



US007215398B2

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

(10) **Patent No.:** **US 7,215,398 B2**
(45) **Date of Patent:** **May 8, 2007**

(54) **LIQUID CRYSTAL DISPLAY DEVICE
HAVING AN AUXILIARY ELECTRODE
CORRESPONDING TO THE PERIPHERY OF
THE PIXEL ELECTRODE IN ONLY ONE OF
AT LEAST TWO DOMAIN**

5,608,556 A * 3/1997 Koma 349/143
5,666,179 A 9/1997 Koma
5,953,093 A * 9/1999 Hirata et al. 349/143
6,356,335 B1 * 3/2002 Kim et al. 349/156
6,654,090 B1 * 11/2003 Kim et al. 349/129

(Continued)

(75) Inventors: **Sai Chang Yun**, Taegu-Kwangyokshi
(KR); **Do Sung Kim**, Kumi-shi (KR)

FOREIGN PATENT DOCUMENTS

EP 0 884 626 A2 12/1998

(Continued)

(73) Assignee: **L.G. Philips LCD Co., Ltd.**,
Youngdungapo-ku, Seoul (KR)

OTHER PUBLICATIONS

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 38 days.

Y. Tanaka et al.; Late-News Paper: A New Design to Improve
Performance and Simplify the Manufacturing Process of High-
Quality MVA TFT-LCD Panels; Fujitsu Ltd., Tottori, Japan; SID 99
DIGEST; pp. 206-209.

(Continued)

(21) Appl. No.: **10/405,326**

(22) Filed: **Apr. 3, 2003**

Primary Examiner—Dung T. Nguyen

Assistant Examiner—Thoi V. Duong

(74) *Attorney, Agent, or Firm*—McKenna Long & Aldridge
LLP

(65) **Prior Publication Data**

US 2004/0008312 A1 Jan. 15, 2004

(30) **Foreign Application Priority Data**

Jul. 12, 2002 (KR) 10-2002-0040777

(51) **Int. Cl.**
G02F 1/1343 (2006.01)

(52) **U.S. Cl.** 349/139; 349/129; 349/123

(58) **Field of Classification Search** 349/143,
349/141, 43, 123, 38, 139, 147, 126, 129,
349/106, 110

See application file for complete search history.

(56) **References Cited**

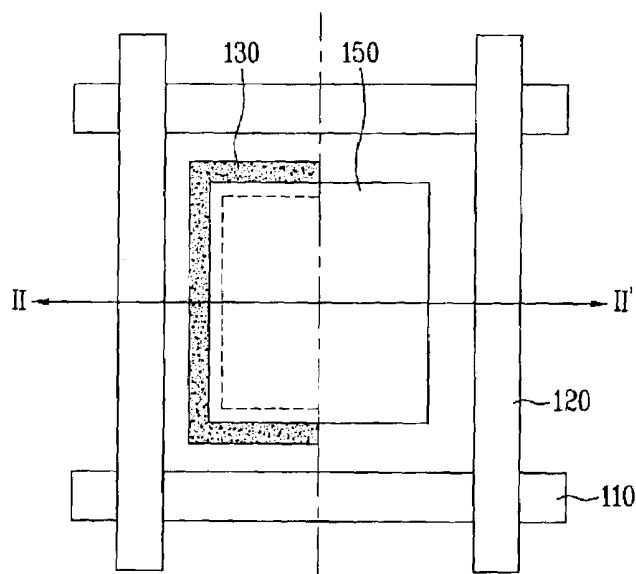
U.S. PATENT DOCUMENTS

4,691,995 A 9/1987 Yamazaki et al.
5,309,264 A 5/1994 Lien et al.

(57) **ABSTRACT**

A liquid crystal display (LCD) device is disclosed, which
obtains a high aperture ratio and a wide viewing angle. The
LCD device includes first and second substrates; a plurality
of gate and data lines on the first substrate to define a
plurality of pixel regions; a pixel electrode in each pixel
region; a common electrode on the second substrate, the
common electrode having an electric field inducing window
dividing each pixel region into at least two domains; an
auxiliary electrode on the first substrate, the auxiliary elec-
trode corresponding to the periphery of the pixel electrode in
one of at least two domains; and a liquid crystal layer
between the first and second substrates.

4 Claims, 7 Drawing Sheets



US 7,215,398 B2

Page 2

U.S. PATENT DOCUMENTS

6,770,910 B2 * 8/2004 Yu et al. 257/72
6,809,787 B1 * 10/2004 Seo et al. 349/129

FOREIGN PATENT DOCUMENTS

JP 6-235925 8/1994
JP 8-101395 4/1996
JP 9-61829 3/1997
JP 10-177178 6/1998
JP 10-333157 12/1998
JP 10-333159 12/1998

JP 11-133438 5/1999
JP 11-142864 5/1999
JP 11-248930 9/1999
JP 11-326922 11/1999
KR 10-2000-0033121 6/2000
KR 10-2000-0035709 6/2000
WO WO 00/08521 2/2000

OTHER PUBLICATIONS

Communication from Korean Patent Office dated Jul. 18, 2006.

