US007808565B2

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

(10) **Patent No.: US 7,808,565 B2**
(45) **Date of Patent: Oct. 5, 2010**

(54) **LIQUID CRYSTAL DISPLAY AND ACTIVE MATRIX SUBSTRATE THEREOF**

(75) Inventors: **Wen-Chun Wang**, Taichung (TW); **Chin-Chang Liu**, Taichung (TW)

(73) Assignee: **Wintek Corporation**, Taichung (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 385 days.

(21) Appl. No.: **12/101,156**

(22) Filed: **Apr. 11, 2008**

(65) **Prior Publication Data**

US 2008/0252802 A1 Oct. 16, 2008

(30) **Foreign Application Priority Data**

Apr. 12, 2007 (TW) ..... 96112823 A

(51) **Int. Cl.**
G02F 1/141 (2006.01)
G09G 3/36 (2006.01)

(52) **U.S. Cl.** **349/37**; 345/96

(58) **Field of Classification Search** 349/37, 349/38, 39; 345/87, 96, 103
See application file for complete search history.

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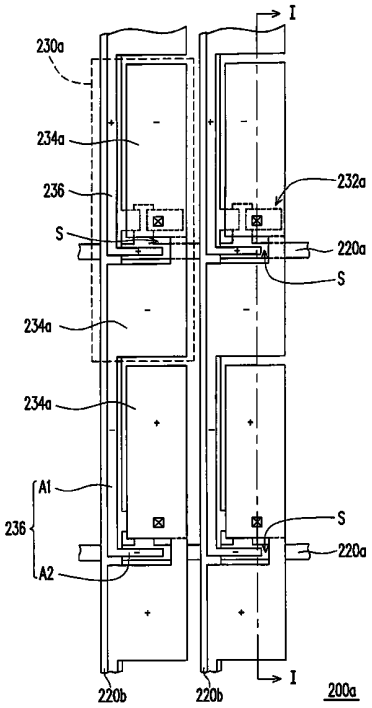
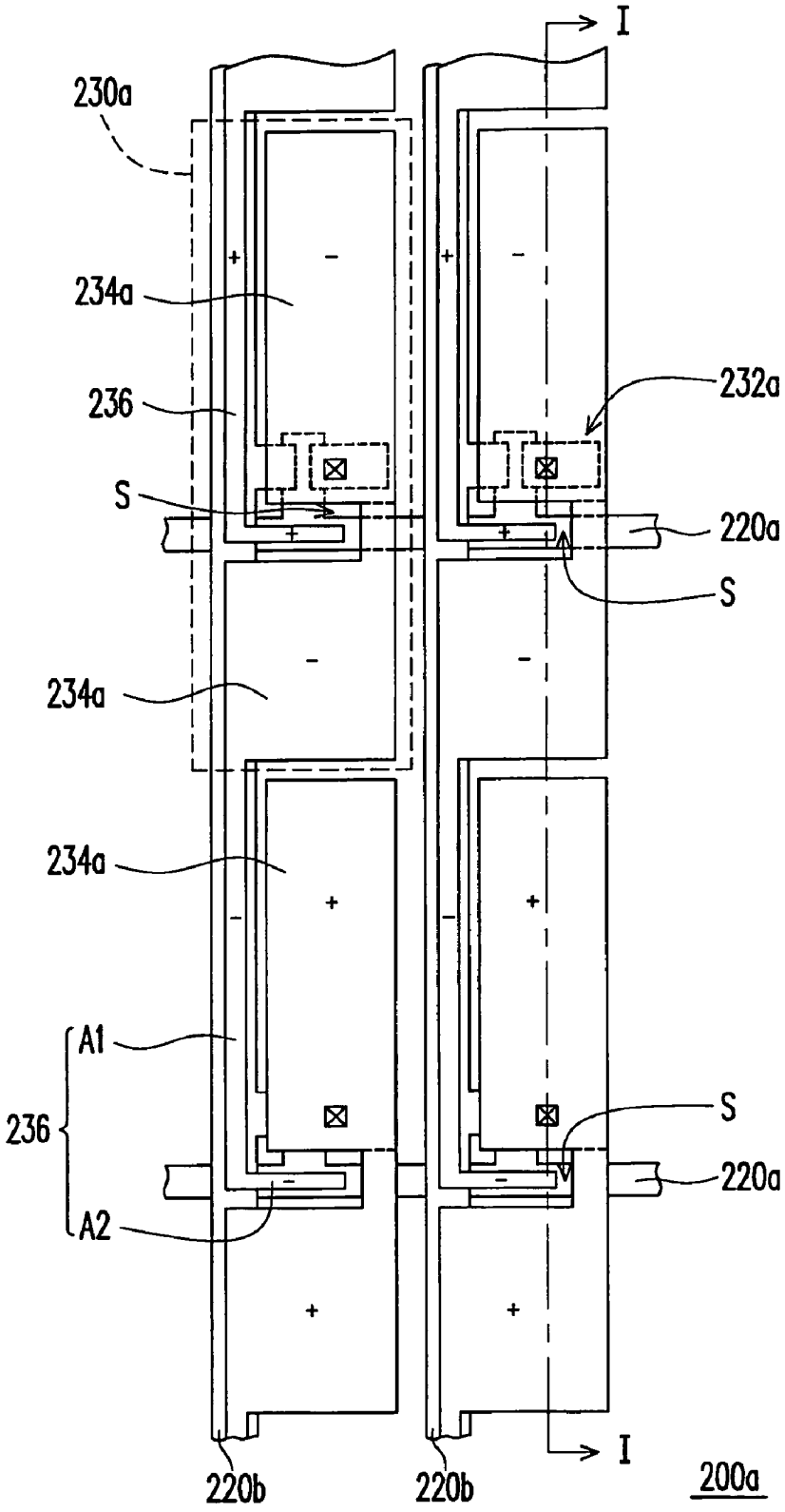
Primary Examiner—David Nelms
Assistant Examiner—David Y Chung
(74) *Attorney, Agent, or Firm*—Jianq Chyun IP Office

(57) **ABSTRACT**

An active matrix substrate is provided. The active matrix substrate includes a substrate, scan lines, data lines, and pixel units. The scan lines, data lines, and pixel units are all disposed over the substrate. The pixel unit includes an active component, a pixel electrode, and an auxiliary electrode. The active components are electrically connected with the scan lines and data lines. The pixel electrode has openings extended from the edge of the pixel electrode to the interior of the pixel electrode. The auxiliary electrode is electrically connected with the pixel electrode controlled by a previous scan line and includes a body portion and extending portions disposed in the openings. The pixel electrode is electrically connected with the auxiliary electrode of a pixel unit controlled by a next scan line.

32 Claims, 9 Drawing Sheets

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A2
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I
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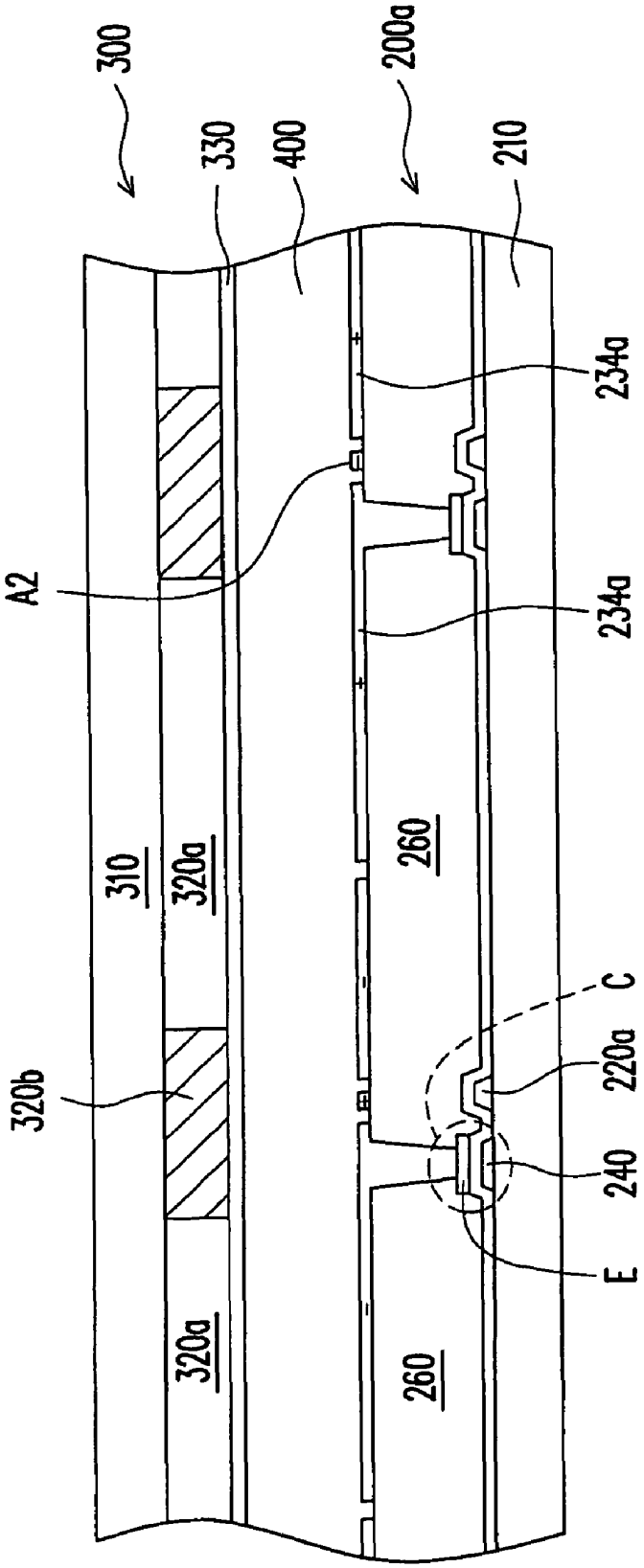
220b
200a

