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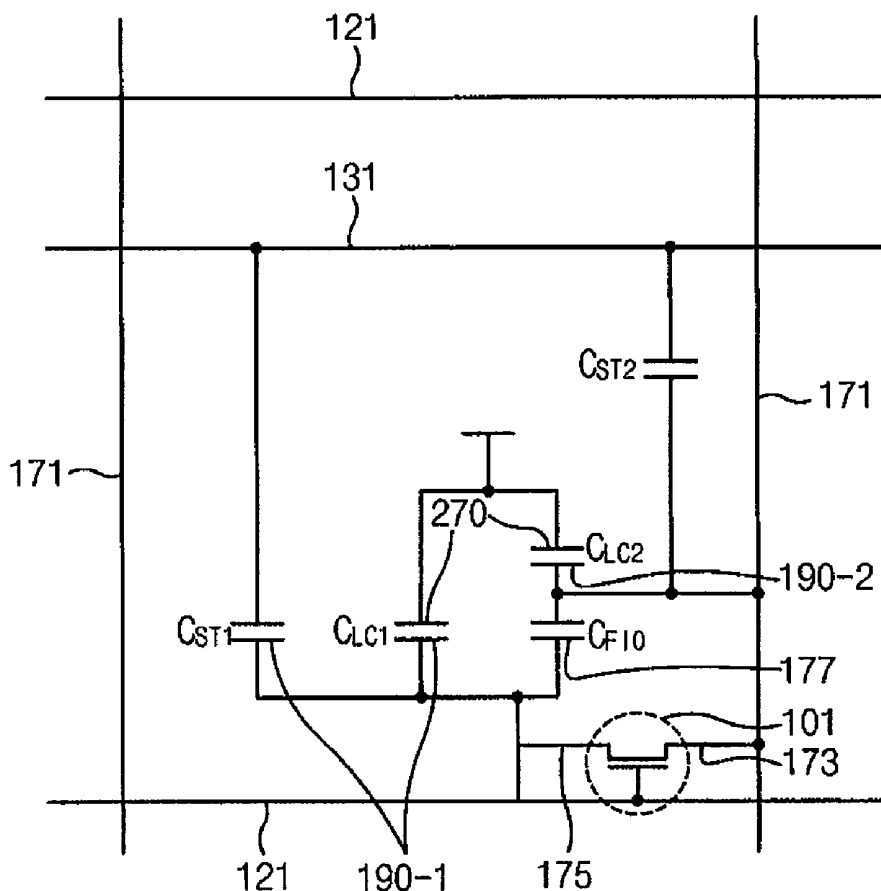


