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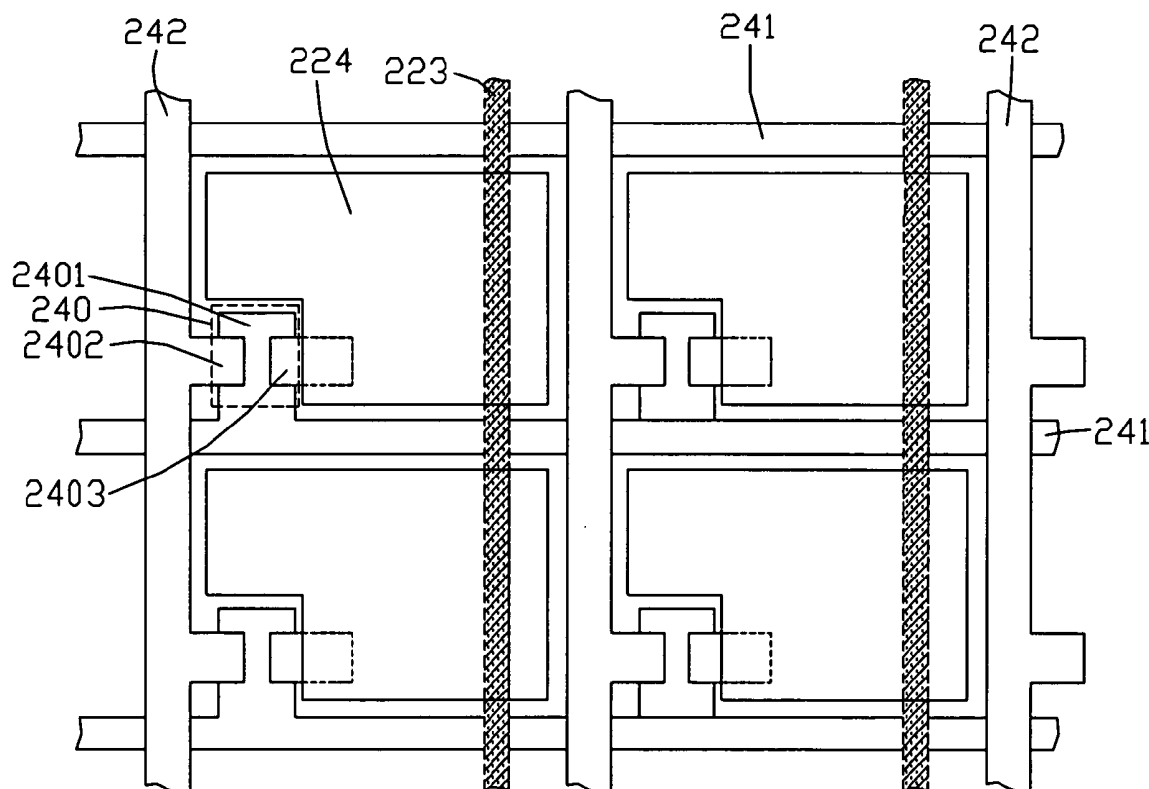
(19) **United States**(12) **Patent Application Publication**
Qi(10) **Pub. No.: US 2008/0129902 A1**(43) **Pub. Date: Jun. 5, 2008**(54) **LIQUID CRYSTAL DISPLAY PANEL HAVING
DIELECTRIC COMPENSATING LAYER**(30) **Foreign Application Priority Data**

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(75) Inventor: **Xiao-Jing Qi, Shenzhen (CN)****Publication Classification**(51) **Int. Cl.**
G02F 1/1333 (2006.01)(52) **U.S. Cl.** **349/33; 349/138**(57) **ABSTRACT**

An exemplary liquid crystal display (LCD) (1) includes a first substrate (211), a second substrate (221), and a liquid crystal layer (230) sandwiched between the two substrates. The LCD further includes a common electrode layer (212) formed at an inner side of; a dielectric compensating layer (213) formed at an inner side of at an inner side of the common electrode layer; and a plurality of pixel electrodes (224) formed at an inner side of the second substrate. The dielectric compensating layer is configured to compensate changes in the dielectric constant of the liquid crystal layer which occur according to gradation voltages provided to the liquid crystal layer.