FIG. 1A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330
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A2
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320b
220a
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E
320a
260

FIG. 1B

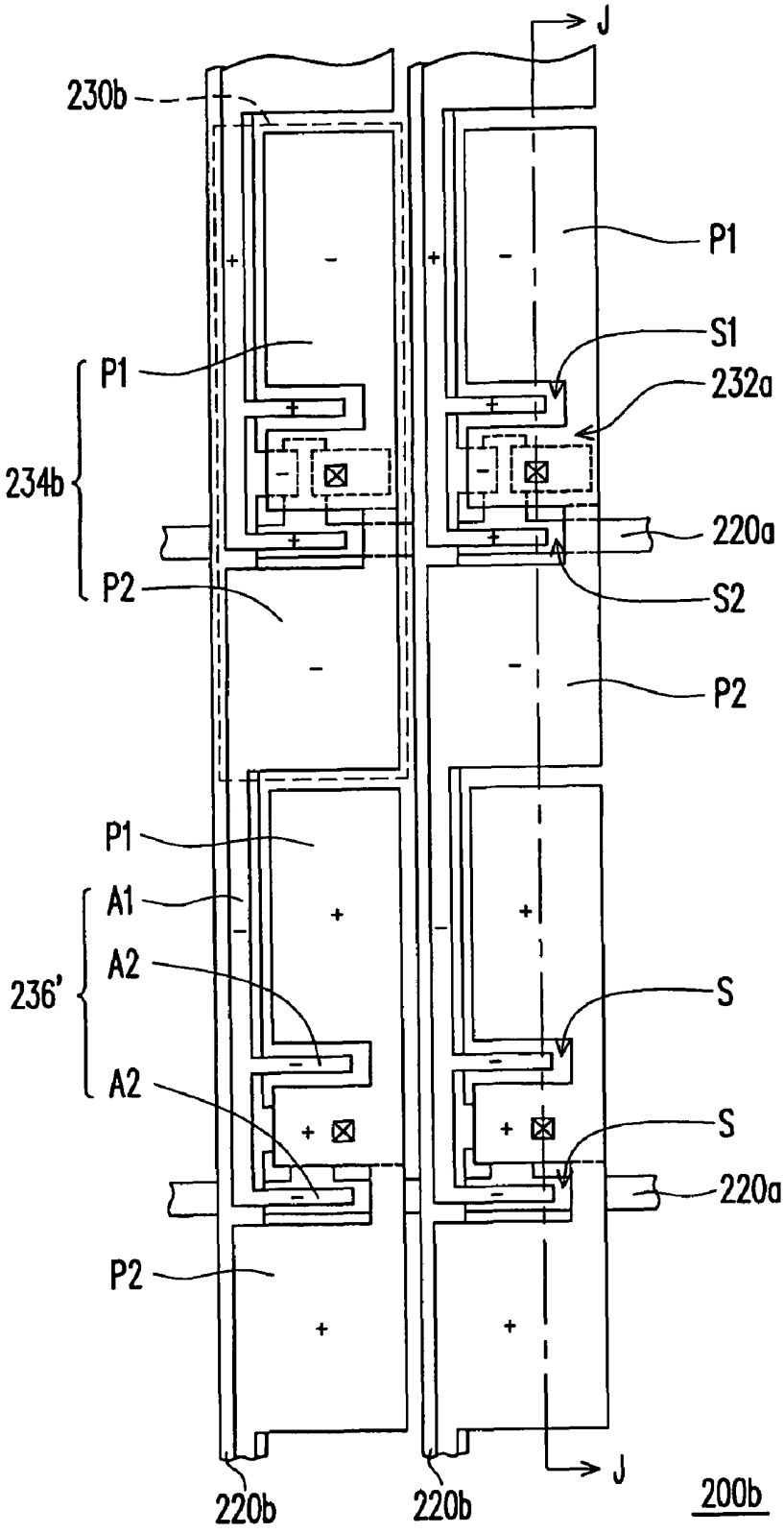
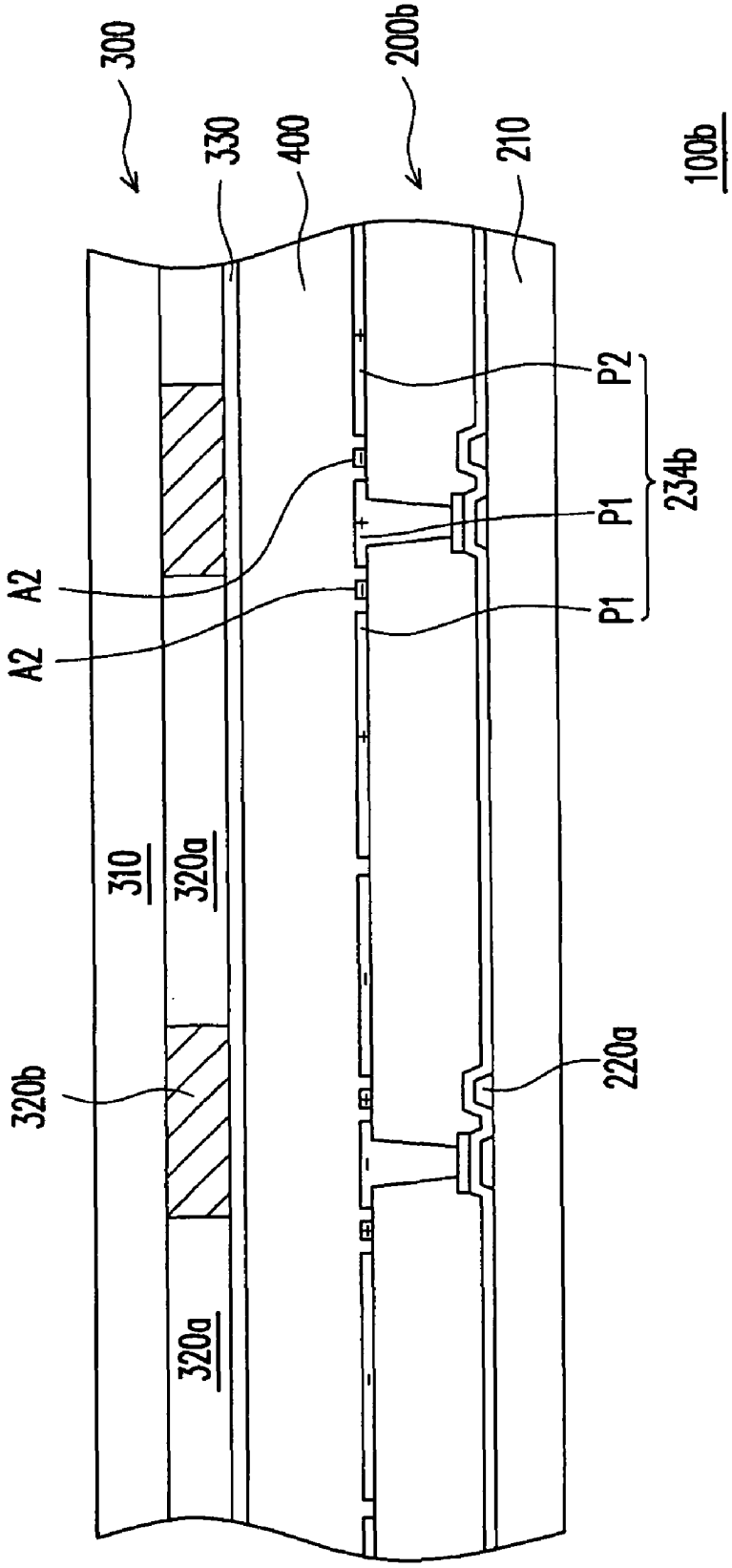

J
230b
P1
S1
232a
P1
234b
220a
P2
S2
P2
P1
A1
A2
236'
S
A2
S
220a
P2
J
220b
220b
200b