FIG. 1

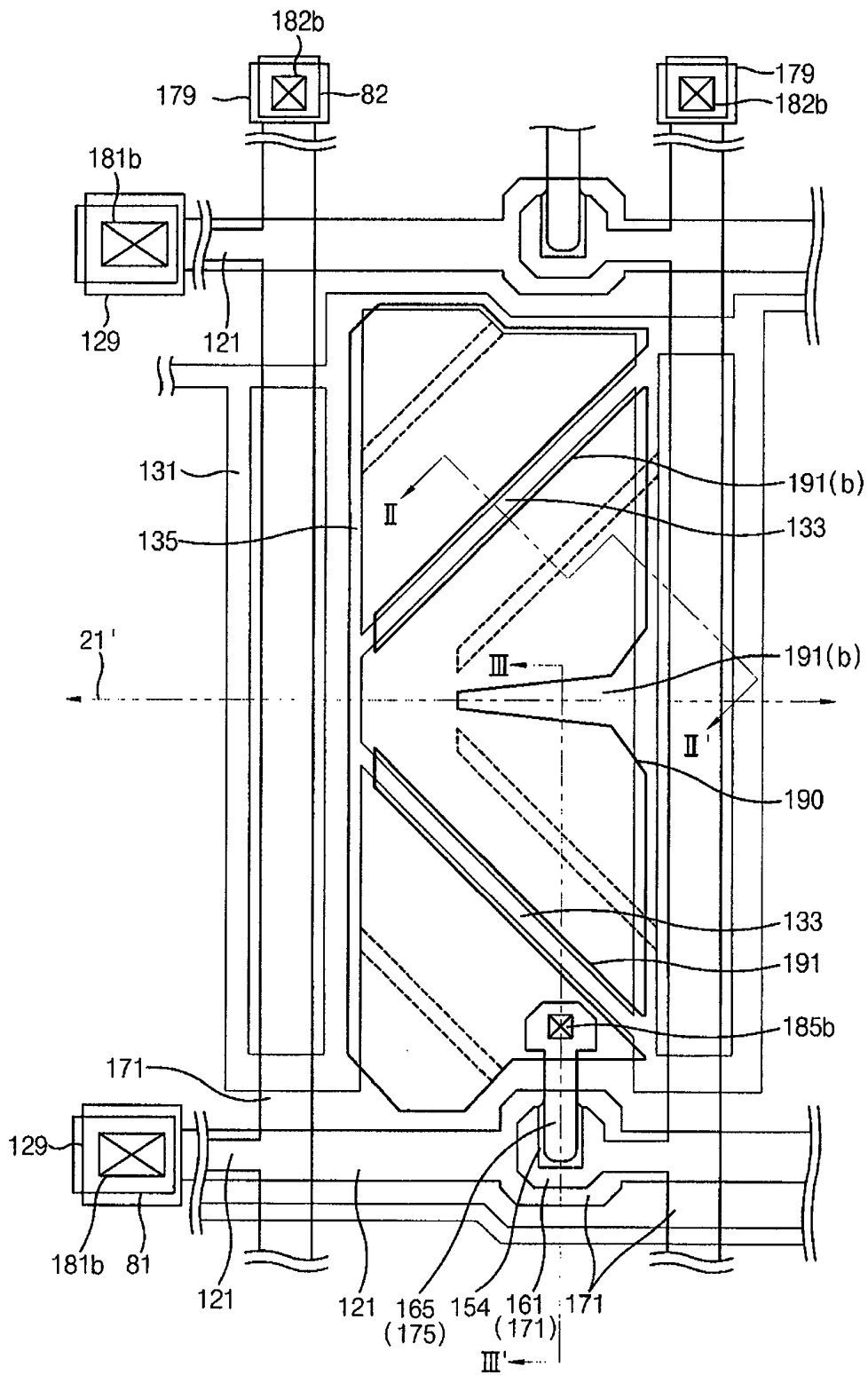


FIG. 2

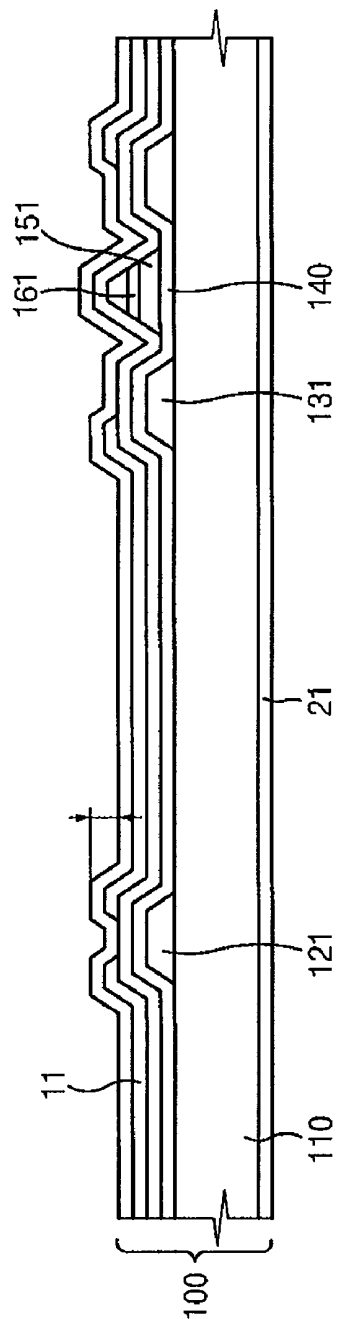


FIG. 3

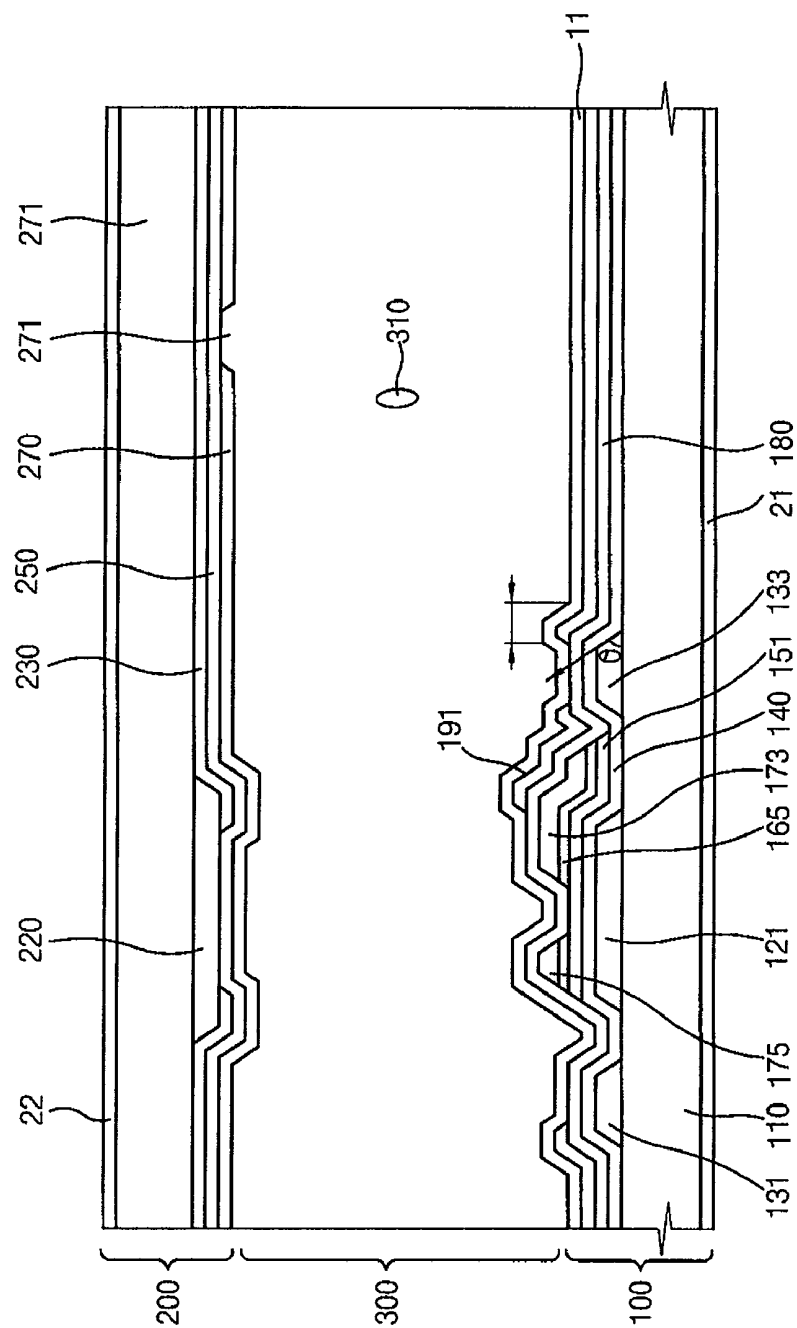


FIG. 4

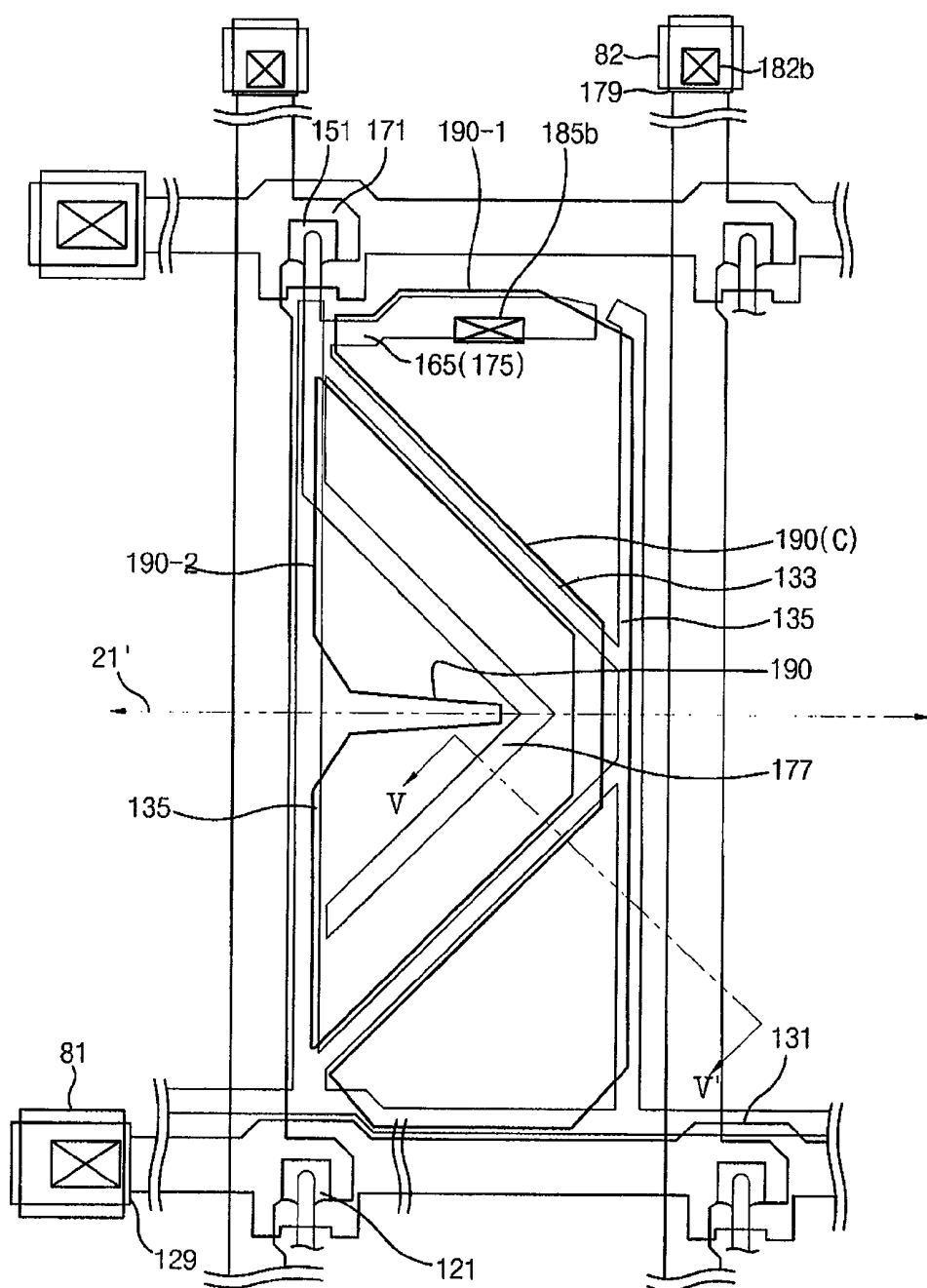


FIG. 5

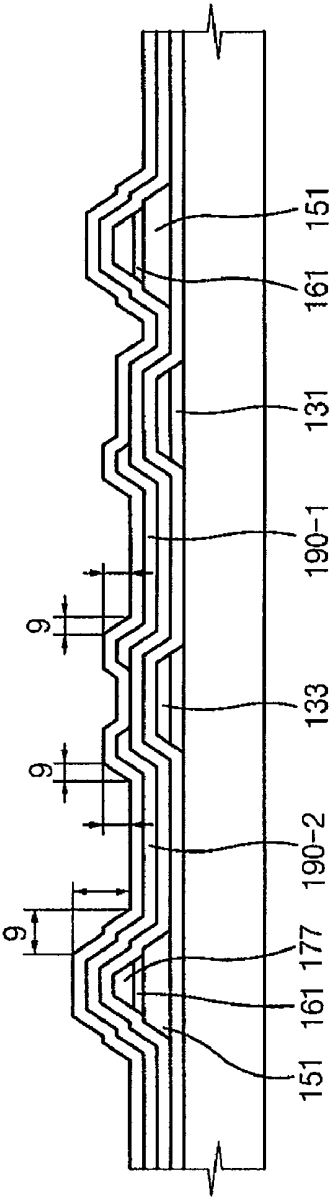
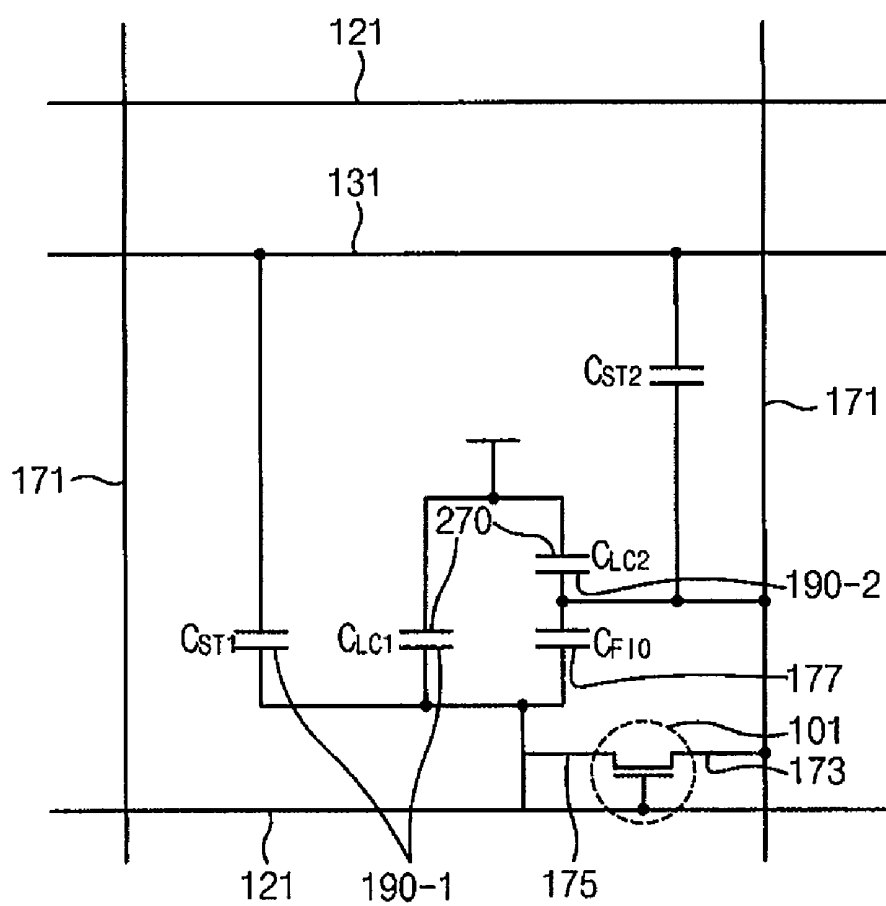


FIG. 6



TFT SUBSTRATE AND LIQUID CRYSTAL DISPLAY DEVICE HAVING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application relies for priority upon Korean Patent Application No. 2004-66468 filed on Aug. 23, 2004, the contents of which are herein incorporated by reference in its entirety.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates to a TFT substrate and a display device having the TFT substrate. More particularly, the present invention relates to a TFT substrate and a liquid crystal display device having the TFT substrate.

[0004] 2. Description of the Related Art

[0005] A liquid crystal display (LCD) device includes a color filter substrate, a thin film transistor (TFT) substrate and a liquid crystal layer. The color filter substrate includes a color filter layer and a common electrode. The TFT substrate includes a TFT and a pixel electrode that is electrically connected to the TFT. The liquid crystal layer is disposed between the TFT substrate and the color filter substrate. When a data voltage is applied to the pixel electrode, an electric field is generated between the pixel electrode and the common electrode to alter an arrangement of liquid crystal molecules of the liquid crystal layer. As a result, an optical transmissivity is altered to display an image.

[0006] When a contrast ratio of the LCD device is high, the LCD device displays a clear image. Therefore, it would be desirable to improve the contrast ratio for LCD devices.

SUMMARY OF THE INVENTION