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INNOLUX DISPLAY CORP.(21) Appl. No.: **11/999,090**(22) Filed: **Dec. 3, 2007**

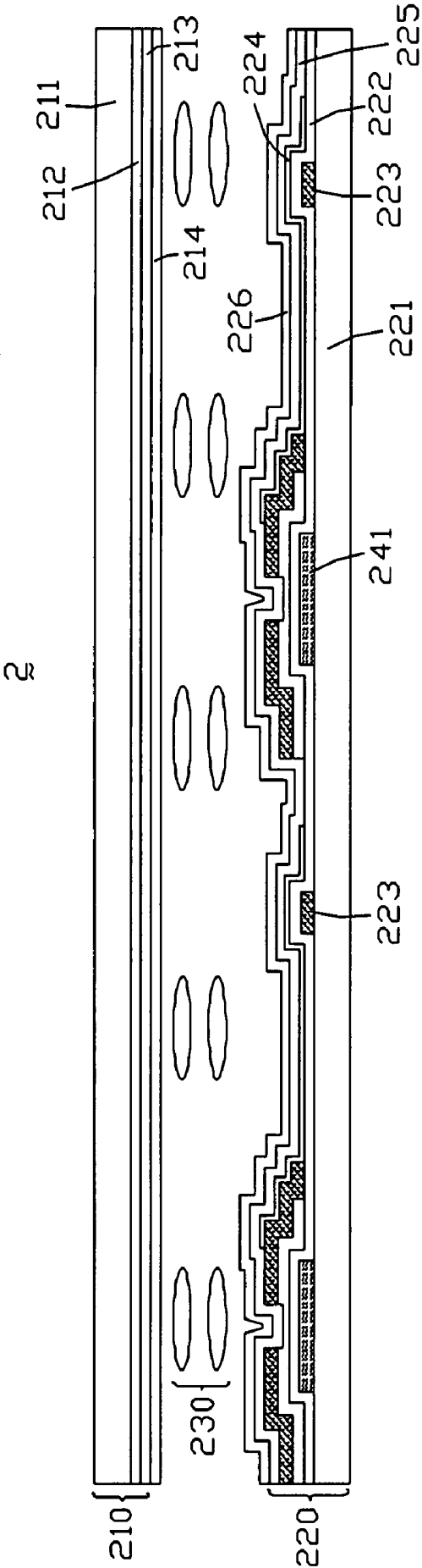
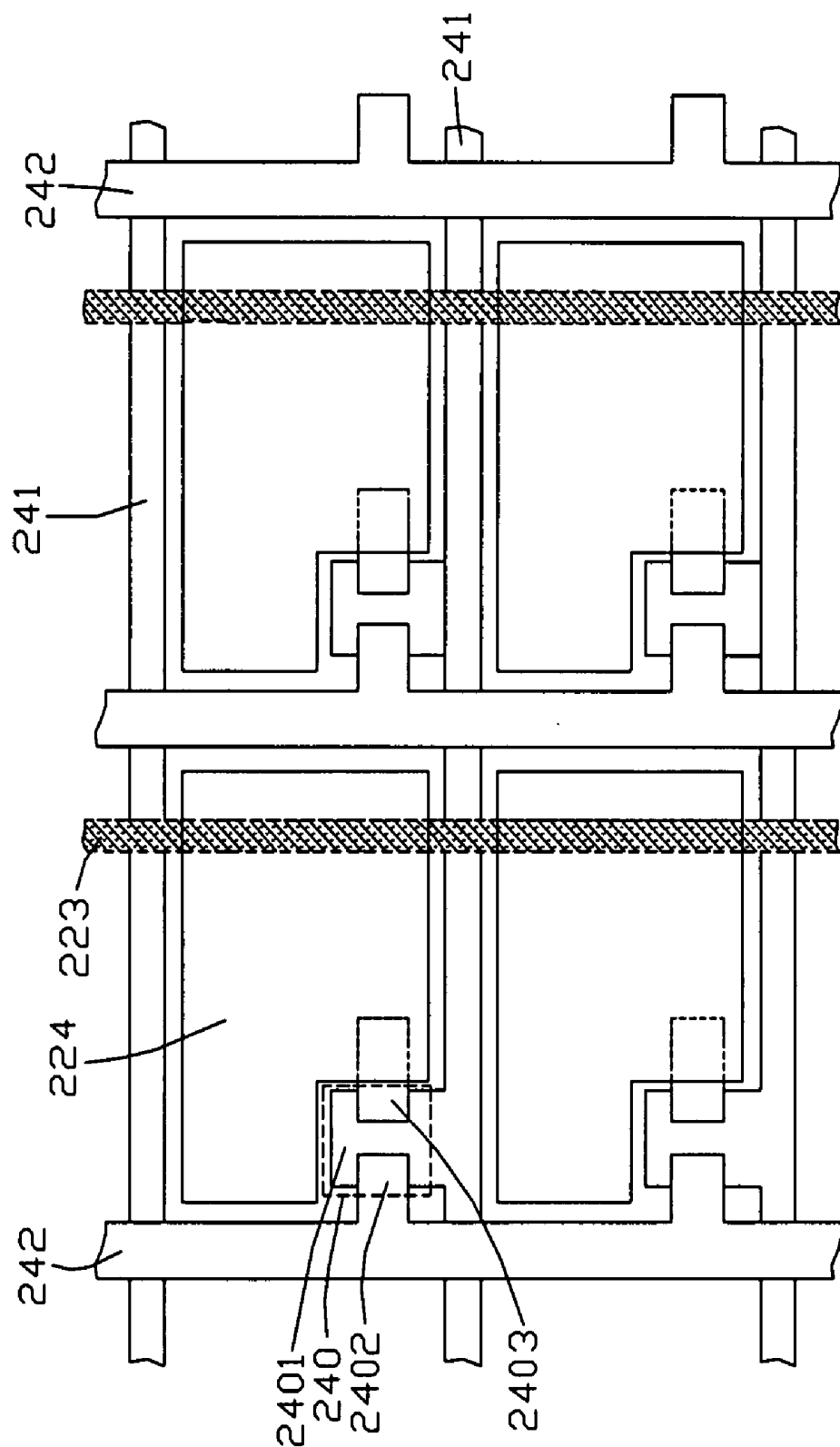