FIG. 2A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320a
220a

FIG. 2B

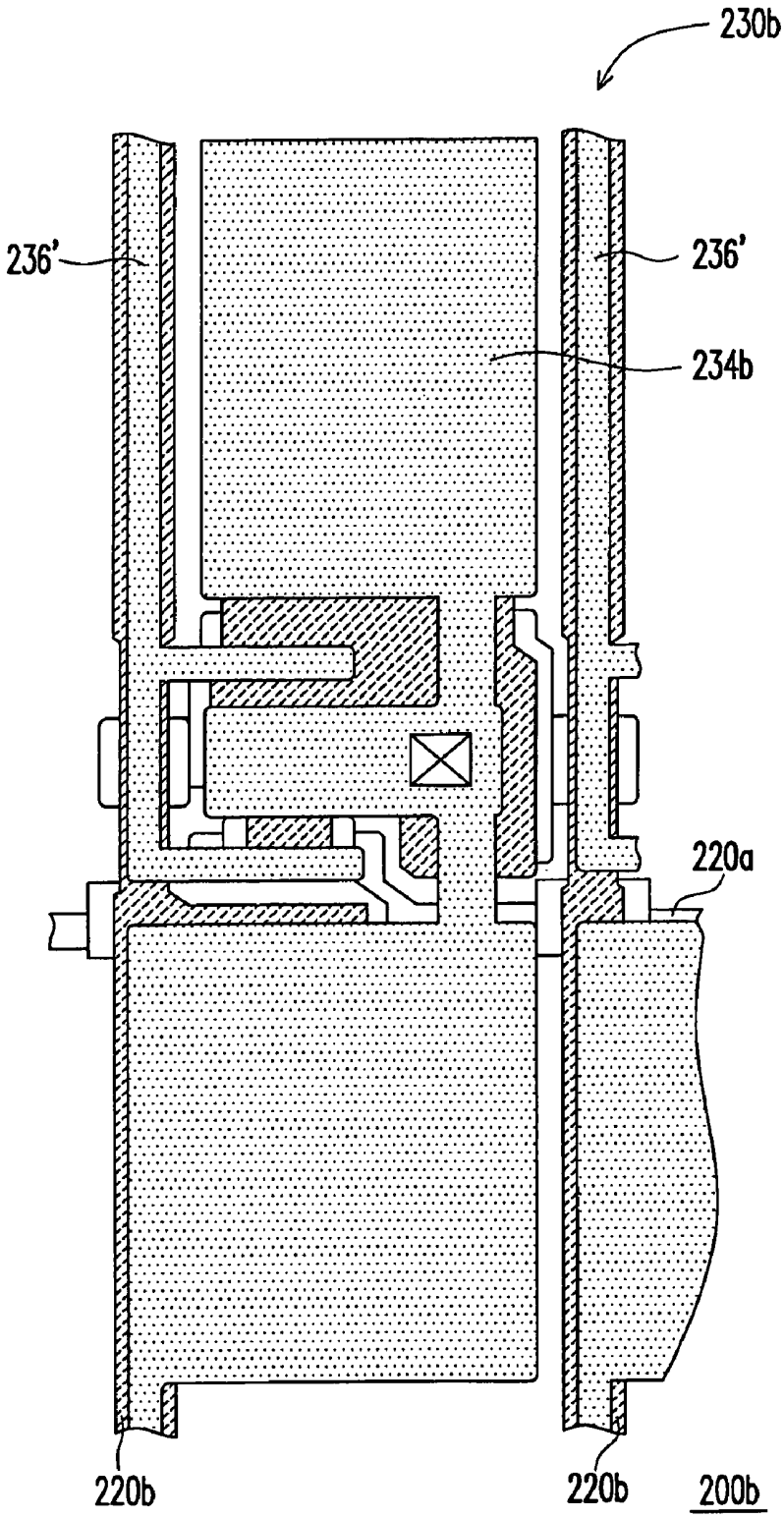


FIG. 2C

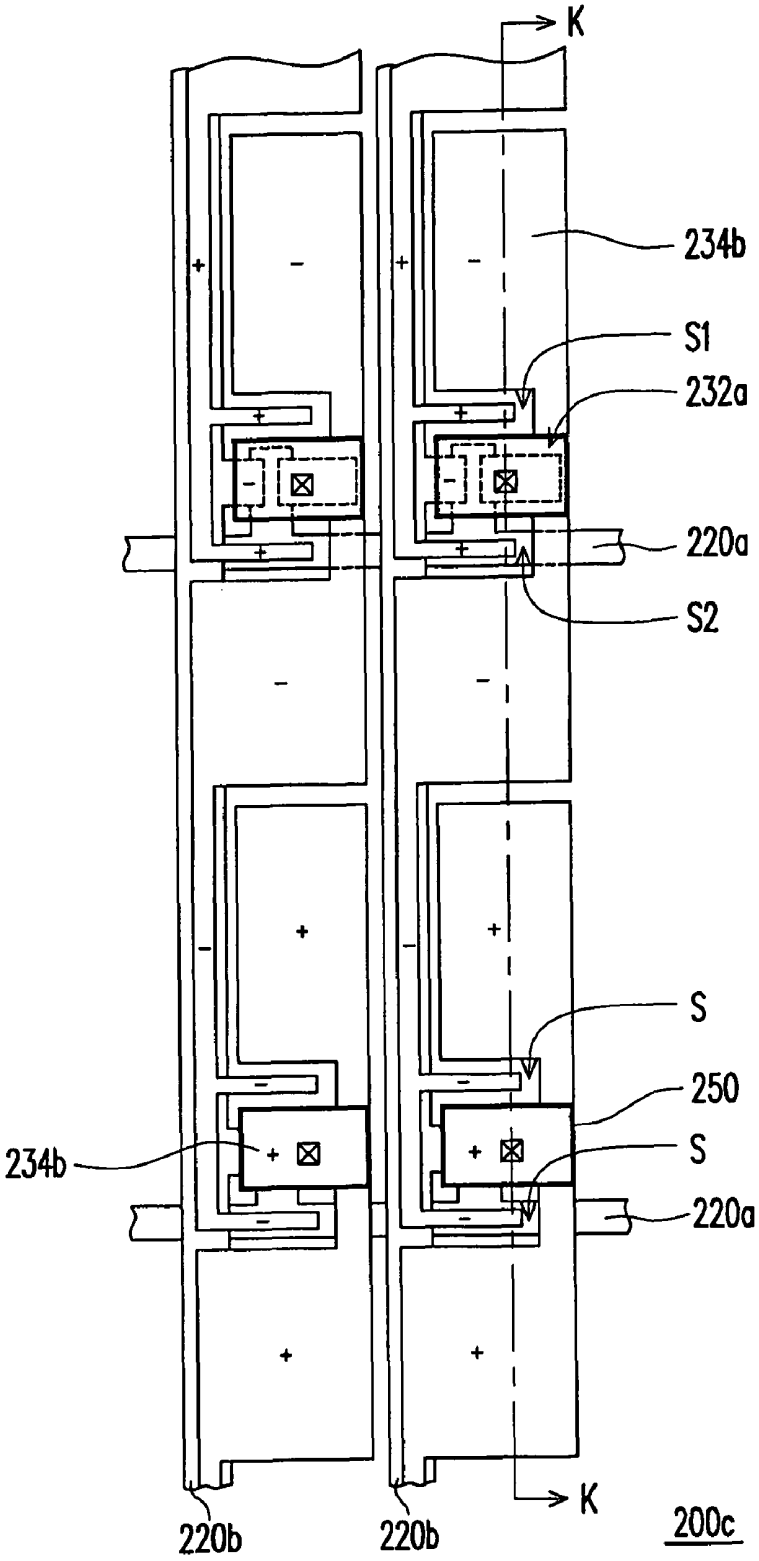


FIG. 3A

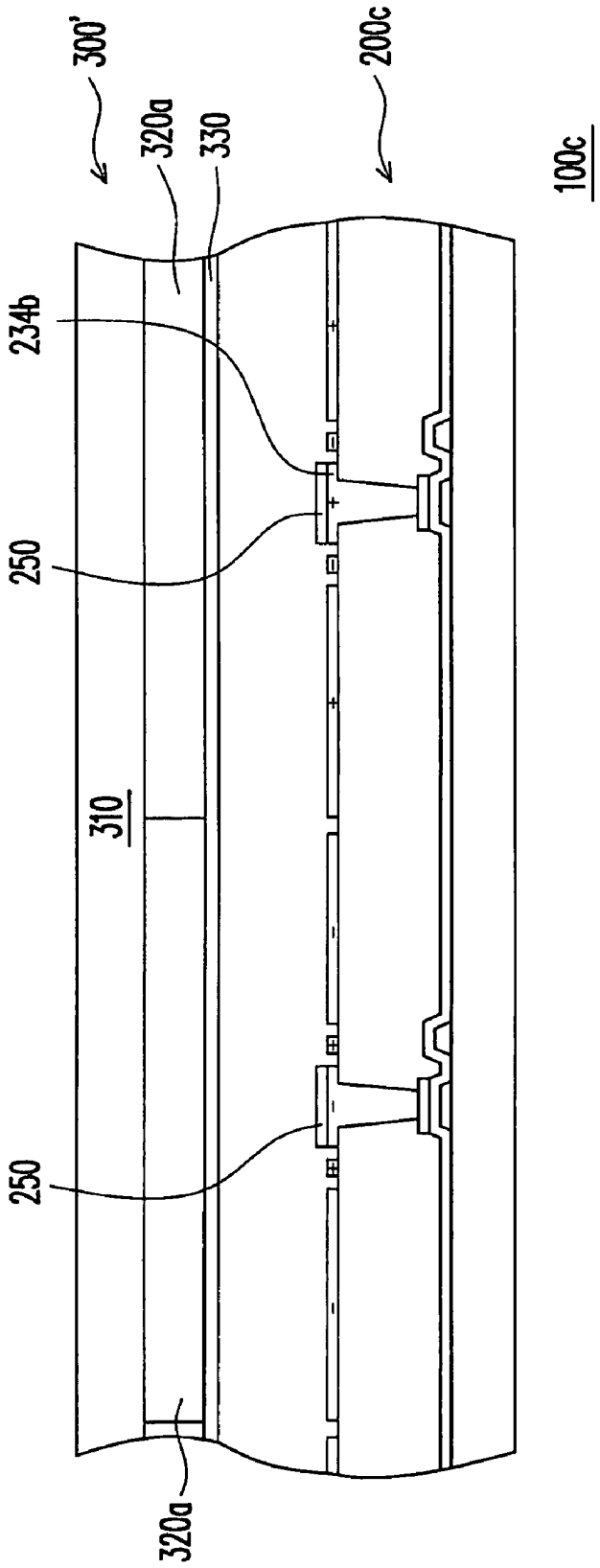
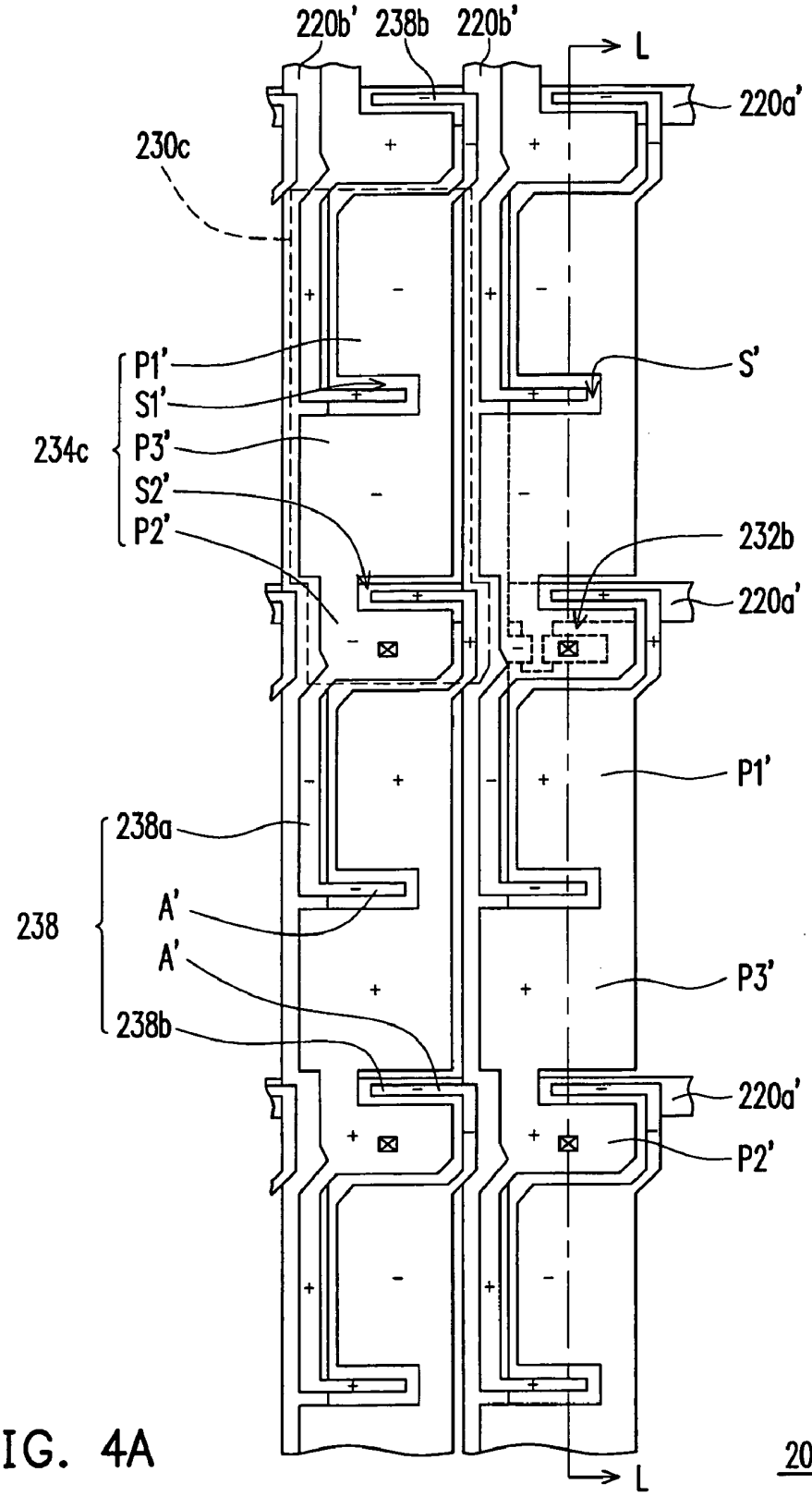


FIG. 3B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P3'
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P1'
238a
238
A'
A'
238b
P3'
220a'
P2'
L
200d

FIG. 4A

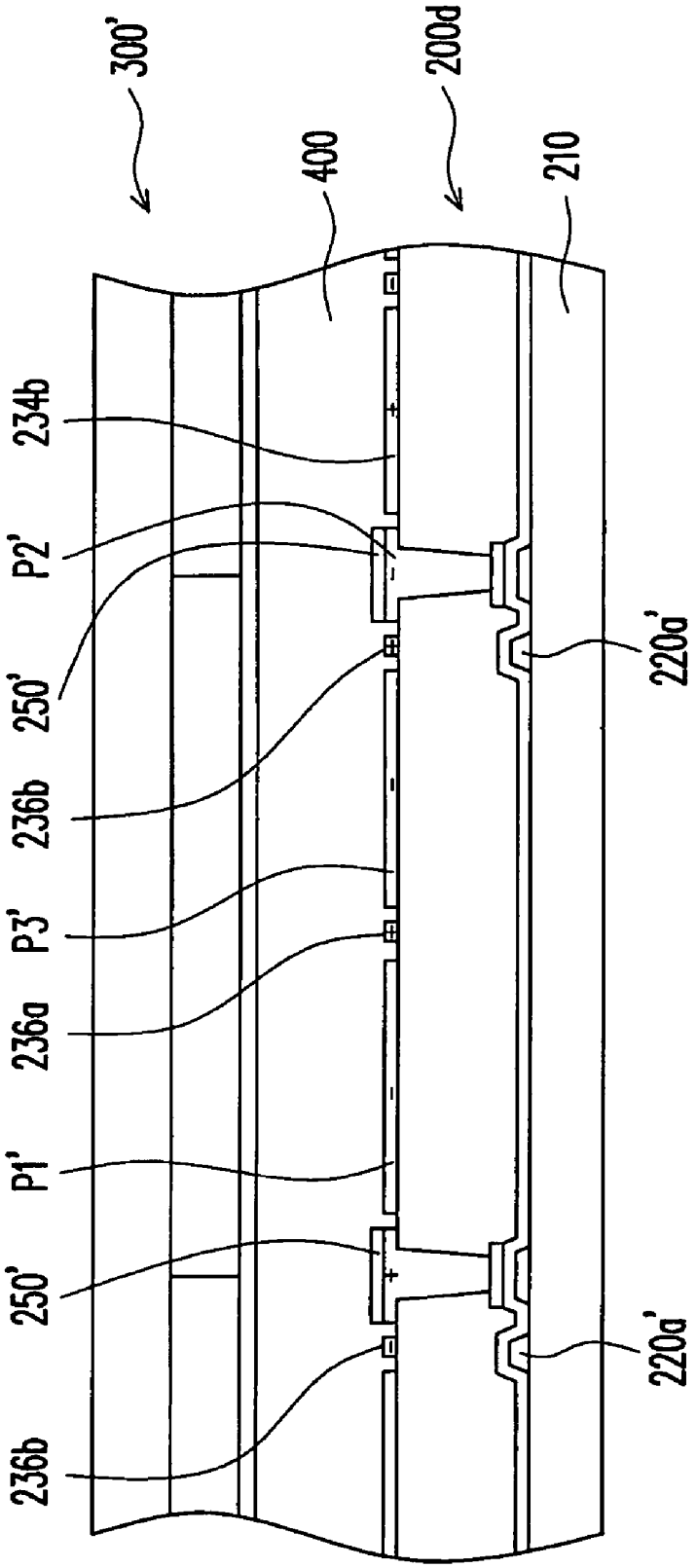
300'
400
200d
210
100d
234b
P2'
250'
236b
P3'
236a
P1'
250'
236b
220a'
220a'

FIG. 4B

LIQUID CRYSTAL DISPLAY AND ACTIVE MATRIX SUBSTRATE THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of Taiwan application serial no. 96112823, filed on Apr. 12, 2007. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed to a liquid crystal display (LCD) panel and an active matrix substrate thereof, and more particularly to an LCD panel with wide viewing angle and an active matrix substrate thereof.