[0007] In accordance with the present invention, a TFT substrate capable of enhancing a contrast ratio by reducing contrast ratio deterioration due to a stepped portion is provided.

[0008] In accordance with the present invention, a liquid crystal display device having the above TFT substrate is also provided.

[0009] In an exemplary TFT substrate according to the present invention, the TFT substrate includes a substrate, a plurality of gate lines, a plurality of data lines, a plurality of pixel electrodes, a protection layer and a pattern. The gate lines are formed on the substrate and extend in a first direction. The data lines are formed on the substrate and extend in a second direction that is substantially perpendicular to the first direction. Each of the pixel electrodes is electrically connected to a TFT that is also electrically connected to a selected gate line and a selected data line. The protection layer is formed on the substrate such that the protection layer covers the gate lines and the data lines. The pattern is disposed in a pixel region of the substrate to induce a stepped portion of the protection layer. The pixel region is defined by adjacent gate lines and adjacent data lines. A longitudinal direction of the pattern forms an angle of about 30 degrees to about 60 degrees with respect to one of the first and second directions. A side of the pattern forms an inclination angle of no more than about 45 degrees when a thickness of the pattern is more than about 3000 angstroms. The side of the pattern forms an inclination angle of no more than about 50 degrees when a thickness of the pattern is in a range of about 2000 angstroms

to about 3000 angstroms. The side of the pattern forms an inclination angle of no more than about 90 degrees when a thickness of the pattern is less than about 2000 angstroms.