* cited by examiner

FIG. 1A
Related Art

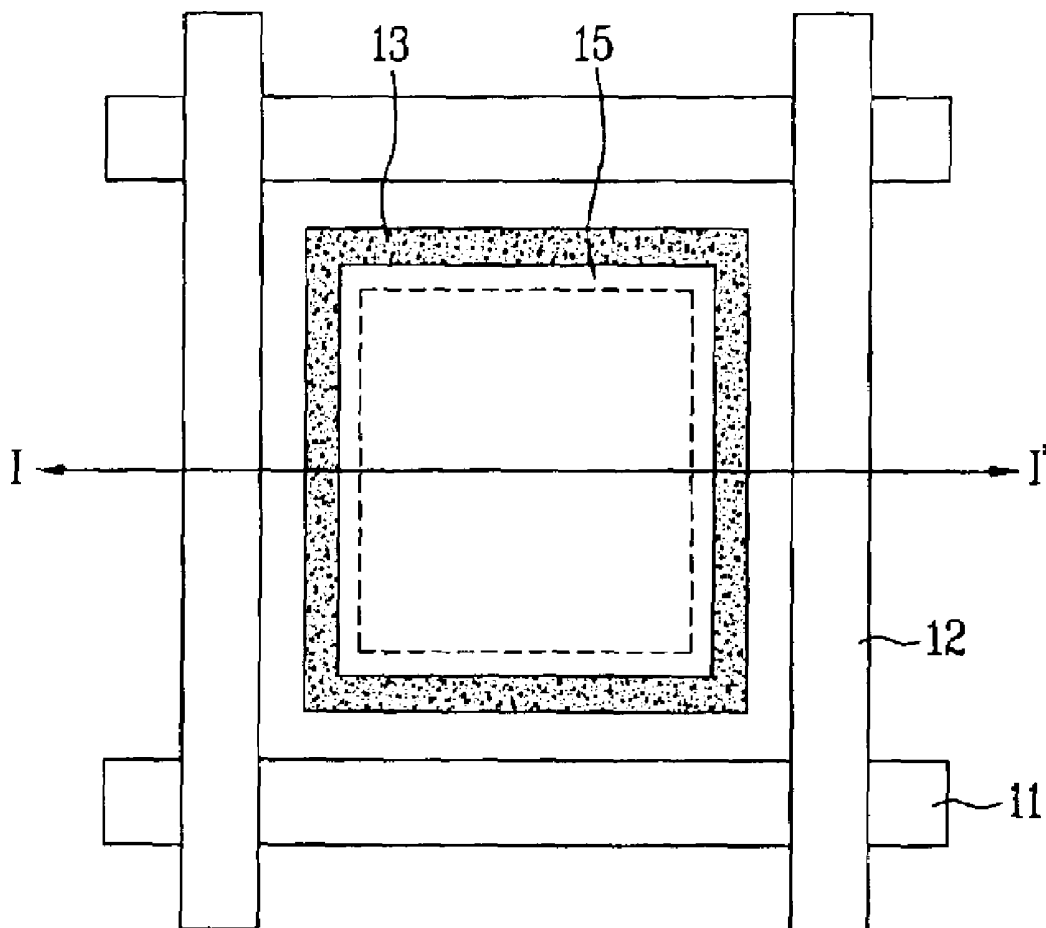


FIG.1B
Related Art

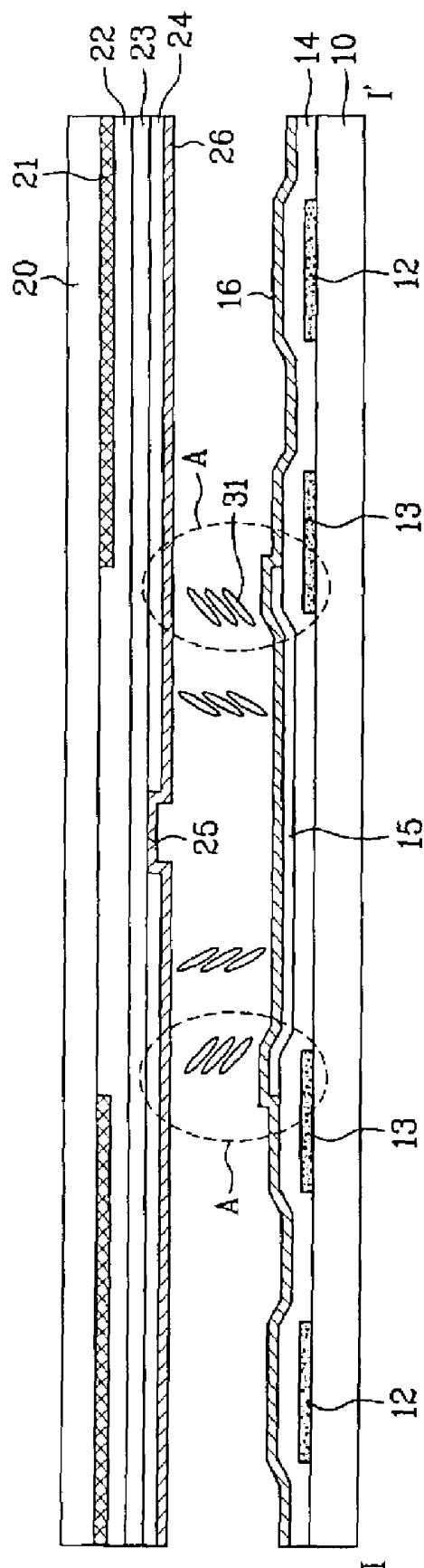


FIG. 2A

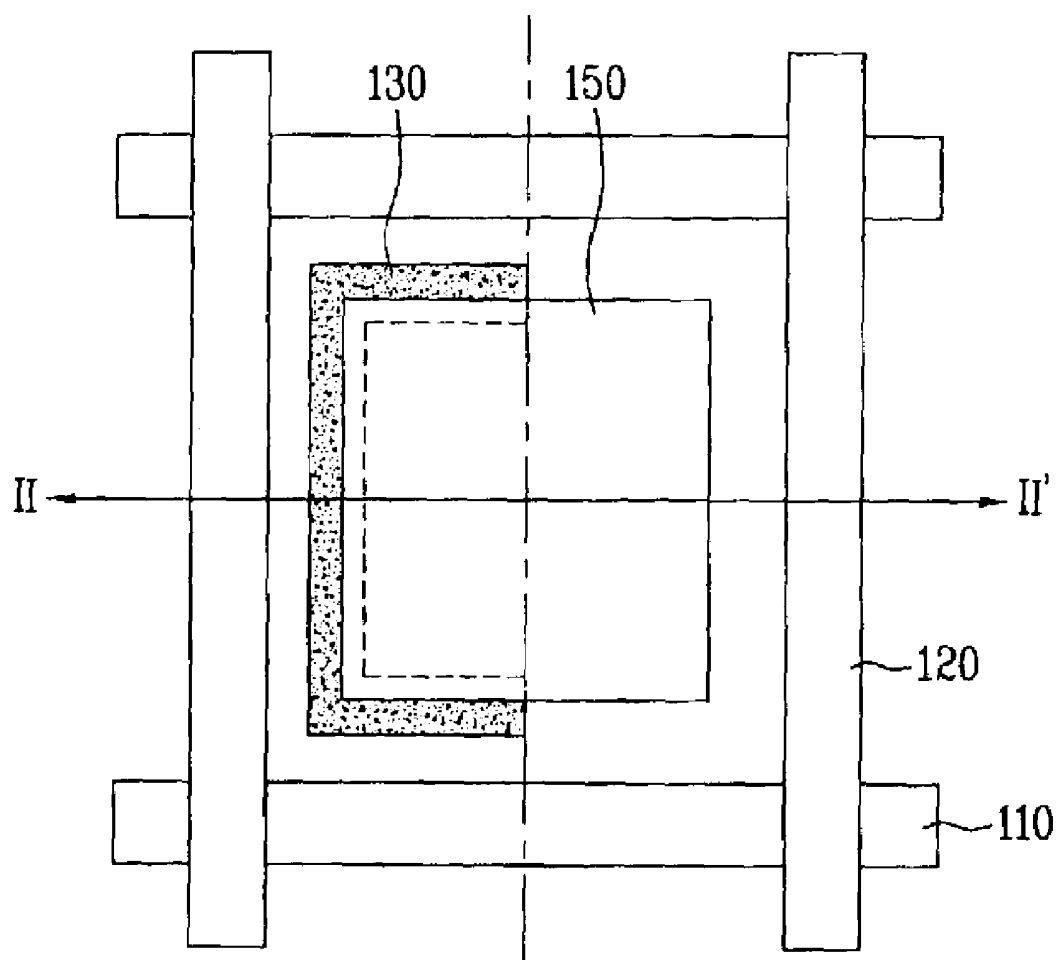


FIG. 2B

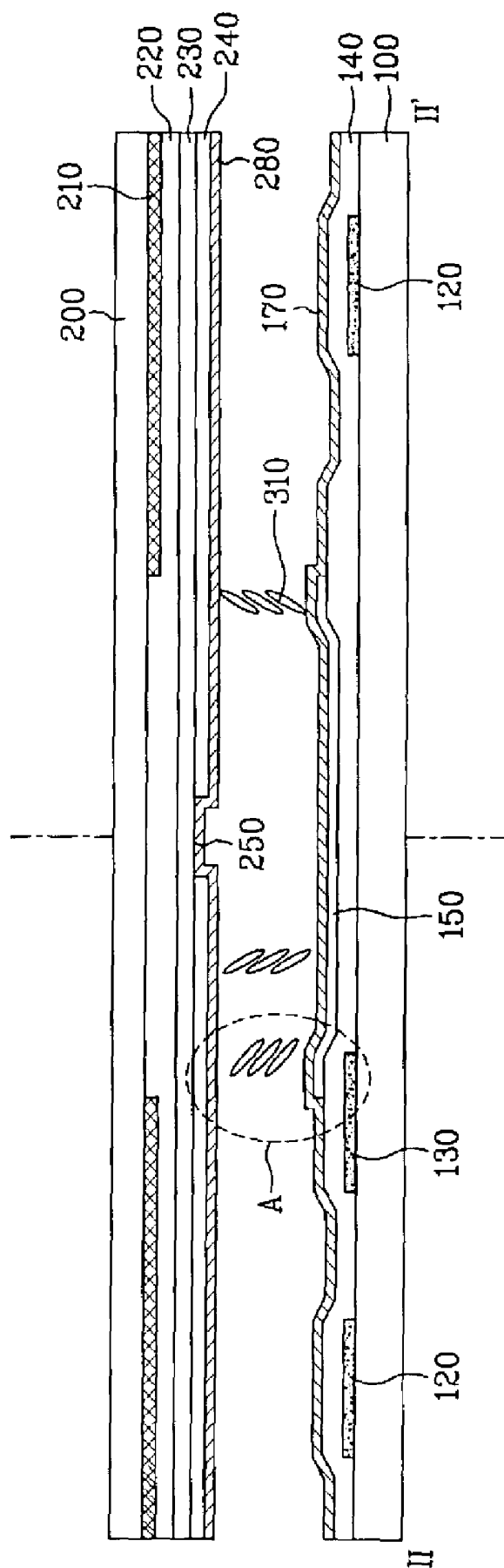


FIG. 3A

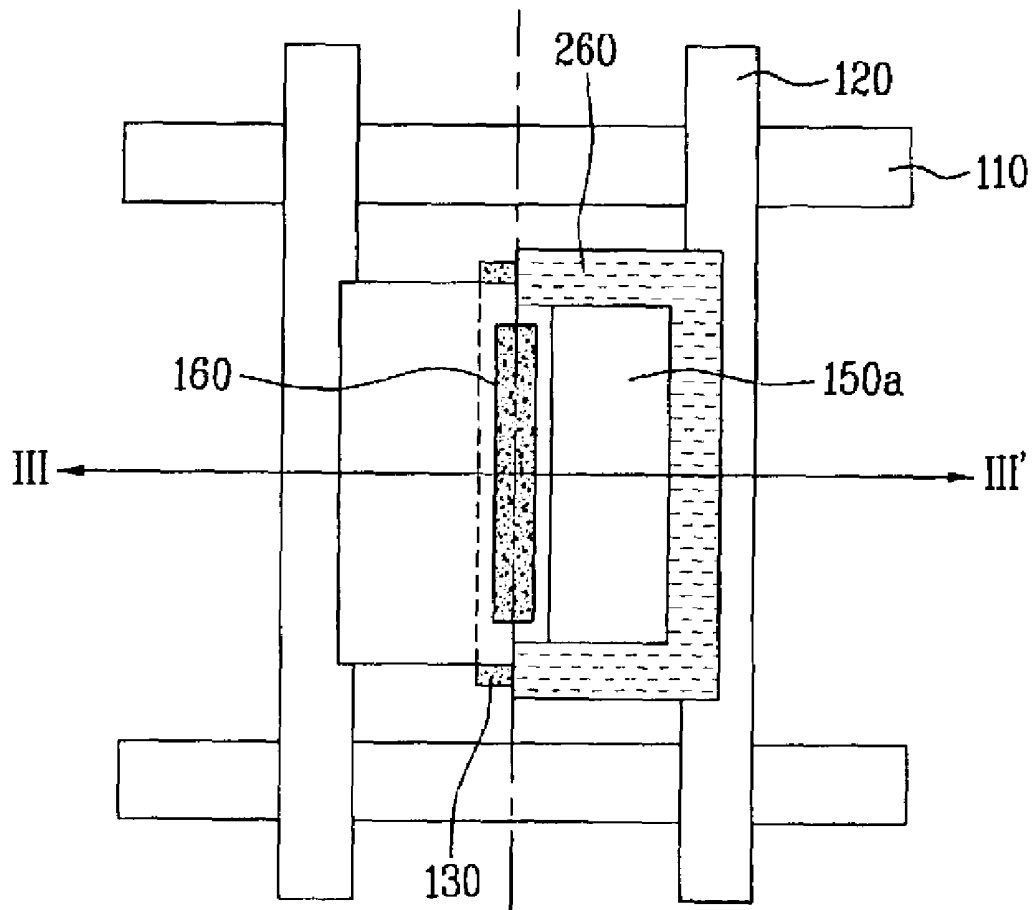


FIG. 3B

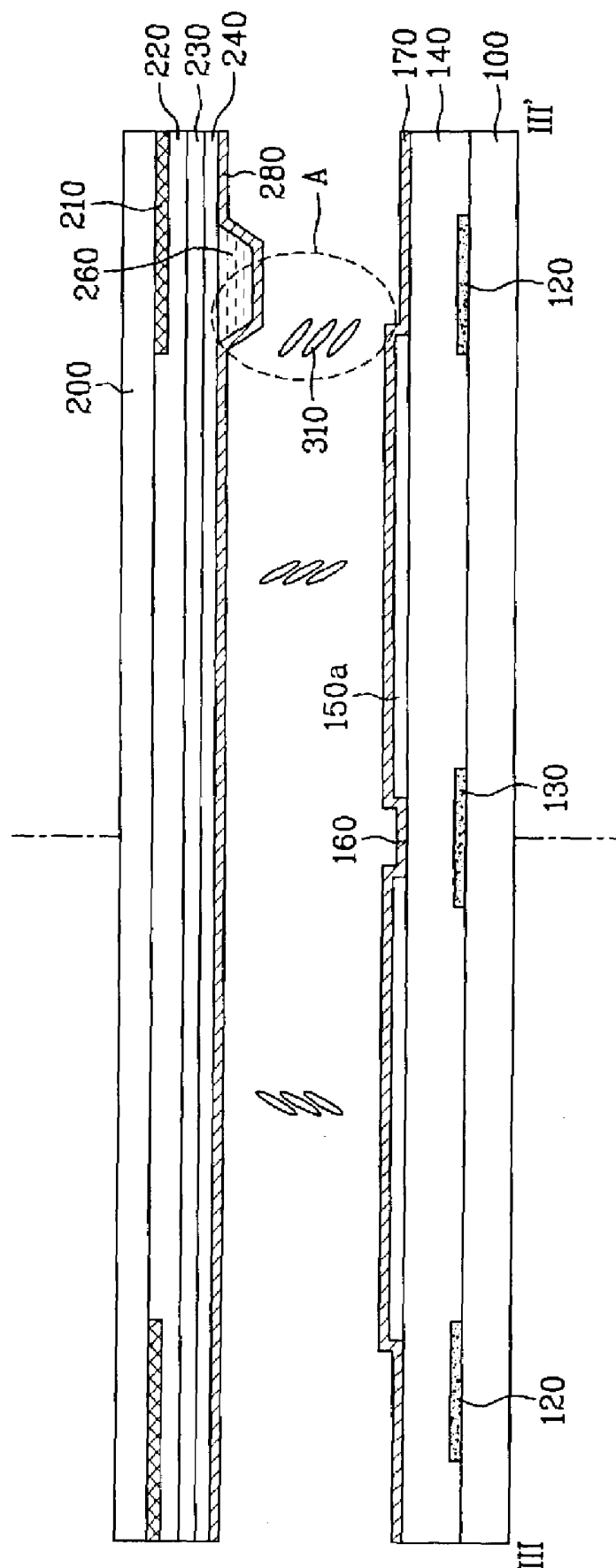
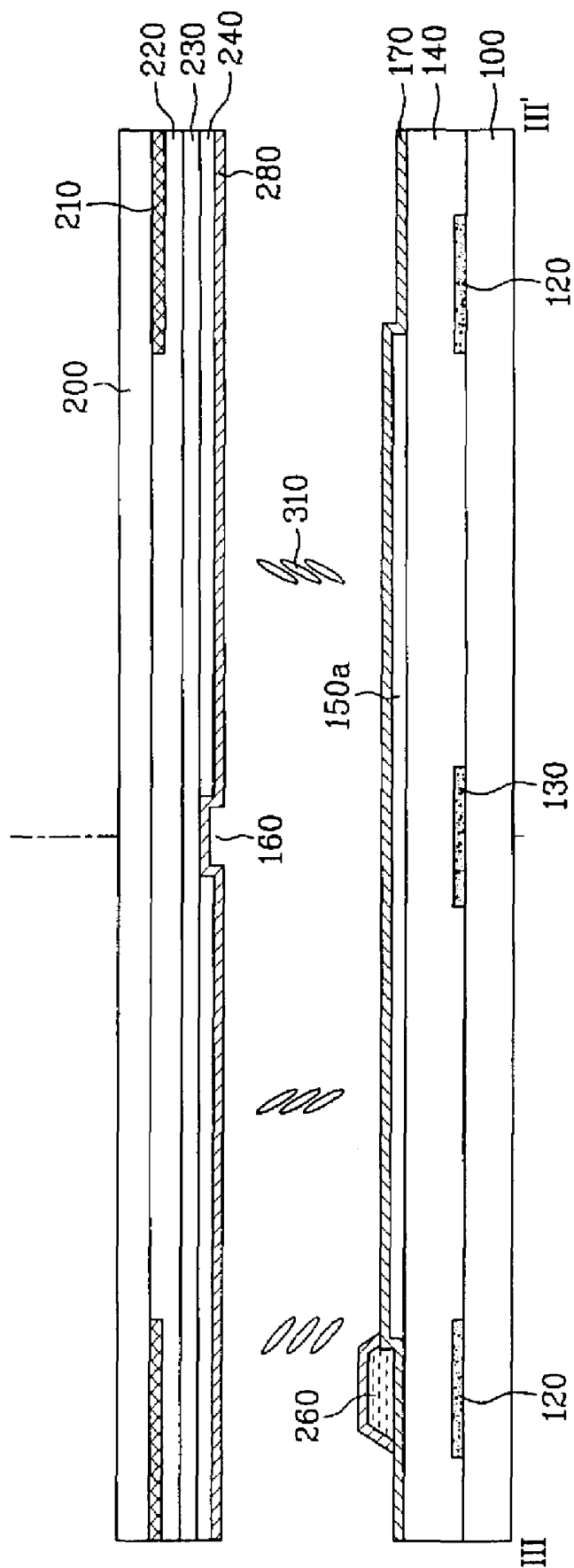


FIG. 4



1

**LIQUID CRYSTAL DISPLAY DEVICE
HAVING AN AUXILIARY ELECTRODE
CORRESPONDING TO THE PERIPHERY OF
THE PIXEL ELECTRODE IN ONLY ONE OF
AT LEAST TWO DOMAIN**

This application claims the benefit of the Korean Application No. P2002-40777 filed on Jul. 12, 2002, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid crystal display (LCD) device, and more particularly, to a liquid crystal display (LCD) device for obtaining high aperture ratio and wide viewing angle.

2. Discussion of the Related Art