2. Description of Related Art

Nowadays, the functions that the market demands of the thin film transistor liquid crystal display (TFT-LCD) tend to be high contrast ratio, high luminance, quick response and wide viewing angle. Currently, the technologies that meet the requirement of wide viewing angle include, for example, the twisted nematic (TN) LCD with a wide viewing film, the in-plane switching (IPS) LCD, the fringe field switching (FFS) LCD and a multi-domain vertical alignment (MVA) TFT-LCD. In the conventional MVA-LCD panel, since alignment protrusions or slits formed on the color filter substrate or the TFT array substrate can render the liquid crystal molecules arranged in multiple directions, thereby achieving multi-domain. Therefore, the MVA-LCD panel can meet the requirement of wide viewing angle. However, the technique of achieving multi-domain by the said slits often results in greater instability of the multi-domain because the tilted electric field generated by the slits is weaker in its intensity.

Moreover, although the conventional MVA-LCD panel meets the requirement of wide viewing angle, it has the problem of color shift. The so-called color shift means users would see an image having gray scales different from the original image when viewing the images on the display device from different viewing angles. For example, users would see an image lighter than the original image if viewing from a large angle. The problem of color shift would deteriorate the display quality of the image. In order to solve the problem of color shift, some solutions have been proposed, and one of the solutions is forming an additional capacitor in one single pixel unit. By electrical coupling, the capacitor makes a pixel electrode within the single pixel unit generate electric fields of different intensities, and thereby generating different arrangements of liquid crystal molecules. Although the method can mitigate the phenomenon of color shift, it tends to result in the resistance-capacitance (RC) delay effect and thus causing distorted image and poor display quality.

Another method is adding one more transistor in one single pixel unit. In other words, one single pixel unit has two transistors. The two transistors make the pixel electrode in the single pixel unit generate different electric fields and thus generating different arrangements of liquid crystal molecules and thereby eliminating color shift. Nevertheless, the method requires two transistors to be formed in one single pixel unit and more conductive lines to be added (such as scan lines) so that the fabricating process is made complicated and the fabricating cost higher as well.

SUMMARY OF THE INVENTION

The embodiments of present invention provide solution to improve the display quality of a liquid crystal display (LCD) device.

The embodiments of the invention further provide LCD panels including the active matrix substrates with characteristics of stable multi-domain and wide viewing angle.

The embodiments of the invention further provide active matrix substrates to mitigate the problem of color shift.

The embodiments of the invention further provide LCD panels including the active matrix substrates so as to mitigate the problem of color shift.

One embodiment of the invention provides an active matrix substrate including a substrate, a plurality of scan lines, a plurality of data lines and a plurality of pixel units. The scan lines, the data lines and the pixel units are all disposed over the substrate. Each of the pixel units includes an active component, a pixel electrode electrically connected with the active component and an auxiliary electrode. The active components are electrically connected with the scan lines and the data lines. The pixel electrode has at least one opening extended from an edge of the pixel electrode to the interior of the pixel electrode. The auxiliary electrode is electrically connected with a pixel electrode controlled by a previous scan line and includes a body portion and at least one extending portion disposed in the openings. The pixel electrode is electrically connected with the auxiliary electrode of a pixel unit controlled by a next scan line.

The other embodiment of the invention further provides an active matrix substrate including a substrate, a plurality of scan lines, a plurality of data lines and a plurality of pixel units. The scan lines, the data lines and the pixel units are all disposed over the substrate. Each of the pixel units includes an active component, a pixel electrode electrically connected with the active component and a plurality of auxiliary electrodes. The active components are electrically connected with the scan lines and the data lines. The pixel electrode has a plurality of openings extended from an edge of the pixel electrode to an interior of the pixel electrode. A portion of the auxiliary electrodes are electrically connected with the pixel electrode controlled by a next scan line, and a remaining portion of the auxiliary electrodes are electrically connected with the pixel electrode controlled by a previous scan line. Each of the auxiliary electrodes includes an extending portion disposed in one of the openings.

Another embodiment of the present invention further provides an LCD panel including the above-mentioned active matrix substrate(s), an opposite substrate and a liquid crystal layer. The opposite substrate is located over the active matrix substrate, and the liquid crystal layer is disposed between the active matrix substrate and the opposite substrate.

With the auxiliary electrodes of the active component, the liquid crystal molecules in the same pixel unit are formed as stable multi-domain including 4-domain and 2-domain on the pixel electrode since the voltage polarities of the pixel electrode and the auxiliary electrode are different. The LCD panel of the invention thus obtains the characteristics of stable multi-domain and wide viewing angle, and the problem of color shift is simultaneously mitigated as well. In addition, since no additional active component or conductive line is required for each of the pixel units, the present invention has the advantages of a simple fabricating process and a low fabricating cost as compared with the prior art.

In order to the make the aforementioned and other objects, features and advantages of the embodiments of present invention more comprehensible, preferred embodiments accompanied with figures are described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A illustrates a schematic top view of the active matrix substrate according to the first embodiment of the present invention.

FIG. **1**B illustrates a schematic cross-sectional view of the LCD panel of the first embodiment of the invention.

FIG. **2**A illustrates a schematic top view of the active matrix substrate according to the second embodiment of the invention.

FIG. **2**B illustrates a schematic cross-sectional view of the LCD panel according to the second embodiment of the invention.

FIG. **2**C illustrates a top view of an actual layout of the active matrix substrate in the pixel unit of FIG. **2**A.

FIG. **3**A illustrates a schematic top view of the active matrix substrate according to the third embodiment of the invention.

FIG. **3**B illustrates a schematic cross-sectional view of the LCD panel according to the third embodiment of the invention.

FIG. **4**A illustrates a schematic top view of the active matrix substrate according to the fourth embodiment of the invention.

FIG. **4**B illustrates a schematic cross-sectional view of the LCD panel according to the fourth embodiment of the invention.

DESCRIPTION OF EMBODIMENTS

The First Embodiment

FIG. **1**A illustrates a schematic top view of the active matrix substrate of the first embodiment of the invention. FIG. **1**B illustrates a schematic cross-sectional view of the liquid crystal display (LCD) panel of the first embodiment of the invention. An active matrix substrate **200***a* as shown in FIG. **1**B is a cross-sectional view obtained from FIG. **1**A along line I-I. Referring to both FIGS. **1**A and **1**B, an LCD panel **100***a* of the present embodiment includes an active matrix substrate **200***a*, an opposite substrate **300** and a liquid crystal layer **400**. The opposite substrate **300** is disposed over the active matrix substrate **200***a*, and the liquid crystal layer **400** is disposed between the active matrix substrate **200***a* and the opposite substrate **300**, as shown in FIG. **1**B.

The active matrix substrate **200***a* includes a substrate **210**, a plurality of scan lines **220***a*, a plurality of data lines **220***b* and a plurality of pixel units **230***a*. The scan lines **220***a*, the data lines **220***b* and the pixel units **230***a* are all disposed over the substrate **210**. Each of the pixel units **230***a* includes an active component **232***a*, a pixel electrode **234***a* and an auxiliary electrode **236**. The active components **232***a* are electrically connected with the scan lines **220***a* and the data lines **220***b*, and the active component **232***a* is, for example, an amorphous silicon thin film transistor (a-Si TFT) or a polysilicon TFT. Each of the active components **232***a* is electrically connected with one of the pixel electrodes **234***a* correspondingly. Thus, the active component **232***a* can control the corresponding pixel electrode **234***a*.

The pixel electrode **234***a* has a opening S extended from an edge of the pixel electrode **234***a* to an interior of the pixel electrode, and is electrically connected with the auxiliary electrode **236** of an adjacent pixel unit **230***a*. The pixel electrode **234***a* of the adjacent pixel unit **230***a* is controlled by a next scan line **220***a*. In other words, each of the auxiliary electrodes **236** in a corresponding pixel unit **230***a* is electrically connected with a pixel electrode **234***a* controlled by a previous scan line **220***a* in an adjacent pixel unit **230***a*. Furthermore, the auxiliary electrode **236** includes a body portion A**1** and an extending portion A**2** disposed in the openings S. The pixel electrode **234***a* and the auxiliary electrode **236** can be fabricated using transparent conductive materials, such as indium tin oxide (ITO) or indium zinc oxide (IZO).

The LCD panel **100***a* is driven, for example, by the line inversion driving technique. When the LCD panel **100***a* is driven, a voltage polarity of the pixel electrode **234***a* in the same pixel unit **230***a* is contrary to voltage polarities of the pixel electrodes **234***a* controlled by a previous and a next scan lines **220***a*. Since the pixel electrode **234***a* in one corresponding pixel unit **230***a* is electrically connected with the auxiliary electrode **236** in an adjacent pixel unit **230***a*, the voltages of the pixel electrode **234***a* and the auxiliary electrode **236** in the adjacent pixel unit **230***a* are the same. Therefore, the voltage polarities of the pixel electrode **234***a* and the auxiliary electrode **236** in the same corresponding pixel unit **230***a* are contrary to each other. In the same pixel unit **230***a*; for instance, when the pixel electrode **234***a* has positive voltage polarity, the auxiliary electrode **236** has negative voltage polarity and vice versa.