[0010] In an exemplary LCD device according to the present invention, the LCD device includes an upper substrate, a polarization layer, a lower substrate and a liquid crystal layer. The polarization plate has a transmission axis. The lower substrate faces the upper substrate, and is disposed on the polarization plate. The lower substrate includes a plurality of gate lines, a plurality of data lines, a plurality of pixel electrodes, a protection layer and a pattern. The gate lines are formed on the substrate and extend in a first direction. The data lines are formed on the substrate and extend in a second direction that is substantially perpendicular to the first direction. Each of the pixel electrodes is electrically connected to a TFT that is also electrically connected to a selected gate line and a selected data line. The protection layer is formed on the substrate such that the protection layer covers the gate lines and the data lines. The pattern is disposed in a pixel region of the substrate to induce a stepped portion of the protection layer. The pixel region is defined by adjacent gate lines and adjacent data lines. A longitudinal direction of the pattern forms an angle of about 30 degrees to about 60 degrees with respect to one of the first and second directions. A side of the pattern forms an inclination angle of no more than about 45 degrees when a thickness of the pattern is more than about 3000 angstroms. The side of the pattern forms an inclination angle of no more than about 50 degrees when a thickness of the pattern is in a range of about 2000 angstroms to about 3000 angstroms. The side of the pattern forms an inclination angle of no more than about 90 degrees when a thickness of the pattern is less than about 2000 angstroms. The liquid crystal layer is disposed between the upper and lower substrates.

[0011] In another exemplary LCD device according to the present invention, the LCD device includes a first substrate, a second substrate, a liquid crystal layer and a voltage applying part. The first substrate has a first base substrate, a plurality of patterns disposed at different height with respect to the first base substrate, and an insulation layer formed on the first base substrate. The insulation layer has a plurality of raised portions by covering the patterns. The second substrate faces the first substrate. The liquid crystal layer is disposed between the first and second substrates. The voltage applying part generates electric fields passing through the liquid crystal layer. A side of the raised portions forms an inclination angle of no more than about 45 degrees when a height of the raised portions is more than about 3000 angstroms, the side of the raised portions forms an inclination angle of no more than about 50 degrees when a height of the raised portions is in a range of about 2000 angstroms to about 3000 angstroms, and the side of the raised portions forms an inclination angle of no more than about 90 degrees when a height of the raised portions is less than about 2000 angstroms.

[0012] When a pattern (for example, a protruding portion) disposed in the pixel region induces a stepped portion of an alignment film, a longitudinal direction of the patterns forms an angle of about 30 degrees to about 60 degrees with respect to the transmission axis of the polarizing plate. The pattern satisfies the above-mentioned relation between thickness and inclination angle, and as a result, a light leakage is minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The above and other features and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the accompanying drawings, in which:

[0014] FIG. 1 is a layout illustrating a TFT substrate of an LCD according to a first exemplary embodiment of the present invention;

[0015] FIG. 2 is a cross-sectional view taken along a line II-II' in FIG. 1;

[0016] FIG. 3 is a cross-sectional view taken along a line III-III' in FIG. 1;

[0017] FIG. 4 is a layout illustrating a TFT substrate according to a second exemplary embodiment of the present invention;

[0018] FIG. 5 is a cross-sectional view taken along a line V-V' in FIG. 4; and

[0019] FIG. 6 is a circuit diagram of the LCD device in FIG. 4.

DESCRIPTION OF THE EMBODIMENTS

[0020] When patterns being disposed in a pixel region and inducing a stepped portion forms an angle of about 30 degrees to about 60 degrees, liquid crystal molecules that makes contact with the stepped portion are not vertically erected, so that light is leaked through the stepped portion to lower a contrast ratio. According to the present invention, a condition of the patterns for reducing the patterns.

[0021] It should be understood that the exemplary embodiments of the present invention described below may be varied and modified in many different ways without departing from the inventive principles disclosed herein, and the scope of the present invention is therefore not limited to these particular embodiments. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art by way of example and not of limitation.

[0022] Hereinafter, the embodiments of the present invention will be described in detail with reference to the accompanying drawings. It is noted that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by embodiments that will be described below. The embodiments are only examples for showing the spirit of the present invention to a person skilled in the art. In the figures, a thickness of layers is exaggerated in order to improve clarity. The term "disposed on" means "disposed over". In other words, another structure may be disposed therebetween. The term "disposed directly on" means that no other structures are disposed therebetween.

[0023] FIG. 1 is a layout illustrating a TFT substrate of an LCD according to a first exemplary embodiment of the present invention. FIG. 2 is a cross-sectional view taken along a line II-II' in FIG. 1, and FIG. 3 is a cross-sectional view taken along a line III-III' in FIG. 1.

[0024] Referring to FIGS. 1, 2 and 3, a liquid crystal display (LCD) device according to the present embodiment includes a thin film transistor (TFT) substrate 100, a color filter substrate 200 facing the TFT substrate 100, and a liquid crystal layer 300 disposed between the TFT substrate 100 and the color filter substrate 200. Liquid crystal molecules 310 of the liquid crystal layer 300 are arranged such that a longitudinal

direction of the liquid crystal molecules is substantially perpendicular to the TFT substrate 100 and the color filter substrate 200.

[0025] The TFT substrate 100 and the color filter substrate 200 include a first alignment layer 11 and optionally a second alignment layer (not shown) in order to arrange the liquid crystal molecules 310 in the longitudinal direction.

[0026] A plurality of gate lines 121 and a plurality of storage electrode lines 131 are formed on a first insulation substrate 110.

[0027] The gate line 121 transfers a gate signal, and a portion of the gate line 121 corresponds to a gate electrode. An end portion 129 of the gate line 121 is enlarged to form the gate electrode, and the gate line 121 is electrically connected to an external device through the end portion 129. When a gate driving circuit is mounted directly on the first insulation substrate 110, the end portion 129 of the gate line 121 is connected to an output terminal of the gate driving circuit.

[0028] The storage electrode lines 131 are formed such that the storage electrode lines 131 are substantially parallel with the gate line 121. Alternatively, the storage electrode lines 131 are formed substantially parallel with data lines 171 (as shown in FIG. 1). The storage electrode line 131 includes a storage electrode 135. The storage electrode 135 includes a protruding portion 133. A longitudinal direction of the protruding portion 133 forms an angle of about 45 degrees with respect to a longitudinal direction of the storage electrode lines 131. A voltage applied to the storage electrode 135 is substantially the same as a reference voltage applied to a common electrode 270 of the color filter substrate 200.