FIG. 1



251

FIG. 4

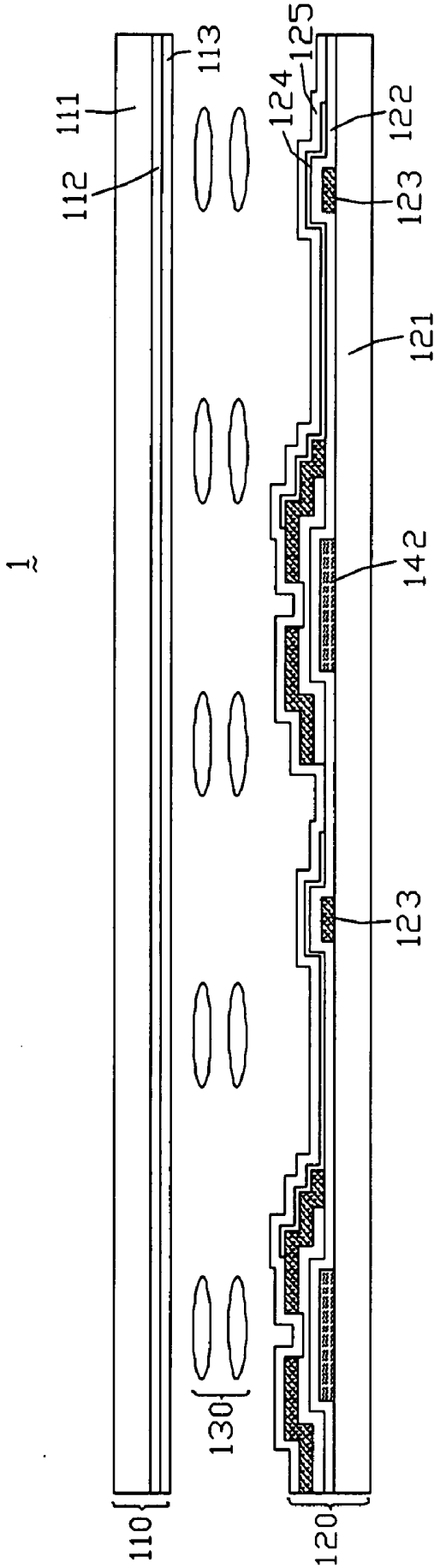


FIG. 5
(RELATED ART)