It is known from the aforementioned and FIG. **1**A that the pixel electrode **234***a* can be further identified as two portions by the opening S of the pixel electrode **234***a*. One portion is partially or fully surrounded by two auxiliary electrode **236** with a different voltage polarity and by a previous pixel electrode **234***a* controlled by the previous scan line **220***a*. As a result, the liquid crystal molecules corresponding to the portion mentioned above would form 4-domain effect. The other portion is located between an extending portions A**2** of an auxiliary electrode **236** with a different voltage polarity and a pixel electrode **234***a* controlled by the next scan line **220***a*. As a result, the liquid crystal molecules corresponding to the other portion mentioned above would form 2-domain effect. Hence, in one single pixel unit **230***a*, the liquid crystal molecules would form as stable multi-domain including 4-domain and 2-domain because the voltage polarities of the pixel electrode **234***a* and the auxiliary electrode **236** are different. The LCD panel **100***a* can thus achieve the effect of stable multi-domain and obtain the characteristic of wide viewing angle, thereby mitigating the problem of color shift.

The extending directions of the openings S may be substantially the same. In other words, the openings S may extend from the same side of the pixel electrode **234***a* to the interior of the pixel electrode and are substantially parallel to each other. If the openings S are parallel to each other, the extending portions A**2** inside of them can also be parallel to each other. In addition, the openings S may substantially parallel the scan lines **220***a* as well, as shown in FIG. **1**A.

However, in the present embodiment, even if the extending directions of the openings S differ from each other, the overall performance of the active matrix substrate **200***a* would not be significantly affected. In other words, even if the openings S do not parallel each other, the active matrix substrate **200***a* still possesses the characteristic of wide viewing angle. Hence, the openings S shown in FIG. **1**A only serve as examples to facilitate illustration and are not intended to limit the present invention.

In the present embodiment, the active matrix substrate **200***a* includes a plurality of conductive layers **240** located under source/drain E of the active components **232***a*. The

conductive layers **240** may be fabricated using metallic materials, ITO or IZO. Each of the conductive layers **240** is electrically coupled to one of the sources/drains E correspondingly so as to form a storage capacitor C. With the storage capacitors C, the display quality of the LCD panel **100***a* is enhanced. Furthermore, each of the conductive layers **240** may be a common line formed on the active matrix substrate **200***a*.

The active matrix substrate **200***a* further includes a planarization layer **260** as shown in FIG. **1**B. In one preferred embodiment, the thickness of the planarization layer **260** is 2-3 micrometers (μm). A plurality of pixel electrodes **234***a* and auxiliary electrodes **236** are disposed on the planarization layer **260**. The planarization layer **260** is disposed on a substrate **210** covering a plurality of scan lines **220***a*, a plurality of data lines **220***b* and a plurality of active components **232***a* so as to avoid generating crosstalk resulted from parasitic capacitance.

Further, referring to FIG. **1**B, the opposite substrate **300** of the embodiment may be a color filter substrate including a substrate **310**, a plurality of color filter patterns **320***a*, a black matrix (BM) layer **320***b* and a common electrode **330**.

The plurality of color filter patterns **320***a* and the BM layer **320***b* are disposed on the substrate **310**. The common electrode **330** is disposed on the color filter patterns **320***a* and the BM layer **320***b*. The plurality of color filter patterns **320***a* includes a plurality of red filter patterns, green filter patterns and blue filter patterns. Moreover, the color filter patterns **320***a* may be fabricated using resin materials.

The BM layer **320***b* is located between the plurality of color filter patterns **320***a*. In the present embodiment, the LCD panel **100***a* may be a transmissive LCD. The BM layer **320***b* is suitable for covering the scan lines **220***a*, the data lines **220***b* and the active components **232***a* on the active matrix substrate **200***a* so as to prevent the display quality of the LCD panel **100***a* from being deteriorated. Moreover, the BM layer **320***b* may be fabricated using resin materials or metals.

The Second Embodiment

FIG. **2**A illustrates a schematic top view of the active matrix substrate according to the second embodiment of the invention. FIG. **2**B illustrates a schematic cross-sectional view of the LCD panel according to the second embodiment of the invention. FIG. **2**B is a cross-sectional view of the active matrix substrate **200***b* obtained from FIG. **2**A along line J-J. FIG. **2**C illustrates a top view of an actual layout of the active matrix substrate in the pixel unit of FIG. **2**A. Referring to both FIGS. **2**A, **2**B and **2**C, the present embodiment is similar to the first one. The primary difference between the two embodiments lies in that an LCD panel **100***b* includes an active matrix substrate **200***b* having a plurality of pixel units **230***b*. Each of the pixel units **230***b* includes an active component **232***a*, a pixel electrode **234***b* and an auxiliary electrode **236'**.

Specifically, in the same pixel unit **230***b*, the pixel electrode **234***b* has a plurality of openings S extended from an edge of the pixel electrode **234***b* to an interior of the pixel electrode **234***b*. The auxiliary electrode **236'** includes a body portion A**1** and a plurality of extending portions A**2** disposed in the openings S respectively.

In the embodiment, the pixel electrode **234***b* in the same pixel unit **230***b* has two openings S and includes a first electrode portion P**1** and a second electrode portion P**2** electrically connected with the first electrode portion P**1**. The two openings S is a first opening S**1** and a second opening S**2**. The first electrode portion P**1** has the first opening S**1**, and the second opening S**2** is located between the first electrode portion P**1** and the second electrode portion P**2**.

In the same pixel unit **230***b*, the plurality of extending portions A**2** of the auxiliary electrode **236'** is respectively disposed in the first opening S**1** and the second opening S**2**. In the pixel units **230***b* of the same column, each of the first electrode portions P**1** is located between two adjacent body portions A**1**. Therefore, the two adjacent auxiliary electrodes **236'** and a previous pixel electrode **234***b* surround each of the first electrode portions P**1**.

In the pixel units **230***b* of the same column, each of the second electrode portions P**2** is located between the extending portions A**2** of the auxiliary electrode **236'** and the pixel electrode **234***b* controlled by a next scan line **220***a*. In detail, each of the second electrode portions P**2** is located between one of the extending portions A**2** in same pixel unit **230***b* and the first electrode portion P**1** of a pixel electrode **234***b* controlled by a next scan line in next pixel unit **230***b*.

Further, in the same pixel unit **230***b*, the active component **232***a* is located under the pixel electrode **234***b*. Specifically, the active component **232***a* may be under the first electrode portion P**1** and located between the first opening S**1** and the second opening S**2**. However, each of the active components in the embodiment may also be Linder the second electrode portion P**2** of one of the pixel electrodes **234***b*. Accordingly, dispositions of every active component **232***a* disclosed in FIGS. **2**A and **2**B only serve as examples to facilitate illustration, and are not intended to limit the present invention.

The extending directions of the openings S (the first opening S**1** and the second opening S**2**) can be the same. Alternatively speaking, the first opening S**1** and the second opening S**2** may extend from the same side of the pixel electrode **234***b* to an interior of the pixel electrode **234***b*, and the S**1** and S**2** are parallel to each other. If the first openings S**1** and the second openings S**2** are parallel to each other, so are the first openings S**1** and the extending portions A**2** in the second openings S**2**. Additionally, the first openings S**1** and the second openings S**2** may parallel the scan lines **220***a* as well, as shown in FIG. **2**A.

However, in the present embodiment, even if the extending directions of the first openings S**1** and the second openings S**2** differ, the overall performance of the active matrix substrate **200***b* would not be affected. In other words, even if the first openings S**1** and the second openings S**2** do not parallel each other, the active matrix substrate **200***b* still possesses the characteristic of wide viewing angle. Hence, the first openings S**1** and the second openings S**2** shown in FIG. **2**A only serve as examples to facilitate illustration, and are not intended to limit the invention.

The Third Embodiment

FIG. **3**A illustrates a schematic top view of the active matrix substrate according to the third embodiment of the invention. FIG. **3**B illustrates a schematic cross-sectional view of the LCD panel according to the third embodiment of the invention. An active matrix substrate **200***c* as shown in FIG. **3**B is a cross-sectional view obtained from FIG. **3**A along line k-k. Referring to FIGS. **3**A and **3**B, the present embodiment is similar to the second one. The primary difference between the two embodiments lies in that an LCD panel **100***c* of the present embodiment is a transflective LCD panel. Specifically, in the LCD panel **100***c* of the embodiment, an active matrix substrate **200***c* further includes a plurality of reflective layers **250**. The reflective layers **250** are respectively disposed on pixel electrodes **234***b* of the active matrix

substrate **200***c* and located over active components **232***a* of the active matrix substrate **200***c* so as to reflect light outside of the LCD panel **100***c*.

In addition, an opposite substrate **300'** of the LCD panel **100***c* is similar to the opposite substrate **300** of the previous first embodiment. Nevertheless, since the LCD panel **100***c* is a transmissive LCD panel, the opposite substrate **300'** only includes a substrate **310**, a plurality of color filter patterns **320***a* and a common electrode **330**, and does not include a black matrix (BM) layer. Consequently, the light reflected from the reflective layers **250** may penetrate through the opposite substrate **300'** and reveal bright and clear images.