[0029] The gate line 121 and the storage electrode line 131 have a single layered structure as shown in FIGS. 2 and 3. Alternatively, the gate line 121 and the storage electrode line 131 may have a multi-layered structure. For example, the gate line 121 and the storage electrode line 131 may include a lower layer (not shown) and an upper layer (not shown). The lower and upper layers may have different physical characteristics. The upper layers of the gate line 121 and the storage electrode line 131 may comprise a metal having a relatively low electric resistivity, such as aluminum, aluminum alloy, etc. The lower layer may comprise a material having a relatively high adhesive force to indium tin oxide (ITO), such as molybdenum (Mo), molybdenum alloy, chromium (Cr), etc. For example, the lower layer may comprise chromium (Cr) and the upper layer may comprise aluminum neodymium alloy (AlNd).

[0030] A first polarizing layer 21 is disposed under the first insulation substrate 110. The first polarizing layer 21 has a transmission axis 21' that is disposed substantially parallel with the gate line 121. The storage electrode 135 includes the protruding portion 133 protruded such that a longitudinal direction of the protruding portion 133 forms an angle of about 45 degrees with respect to a longitudinal direction of the transmission axis 21'.

[0031] The protruding portion 133 induces a stepped portion at a pixel region for displaying an image when the layers are formed on the protruding portion 133. In other words, due to the formation of the protruding portion 133 on the substrate 110, a surface of the pixel region is not planar. Therefore, the liquid crystal molecules 310 that are disposed at the stepped portion are inclined. In other words, the liquid crystal molecules 310 disposed on a flat region are vertically arranged, but the liquid crystal molecules 310 disposed at the stepped portion are not vertically arranged, so that light leaks through

the liquid crystal layers **310** disposed at the stepped portion. Therefore, the resulting a contrast ratio of the display device is lowered.

[0032] Hereinafter, a stepped portion condition for reducing light leakage will be explained. In an experiment, amount of light leakage was measured by varying a thickness and an inclination of the protruding portion **133**. In order to reduce light leakage, a thickness of the protruding portion and an inclination of the protruding portion were adjusted. According to results of the experiment, an inclination of the protruding portion **133** was adjusted according to a thickness of the protruding portion **133**. The inclination of the protruding portions **133** were set in cases when the thickness of the protruding portion **133** was no thicker than about 2000 angstroms, when the thickness of the protruding portion **133** was in a range from about 2000 angstroms to about 3000 angstroms, and when the thickness of the protruding portion was thicker than about 3000 angstroms, respectively.

[0033] Table 1 below shows a portion of results of the experiment.

TABLE 1

Thickness (Angstrom)	Inclination θ (Degrees)	Light leakage	Contrast ratio acceptable?
3000	90	0.056	No
2000	90	0.0279	Yes
1000	90	0.0012	Yes
3000	45	0.0154	Yes
2000	45	0.0066	Yes
1000	45	0.0018	Yes
3000	22.5	0.0024	Yes

[0034] In an embodiment in which the protruding portion has a thickness greater than about 3000 angstroms and has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis **21'** of the first polarizing layer **21**, the inclination angle of the protruding portion is substantially equal to or less than about 45 degrees. In an embodiment in which the protruding portion has a thickness in the range of about 2000 angstroms to about 3000 angstroms and has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis **21'** of the first polarizing layer **21**, the inclination angle of the protruding portion is substantially equal to or less than about 50 degrees. In an embodiment in which the protruding portion has a thickness less than about 2000 angstroms and has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis **21'** of the first polarizing layer **21**, the inclination angle of the protruding portion is substantially equal to or less than about 90 degrees.

[0035] That is, when a protruding portion has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis **21'** of the first polarizing layer **21**, and has an inclination angle substantially equal to or less than about 90 degrees, an allowable thickness of the protruding portion is substantially equal to or less than about 2000 angstroms. When the protruding portion has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis **21'** of the first polarizing layer **21**, and has an inclination angle substantially equal to or less than about 50 degrees, an allowable thickness of the protruding portion is substantially equal to or less than about 3000 angstroms. When the protruding

portion has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis **21'** of the first polarizing layer **21**, and has an inclination angle substantially equal to or less than about 45 degrees, a thickness more than about 3000 angstroms is allowable.

[0036] The protruding portion **133** induces stepped portions of the alignment film **11** that make contact with liquid crystal molecules of the liquid crystal layer **300**. Therefore, the same logic is applied when the 'protruding portion' is replaced by the 'stepped portions of the alignment film' in the above explanation.

[0037] Electrical resistivity decreases as a thickness of the storage electrode increases. However, when the inclination of the protruding portion **133** that protrudes from the storage electrode satisfies the inclination condition described above, the light leakage is minimized.

[0038] In FIG. 1, an opening portion of a pixel electrode **190** is disposed over the protruding portion **133**, so that the pixel electrode **190** does not overlap with the protruding portion **133**. Alternatively, even when the protruding portion **133** overlaps with the pixel electrode **190** to generate a storage capacitance, the above-mentioned condition is not changed.

[0039] The protruding portion **133** and the gate electrode **190** are formed from the same metal layer during the same manufacturing process, so that the protruding portion **133** is optically opaque like the gate electrode **190**. The protruding portion **133** is disposed in the pixel region (or display region), so that reducing a width of the protruding portion **133** is preferable. A width of the protruding portion **133** is, preferably, no wider than about 10 μm . According to the present embodiment, the protruding portion **133** has a width of about 7 μm .

[0040] Inclination of the gate line **121** and the storage electrode line **131** are substantially the same as that of the protruding portion **133**.

[0041] A gate insulation layer **140** is formed on the first insulation substrate **110** having the gate line **131**, the storage electrode line **131** and the protruding portion **133** formed thereon. The gate insulation layer **140** comprises silicon nitride (SiN_x) as an exemplary embodiment.

[0042] A semiconductor layer **151** comprising, for example, amorphous silicon (a-Si), is formed on the gate insulation layer **140**. The semiconductor layer **151** extends substantially parallel with the data line **171**, and overlaps with the data line **171**. A portion **154** of the semiconductor layer **151** extends toward the gate electrode **124**. A width of the semiconductor layer **151** is increased at a region where the gate line **121** and the storage electrode line **131** are merged.

[0043] Ohmic contact layers **161** are formed on the semiconductor layer **151**. The ohmic contact layers **161** comprise n-type dopant in amorphous silicon ($n^+ \text{a-Si}$). The ohmic contact layers **161** are disposed over the portion **154** of the semiconductor layer **151**.

[0044] The sides of the semiconductor layer **151** and the ohmic contact layers **161** are inclined to have an inclination angle of about 30 degrees to about 80 degrees with respect to the substrate **110**.

[0045] A plurality of data lines **171** and a plurality of drain electrodes **175** are formed on the gate insulation layer **140** and the ohmic contact layers **161**, respectively.

[0046] The data lines **171** extend such that a longitudinal direction of the data lines **171** is substantially perpendicular to a longitudinal direction of the gate line **121** and the data

lines 171 are substantially parallel with the storage electrode line 131. The data lines 171 transmit data voltages. The data lines 171 extend in a straight line. Alternatively, when one pixel has a chevron shape having a bent portion, the data line 171 may be bent along an edge portion of the pixel.

[0047] The drain electrode 175 extends toward the storage electrode 135 such that the drain electrode 175 overlaps with the storage electrode 135. A source electrode 173 protrudes from the data line 171. The gate electrode 124, the source electrode 173 and the drain electrode 175 form a thin film transistor TFT. A channel layer is formed at the portion 154 between the source electrode 173 and the drain electrode 175. An end portion 179 of the data line 171 has a wider width than other portions of the data line 171 in order to be easily connected to an external circuit.