In general, a liquid crystal display (LCD) device includes lower and upper substrates facing each other with a predetermined interval therebetween, and a liquid crystal layer between the lower and upper substrates. The liquid crystal layer is driven by an electric field generated between the lower and upper substrates, thereby displaying an image.

Among the LCD devices, a Twisted Nematic (TN) mode liquid crystal display (LCD) device has been most generally used. In TN mode, longitudinal directions of liquid crystal molecules between the lower and upper substrates are parallel with the lower and upper substrates, and the liquid crystal molecules are spirally twisted with a predetermined pitch, so that the longitudinal directions of the liquid crystal molecules are aligned to change continuously.

The TN mode LCD device has characteristics of varying the transmittance of light at each gray level in accordance with a corresponding viewing angle. Specifically, the transmittance of light is distributed symmetrically in right and left directions of the TN mode LCD device, but asymmetrically in lower and upper directions, whereby gray inversion is generated. In order to overcome such a problem, a method is proposed to compensate for the variation of light transmittance in accordance with a corresponding viewing angle by providing domains with differentiating an alignment directions of a liquid crystal layer in a pixel region.

An example of a multi-domain technology dividing a pixel region into a plurality of domains is Two Domain Twisted Nematic (TDTN) mode, in which one pixel region is divided into two domains by a boundary at the center portion of the pixel region, and liquid crystal molecules are symmetrically aligned in the two domains in accordance with the boundary. The TDTN mode has a problem in that manufacturing process steps are complicated due to repetitive photolithography process steps. In this respect, a method for forming an auxiliary electrode and an electric field inducing window is applied to the TDTN mode, which has been usually applied to a vertical alignment (VA) mode LCD device. Herein, the method for forming the auxiliary electrode and the electric field inducing window is applied to a TN mode LCD device.

