are each on the second passivation layer.

6. The in-cell touch LCD device of claim 1, wherein the transparent conductive layer is composed of a same material as the pixel electrode.

7. The in-cell touch LCD device of claim 1, wherein the transparent the conductive line is configured to supply the common electrode with the common voltage during a display period and to supply the common electrode with a touch driving signal during a touch period.

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