The Fourth Embodiment

FIG. **4**A illustrates a schematic top view of the active matrix substrate according to the fourth embodiment of the invention. FIG. **4**B illustrates a schematic cross-sectional view of the LCD panel of the fourth embodiment of the invention. An active matrix substrate **200***d* as shown in FIG. **4**B is a cross-sectional view obtained from FIG. **4**A along line L-L. Referring to both FIGS. **4**A and **4**B, an LCD panel **100***d* includes an active matrix substrate **200***d*, an opposite substrate **300'** and a liquid crystal layer **400**. The opposite substrate **300'** is located over the active matrix substrate **200***d*, and the liquid crystal layer **400** is disposed between the opposite substrate **300'** and the active matrix substrate **200***d*.

The active matrix substrate **200***d* includes a substrate **210**, a plurality of scan lines **220***a'*, a plurality of data lines **220***b'* and a plurality of pixel units **230***c*. The plurality of scan lines **220***a'*, the plurality of data lines **220***b'* and the plurality of pixel units **230***c* are all disposed over the substrate **210**. Each of the pixel units **230***c* includes an active component **232***b*, a pixel electrode **234***c* and a plurality of auxiliary electrodes **238**. The active components **232***b* are electrically connected with the scan lines **220***a'* and the data lines **220***b'*. The active component **232***b* is, for example, an a-Si TFT or a polysilicon TFT.

In the same pixel unit **230***c*, the pixel electrode **234***c* is electrically connected with the active component **232***b* and has a plurality of openings S' extended from an edge of the pixel electrode **234***c* to an interior of the pixel electrode **234***c*. A portion of the auxiliary electrodes **238** are electrically connected with the pixel electrode **234***c* controlled by a next scan line **220***a'*. A remaining portion of the auxiliary electrodes **238** are electrically connected with the pixel electrode **234***c* controlled by a previous scan line **220***a'*. Each of the auxiliary electrodes **238** includes an extending portion A' disposed in one of the openings S'. In addition, the pixel electrodes **234***c* and the auxiliary electrodes **238** may be fabricated using transparent conductive materials, such as indium tin oxide (ITO) or indium zinc oxide (IZO).

In the present embodiment, the pixel electrode **234***c* in the same pixel unit **230***c* includes a first electrode portion P**1'**, a second electrode portion P**2'** and a third electrode portion P**3'**. The third electrode portion P**3'** is located between the first electrode portion P**1'** and the second electrode portion P**2'** and is electrically connected with the first electrode portion P**1'** and the second electrode portion P**2'**. The openings S' in the same pixel unit **230***c* may be a first opening S**1'** and a second opening S**2'**. The first opening S**1'** is located between the first electrode portion P**1'** and the third electrode portion P**3'**. The second opening S**2'** is located between the second electrode portion P**2'** and the third electrode portion P**3'**. Hence, each of the third electrode portions P**3'** is disposed between two extending portions A'.

The same pixel unit **230***c* includes two auxiliary electrodes **238**. The two auxiliary electrodes **238** are a first auxiliary electrode **238***a* and a second auxiliary electrode **238***b*. The first auxiliary electrode **238***a* is electrically connected with the second electrode portion P**2'** of a previous pixel electrode **234***c*. The second auxiliary electrode **238***b* is electrically connected with the first electrode portion P**1'** of a pixel electrode **234***c* controlled by a next scan line. In the pixel electrodes **234***c* arranged in the same column, each of the first auxiliary electrodes **238***a* stretches out from the second electrode portion P**2'** of a previous pixel electrode **234***c* with which it is electrically connected to an interior of the first opening S**1'**. Each of the second auxiliary electrodes **238***b* extends from the first electrode portion P**1'** of a pixel electrode **234***c* with which it is electrically connected to an interior of the second opening S**2'**. Consequently, each of the second electrode portions P**2'** is surrounded by a second auxiliary electrode **238***b* and the first electrode portion P**1'** of a pixel unit **230***c*, as shown in FIG. **4**A. Each of the first electrode portions P**1'** is surrounded by a first auxiliary electrode **238***a* and a second electrode portion P**2'** of a previous pixel unit **230***c*, as shown in FIG. **4**A as well.

The LCD panel **100***d* is driven by the line inversion technique as the foregoing embodiment. Therefore, a voltage polarity of each of the pixel electrodes **234***c* is contrary to a voltage polarity of the pixel electrodes **234***c* controlled by a previous scan line **220***a'* or controlled by a next scan line **220***a'*. Since each of the first auxiliary electrodes **238***a* and each of the second auxiliary electrodes **238***b* are electrically connected with a previous and a next pixel electrodes **234***c* respectively, in the same pixel unit **230***c*, voltage polarities of the auxiliary electrodes **238** are both the same and contrary to the voltage polarity of the pixel electrode **234***c*. For example, when the pixel electrode **234***c* has a positive voltage polarity, the surrounding auxiliary electrodes **238** have a negative voltage polarity, as shown in FIG. **4**A. Accordingly, liquid crystal molecules in the same pixel unit **230***c* would form as stable multi-domain over the pixel electrode **234***c*, thereby rendering the LCD panel **100***d* with the characteristic of wide viewing angle so as to mitigate the problem of color shift. For instance, when the first electrode portion P**1'** with negative voltage polarity is surrounded by auxiliary electrodes **238** with positive voltage polarity and by a second electrode portion P**2'** of an adjacent pixel unit with positive voltage polarity, liquid crystal molecules in first electrode portion P**1'** would form as 4-domain. The second electrode portion P**2'** also has 4-domain effect. The third electrode portion P**3'** has 2-domain effect.

In the present embodiment, the extending directions of the openings S' may be contrary. For example, the first openings S**1'** and the second openings S**2'** may extend from the two opposite sides of the pixel electrode **234***c* to an interior of the pixel electrode **234***c*, and S**1'** and S**2'** are parallel to each other. Hence, the extending portions A' of the auxiliary electrodes **238** may also be parallel to each other. Moreover, the first openings S**1'** and the second openings S**2'** may also parallel the scan lines **220***b'*. However, even if the extending directions of the openings S' are not contrary, or even they are the same, the overall performance of the active matrix substrate **200***d* in the present embodiment would not be affected. In other words, if the extending directions of the first openings S**1'** and the second openings S**2'** are the same, the active matrix substrate of the embodiment would also have the characteristic of wide viewing angle. Thus, the openings S' shown in FIG. **4**A only serve as examples to facilitate illustration and are not intended to limit the present invention.

Further, in the same pixel unit **230***c*, the active component **232***b* is located under the pixel electrode **234***c*. For example, the active component **232***b* may be located under the first electrode portion P**1**', the second electrode portion P**2**' and the third electrode portion P**3**'. Although each of the active components **232***b* is located under the second electrode portion P**2**' as disclosed in FIG. **4**A, FIG. **4**A simply serves as an example for illustration and is not intended to limit the invention.

Besides, the LCD panel **100***d* of the embodiment may be a transflective LCD panel. Specifically, the active matrix substrate **200***d* further includes a plurality of reflective layers **250'** to reflect light from outside of the LCD panel **100***d*. The reflective layers **250'** are disposed on the pixel electrodes **234***c* respectively and located over one of the active components correspondingly. Taking FIGS. **4**A and **4**B as examples, one of the reflective layers **250'** is located on one of the second electrode portions P**2**'.

Nevertheless, the LCD panel **100***d* may also be fabricated as a transmissive LCD panel, and thus the reflective layers **250'** are not necessary elements for the LCD panel **100***d*. Alternatively speaking, the active matrix substrate **200***d* of the embodiment can do without the reflective layers **250'**. Therefore, the opposite substrate **300'** may also be replaced with an opposite substrate having a BM layer. The reflective layers **250'** of FIG. **4**B and the opposite substrate **300'** are simply examples to facilitate illustration and are not intended to limit the invention.

In summary, the liquid crystal molecules in the same pixel unit are formed as multi-domain on the pixel electrodes by at least one auxiliary electrode in the present invention, thereby rendering the LCD panel with the characteristic of wide viewing angle. The display quality is also simultaneously improved by the aligning effect derived from stable multi-domain and the mitigation of color shift achieved in the invention. Furthermore, the problem of color shift is mitigated without additional active component or line required for the active matrix substrate of the invention. Consequently, the invention possesses the advantages of a simple fabricating process and a low fabricating cost over the prior art.

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

What is claimed is:

1. An active matrix substrate, comprising:
a substrate;
a plurality of scan lines disposed on the substrate;
a plurality of data lines disposed on the substrate;
a plurality of pixel units disposed on the substrate, each of the pixel units comprising:
an active component electrically connected with one of the scan lines and one of the data lines correspondingly;
a first pixel electrode electrically connected with the active component and having a first voltage polarity, wherein the first pixel electrode has at least one opening extended from an edge of the first pixel electrode to an interior of the first pixel electrode; and
an first auxiliary electrode electrically connected with a second pixel electrode of an adjacent pixel unit, the second pixel electrode being controlled by a previous scan line and the auxiliary electrode having a second voltage polarity contrary to the first voltage polarity, wherein the first auxiliary electrode comprises a body portion and at least one extending portion disposed in the opening, and the first pixel electrode is electrically connected with a second auxiliary electrode of another adjacent pixel unit having a third pixel electrode controlled by a next scan line.