A related art LCD device will be explained with reference to the accompanying drawings. FIG. 1A is a plan view illustrating a related art LCD device, and FIG. 1B is a cross-sectional view illustrating a related art LCD device taken along line I-I' of FIG. 1A when voltage is applied.

Referring to FIG. 1A and FIG. 1B, the related art LCD device includes lower and upper substrates **10** and **20** facing each other, and liquid crystal molecules **31** between the

2

lower and upper substrates **10** and **20**. A plurality of gate and data lines **11** and **12** are formed on the lower substrate **10** and each other to define a plurality of pixel regions. A pixel electrode **15** is formed in each pixel region. An auxiliary electrode **13** is formed on the same layer as the data line **12**, and the auxiliary electrode **13** is formed at the periphery of the pixel electrode **15**. Then, a gate insulating layer (not shown) is formed between the gate and data lines **11** and **12**, and a passivation layer **14** is formed between the data line **12** and the pixel electrode **15**. Although not shown, a thin film transistor including a gate electrode, a semiconductor layer, and source/drain electrodes is formed at each crossing point of the gate and data lines **11** and **12**.

An upper substrate **20** includes a black matrix layer **21** that prevents light from leaking in regions other than the pixel region, a color filter layer **22** for displaying red (R), green (G), and blue (B) colors, an overcoat layer **23** for planarizing the upper substrate **20**, and a common electrode **24** on the overcoat layer **23**. At this time, an electric field inducing window **25** is formed in the common electrode **24** for differentiating the alignment direction of the liquid crystal molecules.

A fringe field is formed by the electric field inducing window **25** inside the common electrode **24**. The liquid crystal molecules at both sides of the common electrode **24** are differently aligned in accordance with the fringe field. At this time, the auxiliary electrode **13** reinforces the fringe field in the periphery of the pixel electrode **15**. Also, a liquid crystal layer of the liquid crystal molecules **31** is formed between the lower and upper substrates **10** and **20**.

At this time, first and second alignment layers **16** and **26** are respectively formed on entire surfaces of the lower and upper substrates **10** and **20** for an initial alignment of the liquid crystal molecules **31**. The first alignment layer **16** of the lower substrate **10** is deflected from the second alignment layer **26** of the upper substrate **20**, whereby the liquid crystal molecules **31** adjacent to the first and second alignment layer **16** and **26** are aligned in accordance with the alignment direction of the respective first and second alignment layers.

An operation of the related art LCD device having the aforementioned structure will be explained as follows.

When a voltage is not applied, the longitudinal directions of the liquid crystal molecules are parallel with the lower and upper substrates **10** and **20**, and the liquid crystal molecules are continuously twisted at 90 degrees. Thus, light moves along the longitudinal directions of the twisted liquid crystal molecules, whereby a screen becomes white. When a voltage is applied, as shown in FIG. 1B, the longitudinal directions of the liquid crystal molecules would be perpendicular to the lower and upper substrates **10** and **20**, whereby a screen becomes black, except for the fringe field.

At this time, the fringe field is generated by the electric field inducing window **25** formed inside the common electrode **24**, so that the liquid crystal molecules **31** are differently aligned according to the electric field inducing window **25**, thereby compensating the viewing angle.

The auxiliary electrode **13** may be formed on the same layer as the data line **12** when forming the data line **12**, or may be formed on the same layer as the gate line **11** when forming the gate line **11**, whereby integration is improved. However, in this case, the auxiliary electrode **13** is formed to have a predetermined interval with the gate line **11** or the data line **12** to prevent electrical shorts, thereby decreasing a portion for forming the pixel electrode **15**. Also, the auxiliary electrode **13** is made of a material that does not

transmit light. As the auxiliary electrode **13** is overlapped with the pixel electrode **15**, the aperture ratio becomes low, whereby brightness is reduced.

In the viewing angle aspect, the liquid crystal molecules **31** are slanted in region 'A,' where an electric field is generated between the auxiliary electrode **13** and the pixel electrode **15**, so that a phase difference of light increases in 'A' region, thereby increasing light leakage, and decreasing a contrast ratio.

In case of the general TN mode LCD device in which the domain is not divided, the liquid crystal molecules **31** are at an 80 degree angle to the lower and upper substrates **10** and **20**. Meanwhile, in case of that the TDTN mode LCD device in which the two domains are formed, the liquid crystal molecules **31** are slanted in the periphery of the pixel region due to the auxiliary electrode **13** inducing the electric field distortion. Accordingly, the phase difference of light passing through region 'A' increases, and the light leakage is generated in region 'A', whereby the contrast ratio decreases.

For preventing the light leakage, a black matrix layer may be additionally formed in region 'A'. However, as the black matrix layer is formed, the aperture ratio decreases, thereby decreasing the brightness.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a liquid crystal display (LCD) device that substantially obviates one or more problems due to limitations and disadvantages of the related art.

An advantage of the present invention is to provide to an LCD device for obtaining a high aperture ratio and a wide viewing angle.

Additional advantages and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. These 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 and in accordance with the purpose of the invention, as embodied and broadly described herein, an LCD device includes first and second substrates; a plurality of gate and data lines on the first substrate to define a plurality of pixel regions; a pixel electrode in each pixel region; a common electrode on the second substrate, the common electrode having an electric field inducing window dividing each pixel region into at least two domains; an auxiliary electrode on the first substrate, the auxiliary electrode corresponding to the periphery of the pixel electrode in one of at least two domains; and a liquid crystal layer between the first and second substrates.

In another aspect, an LCD device includes first and second substrates; a plurality of gate and data lines on the first substrate to define a plurality of pixel regions; a pixel electrode in the pixel region, the pixel electrode having an electric field inducing window dividing each pixel into at least two domains; an auxiliary electrode below the electric field inducing window; a common electrode on the second substrate; a dielectric structure on the common electrode, the dielectric structure corresponding to the periphery of the pixel electrode in one of at least two domains; and a liquid crystal layer between the first and second substrates.

In another aspect, an LCD device includes first and second substrates; a plurality of gate and data lines on the first substrate to define a plurality of pixel regions; a pixel

electrode in each pixel region; a common electrode on the second substrate, the common electrode having an electric field inducing window dividing each pixel region into at least two domains; an auxiliary electrode on the first substrate, the auxiliary electrode corresponding to the electric field inducing window; a dielectric structure on the first substrate, the dielectric structure corresponding to the periphery of the pixel electrode in one of at least two domains; and a liquid crystal layer between the first and second substrates.

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

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention.