[0048] The data line 171 has a single layered structure. Alternatively, the data line 171 may have a multi-layered structure. For example, the data line 171 may include a lower layer (not shown) and an upper layer (not shown). The lower and upper layers may have different physical characteristics. The upper layer of the data line 171 may comprise a metal having a relatively low electric resistivity, such as aluminum, aluminum alloy, etc. The lower layer may comprise a material having a relatively high adhesive force to indium tin oxide (ITO), such as molybdenum (Mo), molybdenum alloy such as molybdenum tungsten (MoW), chromium (Cr), etc. For example, the lower layer may comprise chromium (Cr) and the upper layer may comprise aluminum neodymium alloy (AlNd). Alternatively, the data line 171 may have a triple-layered structure of molybdenum or molybdenum alloy/aluminum or aluminum alloy/molybdenum or molybdenum alloy. Molybdenum nitride, molybdenum neodymium, etc. may be used for the molybdenum alloy.

[0049] The ohmic contact layers 161 disposed between the semiconductor layer 151, and the source and drain electrodes 173 and 175 lower a contact resistivity. The semiconductor layer 151 has a portion that is not covered by the data line 171 and the drain electrode 175, but a majority of the semiconductor layer 151 has substantially the same as or wider width than a width of the data line 171.

[0050] A protection layer 180 is formed on the first insulation substrate 110 such that the protection layer 180 covers the semiconductor layer 151 exposed between the source and drain electrodes 173 and 175, and the data line 171. The protection layer 180 comprises, for example, silicon nitride.

[0051] The protection layer 180 includes a contact hole 185b exposing a portion of the drain electrode 175, a contact hole 182b exposing an end portion 179 of the data line 171, and a contact hole 181b. A portion of the gate insulation layer 140, which corresponds to the contact hole 181b, is removed, so that an end portion 129 of the gate line 121 is exposed through the contact hole 181b.

[0052] A side face of the contact holes 181b, 182b and 185b has, for example, an inclination of about 30 degrees to about 85 degrees with respect to the substrate 110.

[0053] The contact holes 181b, 182b and 185b may comprise various cross-sectional shapes such as a polygon, a circle, etc. when viewed from a plan view perspective. The contact holes 181b, 182b and 185b may have, e.g., a cross-sectional area of about $0.5\text{ }\mu\text{m}\times 15\text{ }\mu\text{m}$ to about $2\text{ }\mu\text{m}\times 60\text{ }\mu\text{m}$.

[0054] The upper layer of the end portion 129 of the gate line 121, the end portion 179 of the data line 171, and the drain electrode 175, exposed by the contact holes 181b, 182b, and 185b, respectively, are removed. In detail, the upper layer

including aluminum or aluminum alloy is removed in order to enhance the connection to a conductor layer, as will be described in greater detail below.

[0055] The pixel electrode 190 comprising an optically transparent and electrically conductive material such as indium tin oxide (ITO), indium zinc oxide (IZO), etc., contact supporting members 81 and 82, and a subsidiary electrode 197 are formed on the protection layer 180.

[0056] The pixel electrode 190 is disposed in the pixel region surrounded by the gate lines 121 and the data lines 171. The pixel electrode 190 is electrically connected to the drain electrode 175 through the contact hole 185b.

[0057] The contact supporting members 81 and 82 are electrically connected to the end portion 129 of the gate line 121, and the end portion 179 of the data line 171 through the contact holes 182b and 181b, respectively. The contact supporting members 81 and 82 enhance an electrical contact stability, and protect the end portions 129 and 179 of the gate and data lines 121 and 171, respectively. Here, the contact supporting members 81 and 82 are optional. When the gate line 121 and the data line 171 are electrically connected to output terminals of a gate driving circuit and a data driving circuit formed on the first insulation substrate 110, the contact supporting members 81 and 82 are not required.

[0058] The pixel electrode 190 includes the opening portions 191a and 191b. A first virtual line extending along the opening portion 191a meets a second virtual line extending along the opening portion 191b to form an angle of about 90 degrees. A width of the opening portions 191a and 191b is no wider than about $10\text{ }\mu\text{m}$. The pixel electrode 190 overlaps a portion of the storage electrode 135. In other words, a portion of the storage electrode 135 is not covered by the pixel electrode 190, so that the storage electrode 135 blocks light leakage between the pixel electrodes 190 adjacent to each other.

[0059] The pixel electrode 190 comprises an optically transparent and electrically conductive material such as ITO, IZO, etc. Alternatively, the pixel electrode 190 may comprise a metal that is opaque, when the LCD device corresponds to a reflective type LCD device. The contact supporting members 81 and 82 may comprise the same material as that of the pixel electrode 190. Alternatively, the contact supporting members 81 and 82 may comprise a different material from that of the pixel electrode 190.

[0060] The color filter substrate 200 comprises a second insulating substrate 210, a light blocking layer 220 and a color filter layer 230. The light blocking layer 220 includes an opening portion disposed over the pixel electrode 190. The color filter layer 230 includes a plurality of red color filters, a plurality of green color filters and a plurality of blue color filters. Each of the red, green and blue color filters are formed on the second insulation layer 210 exposed through the opening portions of the light blocking layer 220.

[0061] The color filter substrate 200 further comprises an over-coating layer 250 formed on the color filter layer 230 and the light blocking layer 220. The over-coating layer 250 comprises, for example, an organic material.

[0062] The color filter substrate 200 further comprises a common electrode 270 formed on the over-coating layer 250. The common electrode 270 comprises an optically transparent and electrically conductive material such as ITO, IZO, etc. The common electrode 270 includes an opening portion 271 that is positioned to be substantially parallel and aligned with the opening portion 191a of the pixel electrode 190.

[0063] The opening portion 271 controls a direction of the liquid crystal molecules 310. The opening portion 271 has a width of, e.g., about 9 μm to about 12 μm . Instead of the opening portions 271 of the common electrode 270, an upper protrusion may be formed on the common electrode 270. Instead of the opening portion 191a of the pixel electrode 190, a lower protrusion may be formed on pixel electrode 190. When the upper protruding portion is formed on the common electrode 270, the common electrode 270 may be directly formed on the color filter layer 230. The upper and lower protrusions may be formed at substantially the same position of the opening portions 271 or the opening portion 191a.

[0064] The first and second polarizing layers 21 and 22 are formed on outer surfaces of the first and second insulation substrates 110 and 210, respectively. One of the first and second polarizing layers 21 and 22 has a light transmission axis that is substantially in parallel with the gate line 121.

[0065] The LCD device optionally includes a retardation film for compensating a retardation value of the liquid crystal layer 300.

[0066] The liquid crystal layer 300 includes liquid crystal molecules forming a substantially perpendicular angle with respect to the first and second insulation substrates 110 and 210 in a default state. The liquid crystal layer 300 has a negative permittivity anisotropy.