2. The active matrix substrate of claim **1**, wherein the second auxiliary electrode has the first voltage polarity and the third pixel electrode has the second voltage polarity.

3. The active matrix substrate of claim **2**, wherein the first pixel electrode comprises a first electrode portion and a second electrode portion electrically connected with the first electrode portion, the first electrode portion being surrounded by the first auxiliary electrode, the second pixel electrode, and another auxiliary electrode with second voltage polarity of one adjacent pixel unit.

4. The active matrix substrate of claim **3**, wherein the extending portion of the first auxiliary electrode and the third pixel electrode respectively located near two opposite sides of the second electrode portion.

5. The active matrix substrate of claim **1**, wherein the first pixel electrode has a plurality of openings extended from the edge of the first pixel electrode to the interior of the first pixel electrode, and the first auxiliary electrode comprises a plurality of extending portions disposed in the openings respectively.

6. The active matrix substrate of claim **5**, wherein the first pixel electrode comprises a first electrode portion and a second electrode portion electrically connected with the first electrode portion, and the openings comprise a first opening and a second opening, the first electrode portion having the first opening, the second opening located between the first electrode portion and the second electrode portion.

7. The active matrix substrate of claim **6**, wherein in the same pixel unit, the active component is disposed under the first electrode portion and located between the first opening and the second opening.

8. The active matrix substrate of claim **1**, wherein each of the pixel units further comprises a reflective layer, disposed on the first pixel electrode and located over the active component.

9. The active matrix substrate of claim **1**, wherein each of the active components comprises an amorphous silicon thin film transistor (a-Si TFT) or a poly-silicon TFT.

10. A liquid crystal display (LCD) panel, comprising:
an active matrix substrate, comprising:
a substrate;
a plurality of scan lines disposed on the substrate;
a plurality of data lines disposed on the substrate;
a plurality of pixel units disposed on the substrate, each of the pixel units comprising:
an active component electrically connected with one of the scan lines and one of the data lines correspondingly;
a pixel electrode electrically connected with the active component, wherein the pixel electrode has at least one opening extended from an edge of the pixel electrode to an interior of the pixel electrode;
an auxiliary electrode electrically connected with the pixel electrode controlled by a previous scan line, wherein the auxiliary electrode comprises a body portion and at least one extending portion disposed in the openings, and the pixel electrode is electrically connected with the auxiliary electrode of an adjacent pixel unit, the pixel electrode of the adjacent pixel unit being controlled by a next scan line;

an opposite substrate disposed over the active matrix substrate; and

a liquid crystal layer disposed between the active matrix substrate and the opposite substrate.

11. The LCD panel of claim **10**, wherein in the same pixel unit, a voltage polarity of the pixel electrode is contrary to a voltage polarity of the auxiliary electrode.

12. The LCD panel of claim **10**, wherein in the pixel units of the same column, a voltage polarity of each of the pixel electrodes is the same as a voltage polarity of the auxiliary electrode of the pixel unit controlled by a next scan line.

13. The LCD panel of claim **10**, wherein extending directions of the openings are the same.

14. The LCD panel of claim **10**, wherein the pixel electrode has a plurality of openings extended from the edge of the pixel electrode to the interior of the pixel electrode, and the auxiliary electrode comprises a plurality of extending portions disposed in the openings respectively.

15. The LCD panel of claim **14**, wherein in the same pixel unit, the pixel electrode comprises a first electrode portion and a second electrode portion electrically connected with the first electrode portion, and the openings comprise a first opening and a second opening, the first electrode portion having the first opening, the second opening located between the first electrode portion and the second electrode portion.

16. The LCD panel of claim **15**, wherein in the same pixel unit, the active component is located under the first electrode portion and located between the first opening and the second opening.

17. The LCD panel of claim **10**, further comprising a plurality of reflective layers, disposed on the pixel electrodes and located over the active components.

18. The LCD panel of claim **10**, wherein each of the active components comprises an a-Si TFT or a poly-silicon TFT.

19. An active matrix substrate, comprising:

a substrate;

a plurality of scan lines disposed on the substrate;

a plurality of data lines disposed on the substrate;

a plurality of pixel units disposed on the substrate, each of the pixel units comprising:

an active component electrically connected with one of the scan lines and one of the data lines correspondingly;

a pixel electrode electrically connected with the active component, wherein the pixel electrode has a plurality of openings extended from an edge of the pixel electrode to an interior of the pixel electrode; and

a plurality of auxiliary electrodes, wherein a portion of the auxiliary electrodes are electrically connected with the pixel electrode controlled by a next scan line, a remaining portion of the auxiliary electrodes are electrically connected with the pixel electrode controlled by a previous scan line, and each of the auxiliary electrodes comprises an extending portion disposed in one of the openings.

20. The active matrix substrate of claim **19**, wherein in the same pixel unit, voltage polarities of the auxiliary electrodes are the same and a voltage polarity of the pixel electrode is contrary to the voltage polarities of the auxiliary electrodes.

21. The active matrix substrate of claim **19**, wherein extending directions of the openings are contrary.

22. The active matrix substrate of claim **19**, further comprising a plurality of reflective layers, disposed on the pixel electrodes and located over the active components.

23. The active matrix substrate of claim **19**, wherein in the same pixel unit, the pixel electrode comprises a first electrode portion, a second electrode portion and a third electrode portion, the third electrode portion is electrically connected between the first electrode portion and the second electrode portion, and the openings comprise a first opening between the first electrode portion and the third electrode portion and a second opening between the second electrode portion and the third electrode portion.

24. The active matrix substrate of claim **23**, wherein each of the active components is located under one of the second electrode portions respectively.

25. The active matrix substrate of claim **19**, wherein each of the active components comprises an a-Si TFT or a poly-silicon TFT.

26. An LCD panel, comprising:

an active matrix substrate, comprising:

a substrate;

a plurality of scan lines disposed on the substrate;

a plurality of data lines disposed on the substrate;

a plurality of pixel units disposed on the substrate, each of the pixel units comprising:

an active component electrically connected with one of the scan lines and one of the data lines correspondingly;

a pixel electrode electrically connected with the active component, wherein the pixel electrode has a plurality of openings extended from an edge of the pixel electrode to an interior of the pixel electrode;

a plurality of auxiliary electrodes, wherein a portion of the auxiliary electrodes are electrically connected with the pixel electrode controlled by a next scan line, a remaining portion of the auxiliary electrodes are electrically connected with the pixel electrode controlled by a previous scan line, and each of the auxiliary electrodes comprises an extending portion disposed in one of the openings;

an opposite substrate disposed over the active matrix substrate; and

a liquid crystal layer disposed between the active matrix substrate and the opposite substrate.

27. The LCD panel of claim **26**, wherein in the same pixel unit, voltage polarities of the auxiliary electrodes are the same and a voltage polarity of the pixel electrode is contrary to the voltage polarities of the auxiliary electrodes.

28. The LCD panel of claim **26**, wherein extending directions of the openings are contrary.

29. The LCD panel of claim **26**, further comprising a plurality of reflective layers, disposed on the pixel electrodes and located over the active components.

30. The LCD panel of claim **26**, wherein in the same pixel unit, the pixel electrode comprises a first electrode portion, a second electrode portion and a third electrode portion, the third electrode portion is electrically connected between the first electrode portion and the second electrode portion, and the openings comprise a first opening between the first electrode portion and the third electrode portion and a second opening between the second electrode portion and the third electrode portion.

31. The LCD panel of claim **30**, wherein each of the active components is located under one of the second electrode portions respectively.

32. The LCD panel of claim **26**, wherein each of the active components comprises an a-Si TFT or a poly-silicon TFT.

* * * * *

专利名称(译)	液晶显示器及其有源矩阵基板		
公开(公告)号	US7808565	公开(公告)日	2010-10-05
申请号	US12/101156	申请日	2008-04-11
[标]申请(专利权)人(译)	胜华科技股份有限公司		
申请(专利权)人(译)	胜华科技股份有限公司		
当前申请(专利权)人(译)	胜华科技股份有限公司 KYORITSU OPTRONICS CO.，LTD.		
[标]发明人	WANG WEN CHUN LIU CHIN CHANG		
发明人	WANG, WEN-CHUN LIU, CHIN-CHANG		
IPC分类号	G02F1/141 G09G3/36		
CPC分类号	G02F1/136286 G02F2001/134345		
审查员(译)	内尔姆斯，DAVID		
优先权	096112823 2007-04-12 TW		
其他公开文献	US20080252802A1		
外部链接	Espacenet USPTO		

摘要(译)

提供有源矩阵衬底。有源矩阵基板包括基板，扫描线，数据线和像素单元。扫描线，数据线和像素单元都设置在衬底上。像素单元包括有源组件，像素电极和辅助电极。有源元件与扫描线和数据线电连接。像素电极具有从像素电极的边缘延伸到像素电极的内部的开口。辅助电极与由前一扫描线控制的像素电极电连接，并包括主体部分和设置在开口中的延伸部分。像素电极与由下一扫描线控制的像素单元的辅助电极电连接。