In the drawings:

FIG. 1A is a plan view illustrating a related art liquid crystal display (LCD) device;

FIG. 1B is a cross-sectional view illustrating a related art LCD device taken along line I-I' of FIG. 1A when a voltage is applied;

FIG. 2A is a plan view illustrating a pixel of an LCD device according to the first embodiment of the present invention;

FIG. 2B is a cross-sectional view illustrating an LCD device taken along line II-II' of FIG. 2A when a voltage is applied;

FIG. 3A is a plan view illustrating a pixel of an LCD device according to the second embodiment of the present invention;

FIG. 3B is a cross-sectional view illustrating an LCD device taken along line III-III' of FIG. 3A when a voltage is applied; and

FIG. 4 is a cross-sectional view illustrating an LCD device taken along line III-III' of FIG. 3A according to the third embodiment of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

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

FIG. 2A is a plan view illustrating a pixel of an LCD device according to the first embodiment of the present invention. FIG. 2B is a cross-sectional view illustrating an LCD device taken along line II-II' of FIG. 2A when a voltage is applied.

Referring to FIG. 2A, the LCD device according to the first embodiment of the present invention includes a plurality of gate lines **110** and data lines **120** crossing to each other for defining a plurality of pixel regions on a lower substrate **100**, and a pixel electrode **150** in each pixel region. Also, an auxiliary electrode **130** is formed on the same layer as the data line **120**, which is partially overlapped with the pixel electrode in the periphery of one region (domain) of the

pixel region equally divided into two. That is, the auxiliary electrode is formed along the periphery of roughly half of the pixel electrode **150**.

The structure of the pixel region and the lower and upper substrates will be explained in detail.

As shown in FIG. 2B, the lower substrate **100** includes a plurality of gate lines (not shown), a plurality of data lines **120**, a thin film transistor (not shown), an auxiliary electrode **130**, a passivation layer **140**, a pixel electrode **150**, and a first alignment layer **170**. At this time, the plurality of gate lines (not shown) and data lines **120** cross each other, and a thin film transistor (not shown) is formed at each crossing point of the gate and data lines. The auxiliary electrode **130** is formed at a region where an alignment direction of the liquid crystal molecules is not corresponding to an alignment direction of the lower substrate **100** when applying a voltage to the same layer as the data line **120**. Then, the passivation layer **140** is formed on an entire surface of the lower substrate **100** including the data line **120** and the auxiliary electrode **130**. After that, the pixel electrode **150** is formed in the pixel region, and the first alignment layer **170** is formed on the entire surface of the passivation layer **140** including the pixel electrode **150** for defining the alignment direction of the lower substrate **100**.

In this state, the auxiliary electrode **130** may be formed on the same layer as the gate line (not shown), or may be formed not to be overlapped with the pixel electrode **150**. Also, a gate insulating layer (not shown) is formed between the gate line (not shown) and the data line **120**. The gate insulating layer and the passivation layer **140** may be made of SiNx, SiOx, BenzoCycloButene (BCB), acrylic resin or polyamide compound.

Although not shown, the thin film transistor including a gate electrode, a semiconductor layer and source/drain electrodes is formed at the crossing point of the gate line (not shown) and the data line **120**.

The upper substrate **200** includes a black matrix layer **210**, a color filter layer **220**, an overcoat layer **230**, a common electrode **240**, and a second alignment layer **280**. The black matrix layer **210** prevents light from leaking in regions other than the pixel region, and the color filter layer **220** is formed on the black matrix layer **210** for displaying R, G and B colors. The overcoat layer **230** is formed for protecting the color filter layer **220** and planarizing the upper substrate **200**. The common electrode **240** has an electric field inducing window **250** therein for dividing one pixel into at least two domains. Also, the second alignment layer **280** is formed on the entire surface of the common electrode **240** for defining an alignment direction of the upper substrate. In this state, the overcoat layer **230** may not be formed on the upper substrate **200**.

The first and second alignment layers **170** and **280** may be formed of polyamide or polyimide compound material, polyvinylalcohol (PVA), or polyamic acid with rubbing. Also, the first and second alignment layers **170** and **280** may be formed of any material having photoreaction group such as polyvinylcinnamate (PVCN), polysiloxanecinnamate (PSCN) or cellulosecinnamate (CelCN) by photo-alignment method. In this state, the pretilt angle and alignment direction are simultaneously determined by photo alignment process at least one time. It may be used ultraviolet rays of any one of unpolarized light, non-polarized light, linearly polarized light or partially polarized light.

A liquid crystal layer of the liquid crystal molecules is formed between the lower and upper substrates **100** and **200**. The liquid crystal molecules are Twisted Nematic (TN)

types of positive dielectric anisotropy. Also, a chiral dopant may be added to the liquid crystal layer.

An operation of the LCD device having the aforementioned structure according to the present invention will be explained as follows.

When the voltage is not applied, longitudinal directions of the liquid crystal molecules are parallel with the lower and upper substrates **100** and **200**, and the liquid crystal molecules are continuously twisted at a 90 degree angle. Thus, light moves along the longitudinal direction of the twisted liquid crystal molecules, whereby a screen becomes white. When the voltage is applied, as shown in FIG. 2B, the longitudinal directions of the liquid crystal molecules **310** are roughly in perpendicular to the lower and upper substrates **100** and **200**, whereby a screen becomes black.

The electric field inducing window **250** divides one pixel into first and second domains so that the liquid crystal molecules are symmetrically aligned according to a boundary of the electric field inducing window **250**. At this time, the auxiliary electrode **130** is formed in the first domain of which the alignment direction is different from the alignment direction of the first alignment layer **170**. The alignment direction of first alignment layer **170**, defining the initial alignment of the adjacent liquid crystal molecules **310**, is deflected to the right side, so that the alignment direction of the first alignment layer **170** is different from the alignment direction of the liquid crystal molecules in other regions in the first domain when applying the voltage. Thus, the auxiliary electrode **130** is formed at a portion corresponding to the periphery of the pixel electrode of the first domain, so that the in-plane electric field is induced, thereby deflecting the alignment direction of the liquid crystal molecules **310** to the left side in the first domain.

Meanwhile, the alignment direction of the liquid crystal molecules is same as the alignment direction of the first alignment layer **170** in the second domain, whereby the alignment direction of the liquid crystal molecules is defined according to the first alignment layer **170** in the second domain. Thus, the auxiliary electrode **130** is not additionally required in the second domain.

At this time, the auxiliary electrode is made of a material that does not transmit light, so that the aperture ratio decreases in case of that the pixel electrode is overlapped with the auxiliary electrode. In the pixel region having the two domains according to the present invention, the auxiliary electrode is not required in one domain (second domain). That is, it is possible to prevent the aperture ratio from decreasing in one domain since the auxiliary electrode is not formed in one domain (second domain). Also, the auxiliary electrode is not formed in one domain, thereby increasing the portion for forming the pixel electrode. Furthermore, since the auxiliary electrode is formed in one domain (first domain), a region A where the liquid crystal molecules are severely slanted is removed in one domain when the voltage is applied, thereby decreasing light leakage by about half.

Although not shown, in the LCD device according to the first embodiment of the present invention, it is possible to form the electric field inducing window **250** in the pixel electrode **150**, and the auxiliary electrode **130** in the second domain where the alignment direction of the liquid crystal molecules is different from the alignment direction of the first alignment layer.

FIG. 3A is a plan view illustrating a pixel of an LCD device according to the second embodiment of the present

invention, and FIG. 3B is a cross-sectional view illustrating an LCD device taken along line III-III' of FIG. 3A when a voltage is applied.