[0067] When a reference voltage is applied to the common electrode 270 and a data voltage is applied to the pixel electrode 190, a primary electric field is formed between the common electrode 270 and the pixel electrode 190. The primary electric fields are generated substantially perpendicular to the planar surfaces of the common electrode 270 and the pixel electrode 190. Then, liquid crystal molecules 310 are rearranged such that a direction of the liquid crystal molecules 310 is substantially perpendicular to the primary electric fields. In other words, the liquid crystal molecules 310 are inclined.

[0068] The opening portion 271 of the common electrode 270 and the opening portion 191a of the pixel electrode 190 alter the electric fields to form a horizontal component. Therefore, four domains are generated in the pixel region. Two of the domains adjacent to each other have a different inclination angle. Each domain has a width of about 10 μm to about 30 μm .

[0069] When the pixel region has a size of smaller than about 100 μm ×300 μm , the pixel region includes four domains. When the pixel region has a size of substantially equal to or larger than about 100 μm ×300 μm , the pixel region may include four domains or eight domains.

[0070] When an inclination angle of the liquid crystal molecules 310 forms an angle of 45 degrees with respect to the transmission axis 21' of the first polarizing layer 21, a maximum luminance may be obtained. According to the present invention, all liquid crystal molecules 310 of each domain are inclined at an angle of about 45 degrees with respect to the gate line 121, and the gate line 121 is substantially perpendicular to or parallel with edges of the first and second insulation substrates 110 and 210. Therefore, when the first polarizing layer 21 is attached on the outer surface of the first insulation substrate 110 such that the transmission axis 21' of the first polarizing layer 21 is substantially perpendicular to or parallel with edges of the first insulation substrate 110, a maximum luminance may be obtained.

[0071] FIG. 4 is a layout illustrating a TFT substrate according to a second exemplary embodiment of the present invention. FIG. 5 is a cross-sectional view taken along a line V-V' in FIG. 4, and FIG. 6 is a circuit diagram of the LCD device in FIG. 4.

[0072] Referring to FIGS. 4, 5 and 6, a TFT 101 is formed in a pixel region. The TFT 101 is electrically connected to the gate line 121 and the data line 171. A first liquid crystal capacitor C_{LC1} is formed, the first liquid crystal capacitor C_{LC1} being defined by the pixel electrode 190-1 that is electrically connected to the drain electrode 175 of the TFT 101, a common electrode 270, and liquid crystal layer 300 disposed between the pixel electrode 190-1 and the common electrode 270. A second liquid crystal capacitor C_{LC2} is formed, the second liquid crystal capacitor C_{LC2} defined by the pixel electrode 190-2 that is electrically connected to the drain electrode 175 of the TFT 101, a common electrode 270 and liquid crystal layer 300 disposed between the pixel electrode 190-1 and the common electrode 270.

[0073] When a voltage of about 7V is applied to the pixel electrode 190-1 and a voltage of about 5V is applied to the common electrode 270, a voltage difference of about 2V is applied between the pixel electrode 190-1 and the common electrode 270. However, a voltage difference less than about 2V is applied between the floating pixel electrode 190-2 and the common electrode 270, because the storage capacitor C_{st0} is electrically connected in series with the second liquid crystal capacitor C_{LC2} . That is, by applying a voltage of about 7V, two different voltages may be applied to the first and second liquid crystal capacitors C_{LC1} and C_{LC2} , respectively. Therefore, a first light that passes through the first liquid crystal capacitors C_{LC1} and a second light that passes through the second liquid crystal capacitors C_{LC2} interfere with each other. This interface enhances the display quality.

[0074] Additionally, a storage capacitor C_{st1} for reducing voltage drop caused by a leakage current flowing between the storage electrode line 131 and the pixel electrode 190-1, and a storage capacitor C_{st2} that is electrically connected to the storage electrode line 131 and the floating pixel electrode 190-2 are formed. The pixel electrode 190-1 and the floating pixel electrode 190-2 cover a portion of the data line 171. In detail, when a side of the data line 171 is spaced apart from a side of the storage electrode line 131 by at least about 1 μm , the storage electrode line 131 having a uniform voltage applied thereto blocks light.

[0075] The edges of the pixel electrode 190-1 and the floating pixel electrode 190-2 are aligned at an angle of about 90 degrees, and the protruding portions extending along the edges form an angle of 45 degrees with respect to the transmission axis 21'.

[0076] In embodiments in which the protruding portion has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis 21' of the first polarizing layer 21, and an inclination angle substantially equal to or less than about 45 degrees, the thickness of the protruding portion is thicker than about 3000 angstroms. In embodiments in which the protruding portion has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis 21' of the first polarizing layer 21, and an inclination angle substantially equal to or less than about 50 degrees, the thickness of the protruding portion is in a range of about 2000 angstroms to about 3000 angstroms. In embodiments in which the protruding portion has a longitudinal direction forming an angle

of about 30 degrees to about 60 degrees with respect to the transmission axis 21' of the first polarizing layer 21, and an inclination angle substantially equal to or less than about 90 degrees, the thickness of the protruding portion is thicker than about 3000 angstroms.

[0077] In other words, when the protruding portion has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis 21' of the first polarizing layer 21, and an inclination angle substantially equal to or less than about 90 degrees, an allowable thickness of the protruding portion is substantially equal to or less than about 2000 angstroms. When the protruding portion has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis 21' of the first polarizing layer 21, and an inclination angle substantially equal to or less than about 50 degrees, an allowable thickness of the protruding portion is substantially equal to or less than about 3000 angstroms. When the protruding portion that has a longitudinal direction forming an angle of about 30 degrees to about 60 degrees with respect to the transmission axis 21' of the first polarizing layer 21, and an inclination angle substantially equal to or less than about 45 degrees, a thickness more than about 3000 angstroms is allowable.

[0078] As described above, a pattern (for example, a protruding portion) disposed in the pixel region induces a stepped portion of an alignment film and a longitudinal direction of the pattern forms an angle of about 30 degrees to about 60 degrees with respect to the transmission axis of the polarizing plate. If the pattern satisfies the above-mentioned relationship between the thickness and inclination angle, the light leakage may be minimized.

[0079] Hereinbefore, the present invention was explained with reference to a VA mode LCD device. Alternatively, the present invention may be applied to a TN mode LCD device, or other mode LCD devices.

[0080] Having described the exemplary embodiments of the present invention, it is noted that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by appended claims.

1-26. (canceled)

27. A thin film transistor (TFT) substrate, comprising:
a substrate;

a plurality of gate lines formed on the substrate, the gate lines extending in a first direction;

a plurality of data lines formed on the substrate, the data lines extending in a second direction that is substantially perpendicular to the first direction;

a plurality of pixel electrodes, each of the pixel electrodes being electrically connected to a TFT that is electrically connected to a selected gate line and a selected data line;

a protection layer formed on the substrate such that the protection layer covers the gate lines and data lines; and
a pattern disposed in a pixel region of the substrate to induce a stepped portion of the protection layer, a longitudinal direction of the pattern forming an angle of about 30 degrees to about 60 degrees with respect to one of the first and second directions;

wherein if a thickness of the pattern is thicker than about 3000 angstroms, then a side of the protection layer on the pattern forms an inclination angle of no more than about 45 degrees, if a thickness of the pattern is in a range of about 2000 angstroms to about 3000 angstroms, then the

side of the protection layer on the pattern forms an inclination angle of no more than about 50 degrees, and if a thickness of the pattern is less than about 2000 angstroms, then the side of the protection layer on the pattern forms an inclination angle of no more than about 90 degrees.