In the LCD device according to the first embodiment of the present invention, the electric field is distorted to the outside direction of the pixel when dividing the domains of the pixel. Referring to FIG. 3A and FIG. 3B, the LCD device according to the second embodiment of the present invention is different from the LCD device according to the first embodiment of the present invention in that the electric field is distorted to the center direction of the pixel. For this, an electric field inducing window **160** is formed in a pixel electrode **150a**, and an auxiliary electrode **130** is formed below the pixel electrode **150a** to correspond to the electric field inducing window **160**. A dielectric structure **260** is formed on a common electrode **240** corresponding to the periphery of one domain where the alignment direction of the liquid crystal molecules is different from the alignment direction of the first alignment layer. Except the aforementioned constituent elements, others are same as those of the first embodiment of the present invention, whereby the same reference numbers will be used throughout the drawings to refer to the same or like parts.

In the LCD device according to the second embodiment of the present invention, a lower substrate **100** includes a plurality of gate lines **110** and data lines **120** crossing each other to define a plurality of pixel regions, and a pixel electrode **150a** in each pixel region. An electric field inducing window **160** is formed at the center of the pixel electrode **150a** for dividing alignment direction of liquid crystal molecules when applying a voltage, and an auxiliary electrode **130** is formed below the electric field inducing window **160**. Then, a dielectric structure **260** is formed on a common electrode (not shown) corresponding to the periphery of one domain (or to the periphery of the pixel electrode **150a** in one domain) where the alignment direction of the liquid crystal molecules is different from the alignment direction of the lower substrate when the voltage is applied.

Referring to FIG. 3B, the lower substrate includes the plurality of gate lines (not shown) and data lines **120** crossing each other to define the plurality of pixel regions, a thin film transistor (not shown) at each crossing point of the plurality of gate and data lines, the auxiliary electrode at the center portion of each pixel region on the same layer as the data line **120**, a passivation layer **140** on an entire surface of the lower substrate **100** including the data line **120** and the auxiliary electrode **130**, the pixel electrode **150a** having the electric field inducing window **160** at a portion corresponding to the auxiliary electrode **130** in the pixel region, and a first alignment layer **170** on the entire surface of the passivation layer **140** including the pixel electrode **150a** for defining the alignment direction of the lower substrate **100**.

At this time, the auxiliary electrode **130** may be formed on the same layer as the gate line (not shown), or may be formed not to be overlapped with the pixel electrode **150a**. Also, a gate insulating layer (not shown) is formed between the gate line (not shown) and the data line **120**. The gate insulating layer and the passivation layer **140** may be made of SiNx, SiOx, BenzoCycloButene (BCB), acrylic resin, or polyamide compound.

Although not shown, the thin film transistor including a gate electrode, a semiconductor layer, and source/drain electrodes is formed at each crossing point of the gate lines (not shown) and the data lines **120**.

An upper substrate **200** includes a black matrix layer **210** preventing light from leaking in regions except the pixel region, a color filter layer **220** on the black matrix layer **210**

for displaying R, G and B colors, an overcoat layer **230** protecting the color filter layer **220** and planarizing the upper substrate **200**, the common electrode **240** on an entire surface of the overcoat layer **230**, the dielectric structure **260** on the common electrode (not shown) corresponding to the periphery of the domain where the alignment direction of the liquid crystal molecules is different from the alignment direction of the lower substrate, and a second alignment layer **280** on the common electrode **240** including the dielectric structure for defining the alignment direction of the upper substrate **200**. At this time, the overcoat layer **230** may not be formed on the upper substrate **200**.

Preferably, the dielectric structure **260** has a dielectric constant same as that of the liquid crystal, or less. Also, the dielectric structure **260** may be formed of photosensitive material. For example, the dielectric structure **260** may be formed of photoacrylate or BenzoCycloButene (BCB).

The first and second alignment layers **170** and **280** may be formed of polyamide or polyimide compound material, polyvinylalcohol (PVA) or polyamic acid with rubbing. Also, the first and second alignment layers **170** and **280** may be made of a material having photoreaction group such as polyvinylcinnamate (PVCN), polysiloxanecinnamate (PSCN) or cellulosecinnamate (CelCN) compound by photo-alignment method. In this state, the pretilt angle and alignment direction are simultaneously determined by photo alignment process step at least one time. It may be used ultraviolet rays of any one of unpolarized light, non-polarized light, linearly polarized light or partially polarized light.

A liquid crystal layer of the liquid crystal molecules **310** is formed between the lower and upper substrates **100** and **200**. The liquid crystal molecules **310** are Twisted Nematic (TN) types of positive dielectric anisotropy. Also, a chiral dopant may be added to the liquid crystal layer.

An operation of the LCD device having the aforementioned structure according to the present invention will be explained as follows.

When the voltage is not applied, longitudinal directions of the liquid crystal molecules **310** are parallel with the lower and upper substrates **100** and **200**, and the liquid crystal molecules are continuously twisted at a 90 degree angle. Thus, light moves along the longitudinal direction of the twisted liquid crystal molecules, whereby a screen becomes white. When the voltage is applied, as shown in FIG. 3B, the longitudinal directions of the liquid crystal molecules **310** are roughly perpendicular to the lower and upper substrates **100** and **200**, whereby a screen becomes black.

The electric field inducing window **160** of the lower substrate **100** divides one pixel into first and second domains so that the liquid crystal molecules are symmetrically aligned in the first and second domains according to the electric field inducing window **160**. In this state, the dielectric structure **260** is formed on the common electrode **240** of the upper substrate **200** corresponding to the periphery of the pixel electrode **150a** of the lower substrate **100** in the second domain where the alignment direction of the liquid crystal molecules is different from the alignment direction of the first alignment layer **170** on the lower substrate **100**.

The alignment direction of first alignment layer **170**, defining the initial alignment state of the adjacent liquid crystal molecules **310**, is deflected to the right side, whereby the alignment direction of the first alignment layer **170** is different from the alignment direction of the liquid crystal molecules in the second domain when the voltage is applied. Thus, the dielectric structure **260** is formed at a portion of the upper substrate corresponding to the periphery of the pixel electrode of the lower substrate in the second domain,

so that the in-plane electric field is induced, thereby deflecting the alignment direction of the liquid crystal molecules **310** to the left side in the second domain.

In the first domain, the alignment direction of the liquid crystal molecules is defined by the alignment direction of the first alignment layer **170**, since the alignment direction of the liquid crystal molecules is same as the alignment direction of the first alignment layer **170** in the first domain, so that a structure for distorting the electric field is not additionally formed in the first domain.

Accordingly, in the pixel having the two domains according to the second embodiment of the present invention, the structure for distorting the electric field is not required in one domain. The auxiliary electrode or the dielectric structure are made of a material that does not transmit light, so that aperture ratio decreases in case of that the pixel electrode is overlapped with the dielectric structure or the auxiliary electrode. That is, in the present invention, it is possible to prevent aperture ratio from decreasing since the auxiliary electrode or the dielectric structure is not formed in one of the two domains.