28. The TFT substrate of claim 27, wherein the pixel electrode comprises at least one opening portion disposed over the pattern.

29. The TFT substrate of claim 28, wherein a width of the pattern is substantially smaller than a width of the opening portion of the pixel electrode.

30. The TFT substrate of claim 27, wherein the data line comprises a bent portion, so that the pixel region has a chevron-shape.

31. The TFT substrate of claim 27, wherein the protection layer comprises silicon nitride.

32. The TFT substrate of claim 27, wherein the pattern comprises at least one layer including aluminum or aluminum alloy.

33. The TFT substrate of claim 27, wherein the pattern comprises molybdenum, molybdenum alloy or chromium.

34. The TFT substrate of claim 27, wherein the pattern and the data lines are formed from a single layer.

35. The TFT substrate of claim 27, wherein a first voltage is applied to the pattern and the pixel electrode.

36. The TFT substrate of claim 27, further comprising a floating pixel electrode that is electrically isolated from the pixel electrode.

37. The TFT substrate of claim 27, further comprising an alignment layer on the protection layer, wherein if the thickness of the pattern is thicker than about 3000 angstroms, then a side of the alignment layer on the pattern forms an inclination angle of no more than about 45 degrees, if the thickness of the pattern is in the range of about 2000 angstroms to about 3000 angstroms, then the side of the alignment layer on the pattern forms an inclination angle of no more than about 50 degrees, and if the thickness of the pattern is less than about 2000 angstroms, then the side of the alignment layer on the pattern forms an inclination angle of no more than about 90 degrees.

38. A thin film transistor (TFT) substrate, comprising:

a substrate;

a plurality of gate lines formed on the substrate, the gate lines extending in a first direction;

a plurality of data lines formed on the substrate, the data lines extending in a second direction that is substantially perpendicular to the first direction;

a plurality of pixel electrodes, each of the pixel electrodes being electrically connected to a TFT that is electrically connected to a selected gate line and a selected data line;

an alignment layer formed on the substrate such that the alignment layer covers the gate lines and data lines; and

a pattern disposed in a pixel region of the substrate to induce a stepped portion of the alignment layer, a longitudinal direction of the pattern forming an angle of about 30 degrees to about 60 degrees with respect to one of the first and second directions;

wherein if a thickness of the pattern is thicker than about 3000 angstroms, then a side of the alignment layer on the pattern forms an inclination angle of no more than about 45 degrees, if a thickness of the pattern is in a range of about 2000 angstroms to about 3000 angstroms, then the side of the alignment layer on the pattern forms an incli-

nation angle of no more than about 50 degrees, and if a thickness of the pattern is less than about 2000 angstroms, then the side of the alignment layer on the pattern forms an inclination angle of no more than about 90 degrees.

39. A liquid crystal display (LCD) device comprising:
an upper substrate;

a polarization plate having a transmission axis;

a lower substrate facing the upper substrate and disposed on the polarization plate, the lower substrate comprising:

a plurality of gate lines extending in a first direction;
a plurality of data lines extending in a second direction that is substantially perpendicular to the first direction;

a plurality of pixel electrodes, each of the pixel electrodes being electrically connected to a TFT that is electrically connected to a selected gate line and a selected data line;

a protection layer formed on the substrate such that the protection layer covers the gate lines and the data lines; and

a pattern disposed in a pixel region of the substrate to induce a stepped portion of the protection layer, a longitudinal direction of the pattern forming an angle of about 30 degrees to about 60 degrees with respect to the polarization axis;

wherein if a thickness of the pattern is thicker than about 3000 angstroms, a side of the protection layer on the pattern forms an inclination angle of no more than about 45 degrees, if a thickness of the pattern is in a range of about 2000 angstroms to about 3000 angstroms, then the side of the protection layer on the pattern forms an inclination angle of no more than about 50 degrees, and if a thickness of the pattern is less than about 2000 angstroms, then the side of the protection layer on the pattern forming an inclination angle of no more than about 90 degrees; and

a liquid crystal layer disposed between the upper and lower substrates.

40. The LCD device of claim **39**, further comprising an alignment layer on the protection layer, wherein if the thickness of the pattern is thicker than about 3000 angstroms, then a side of the alignment layer on the pattern forms an inclina-

tion angle of no more than about 45 degrees, if the thickness of the pattern is in the range of about 2000 angstroms to about 3000 angstroms, then the side of the alignment layer on the pattern forms an inclination angle of no more than about 50 degrees, and if the thickness of the pattern is less than about 2000 angstroms, then the side of the alignment layer on the pattern forms an inclination angle of no more than about 90 degrees.

41. A liquid crystal display (LCD) device comprising:
an upper substrate;

a polarization plate having a transmission axis;

a lower substrate facing the upper substrate and disposed on the polarization plate, the lower substrate comprising:

a plurality of gate lines extending in a first direction;
a plurality of data lines extending in a second direction that is substantially perpendicular to the first direction;

a plurality of pixel electrodes, each of the pixel electrodes being electrically connected to a TFT that is electrically connected to a selected gate line and a selected data line;

a alignment layer formed on the substrate such that the alignment layer covers the gate lines and the data lines; and

a pattern disposed in a pixel region of the substrate to induce a stepped portion of the alignment layer, a longitudinal direction of the pattern forming an angle of about 30 degrees to about 60 degrees with respect to the polarization axis;

wherein if a thickness of the pattern is thicker than about 3000 angstroms, a side of the alignment layer on the pattern forms an inclination angle of no more than about 45 degrees, if a thickness of the pattern is in a range of about 2000 angstroms to about 3000 angstroms, then the side of the alignment layer on the pattern forms an inclination angle of no more than about 50 degrees, and if a thickness of the pattern is less than about 2000 angstroms, then the side of the alignment layer on the pattern forming an inclination angle of no more than about 90 degrees; and

a liquid crystal layer disposed between the upper and lower substrates.

* * * * *

专利名称(译)	TFT基板和具有该TFT基板的液晶显示装置		
公开(公告)号	US20080239186A1	公开(公告)日	2008-10-02
申请号	US12/124941	申请日	2008-05-21
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
[标]发明人	NA BYOUNG SUN		
发明人	NA, BYOUNG-SUN		
IPC分类号	G02F1/1368 H01L27/088		
CPC分类号	G02F1/133707 G02F1/134336 G02F1/1393		
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其他公开文献	US7492427		
外部链接	Espacenet USPTO		

摘要(译)

一种LCD装置，包括：第一基板，具有第一基础基板；图案，设置在相对于第一基础基板的不同高度处；以及绝缘层，形成在第一基础基板和图案上。绝缘层具有对应于图案的凸起部分。当凸起部分的高度大于约3000埃时，凸起部分的一侧形成不大于约45°的倾斜角，当凸起部分的侧面形成不大于约50°的倾斜角时凸起部分的高度在约2000埃至约3000埃的范围内，并且当凸起部分的高度大于约2000埃时，凸起部分的侧面形成不大于约90°的倾斜角。因此，可以最小化漏光。