In the related art LCD device, a predetermined interval is required due to the pixel electrode and the auxiliary electrode being adjacent to the pixel electrode. However, in the LCD device according to the present invention, the predetermined interval between the pixel electrode and the auxiliary electrode is not required, thereby increasing the portion for forming the pixel electrode.

Furthermore, since the auxiliary electrode is formed in one domain, a region A where the liquid crystal molecules are severely slanted is removed in one domain when the voltage is applied, thereby decreasing light leakage in half.

When respectively depositing the first and second alignment layers on the entire surfaces of the lower and upper substrates in the LCD device according to the present invention, the protruding dielectric structure is not formed in one domain, thereby improving alignment-treatment efficiency as compared with the related art.

In the LCD device according to the second embodiment of the present invention shown in FIG. 3A, the electric field inducing window and the dielectric structure may be differently formed.

FIG. 4 is a cross-sectional view illustrating an LCD device taken along line III-III' of FIG. 3A according to the third embodiment of the present invention.

Referring to FIG. 4, the LCD device according to the third embodiment of the present invention is different from the LCD device according to the second embodiment of the present invention in that the electric field inducing window **160** is formed in the common electrode **240**, the auxiliary electrode **130** is formed below the electrode **150a** to correspond to the electric field inducing window **160**, and the dielectric structure **260** is formed at a portion of the lower substrate **100** corresponding to the periphery of one domain (or to the periphery of the pixel electrode **150a** in one domain) where the alignment direction of the liquid crystal molecules is different from the alignment direction of the first alignment layer. Except the aforementioned constituent elements, others are same as those of the LCD device according to the second embodiment of the present invention, whereby the same reference numbers will be used throughout the drawings to refer to the same or like parts.

In the LCD device according to the third embodiment of the present invention, a lower substrate **100** includes a plurality of gate lines **110** and data lines **120** crossing each other to define a plurality of pixel regions, and a pixel

electrode **150a** in each pixel region. A common electrode **240** is formed on an upper substrate **200**.

As shown in FIG. 4, an electric field inducing window **160** is formed at the center of the pixel region for dividing the pixel into two domains, so that liquid crystal molecules are differently aligned in the two domains when the voltage is applied. The auxiliary electrode **130** is formed on the lower substrate **100** below the electric field inducing window **160**, and the dielectric structure **260** is formed at a portion of the lower substrate **100** corresponding to the periphery of one domain where the alignment direction of the liquid crystal molecules is different from the alignment direction of the lower substrate. At this time, the dielectric structure **260** may be formed on the common electrode **240** of the upper substrate in one domain where the alignment direction of the liquid crystal molecules is different from the alignment direction of the lower substrate.

In the LCD device according to the illustrated embodiments of the present invention, one pixel is divided into two domains. However, it is possible to divide one pixel into three domains or more in the LCD device according to the present invention.

As mentioned above, the LCD device according to the present invention has the following advantages.

First, the structure for distorting the electric field is formed for differentiating the alignment direction of the liquid crystal molecules in domains. The structure for distorting the electric field is not formed at the portion where the alignment direction of the liquid crystal molecules is same as the alignment direction of the respective substrates. Thus, as the number of the structure for distorting the electric field decreases, the aperture ratio becomes high.

Also, the structure for dividing the alignment direction of the liquid crystal molecules generates the light leakage since the liquid crystal molecules are slanted when applying the voltage. In the LCD device according to the present invention, the structure for dividing the alignment direction of the liquid crystal molecules is not formed in one domain, whereby the light leakage decreases in half.

In case of forming the alignment layer on the protruding dielectric structure, alignment efficiency decreases at the portion of the alignment layer having the protruding dielectric structure. However, in the LCD device according to the present invention, the protruding dielectric structure is removed in the domain where the alignment direction of the liquid crystal molecules is same as the alignment direction of the lower substrate, whereby the alignment efficiency increases. Also, if the number of the protruding dielectric structures increases, electric charges may be easily accumulated on the protruding dielectric structures, thereby generating an afterimage. In the LCD device according to the present invention, the afterimage is overcome since the protruding dielectric structures are removed in the domain where the alignment direction of the liquid crystal molecules is same as the alignment direction of the lower substrate.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A liquid crystal display (LCD) device comprising:
 - first and second substrates;
 - a plurality of gate and data lines on the first substrate to define a plurality of pixel regions;
 - a pixel electrode in each pixel region;

11

a common electrode on the second substrate, the common electrode having an electric field inducing window dividing each pixel region into at least two domains;
 an auxiliary electrode on the first substrate, the auxiliary electrode corresponding to the periphery of the pixel electrode in only one of the at least two domains;
 a liquid crystal layer between the first and second substrates;
 a thin film transistor at each crossing point of the gate and data lines;
 a black matrix layer on the second substrate;
 a color filter layer on the black matrix layer; and
 first and second alignment layers on the first and second substrates,

12

wherein the auxiliary electrode is formed at a portion where an alignment direction of liquid crystal molecules is opposite to an alignment direction of the first alignment layer when a voltage is applied.

2. The LCD device of claim 1, wherein the auxiliary electrode is formed on the same layer as the gate line.

3. The LCD device of claim 1, wherein the auxiliary electrode is formed on the same layer as the data line.

4. The LCD device of claim 1, wherein the auxiliary electrode is formed in a rectangular 'C' shape.

* * * * *

专利名称(译)	液晶显示装置具有仅在至少两个区域中的一个中对应于像素电极的周边的辅助电极		
公开(公告)号	US7215398	公开(公告)日	2007-05-08
申请号	US10/405326	申请日	2003-04-03
[标]申请(专利权)人(译)	YUN SAI 常 KIM DO SUNG		
申请(专利权)人(译)	YUN SAI 常 KIM DO SUNG		
当前申请(专利权)人(译)	L.G. 飞利浦液晶CO. , LTD		
[标]发明人	YUN SAI CHANG KIM DO SUNG		
发明人	YUN, SAI CHANG KIM, DO SUNG		
IPC分类号	G02F1/1343 G02F1/1337 G02F1/1333 G02F1/139		
CPC分类号	G02F1/134336 G02F1/133707 G02F1/1396		
审查员(译)	NGUYEN , 龚便T.		
优先权	1020020040777 2002-07-12 KR		
其他公开文献	US20040008312A1		
外部链接	Espacenet USPTO		

摘要(译)

公开了一种液晶显示 (LCD) 装置, 其获得高孔径比和宽视角。 LCD 装置包括第一和第二基板; 第一基板上的多条栅极线和数据线, 以限定多个像素区域; 每个像素区域中的像素电极; 在第二基板上的公共电极, 公共电极具有将每个像素区域划分为至少两个区域的电场诱导窗口; 第一基板上的辅助电极, 辅助电极对应于至少两个区域之一中的像素电极的周边; 以及第一和第二基板之间的液晶层。