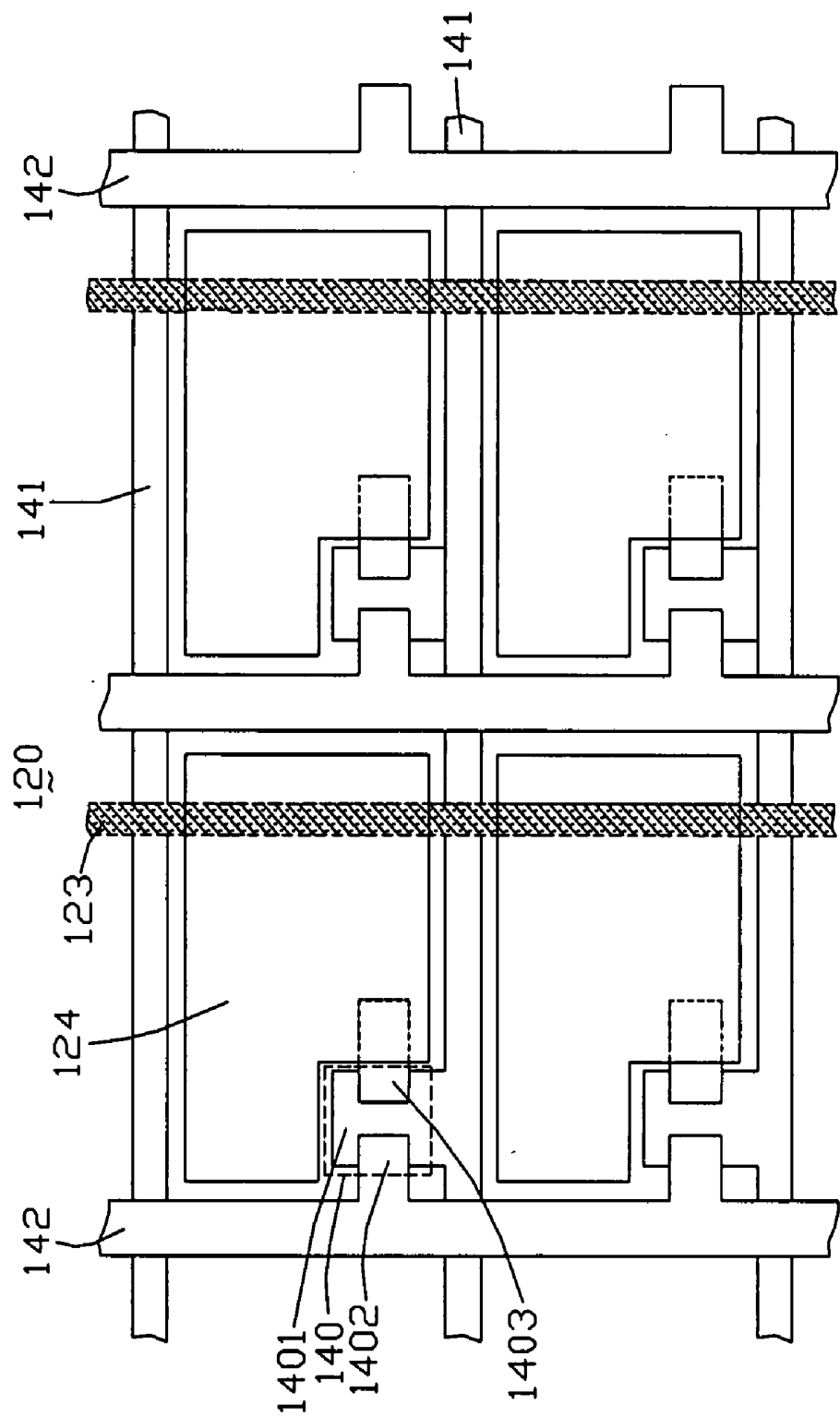


FIG. 6
(RELATED ART)

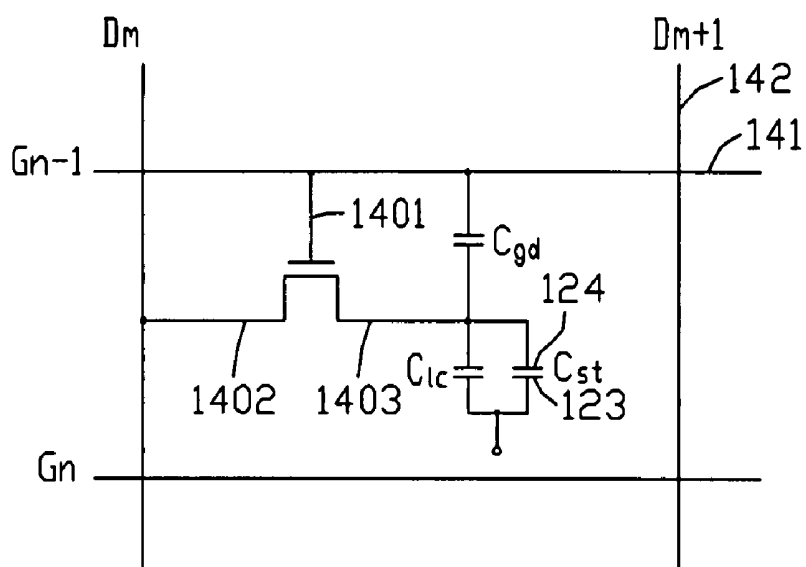


FIG. 7
(RELATED ART)

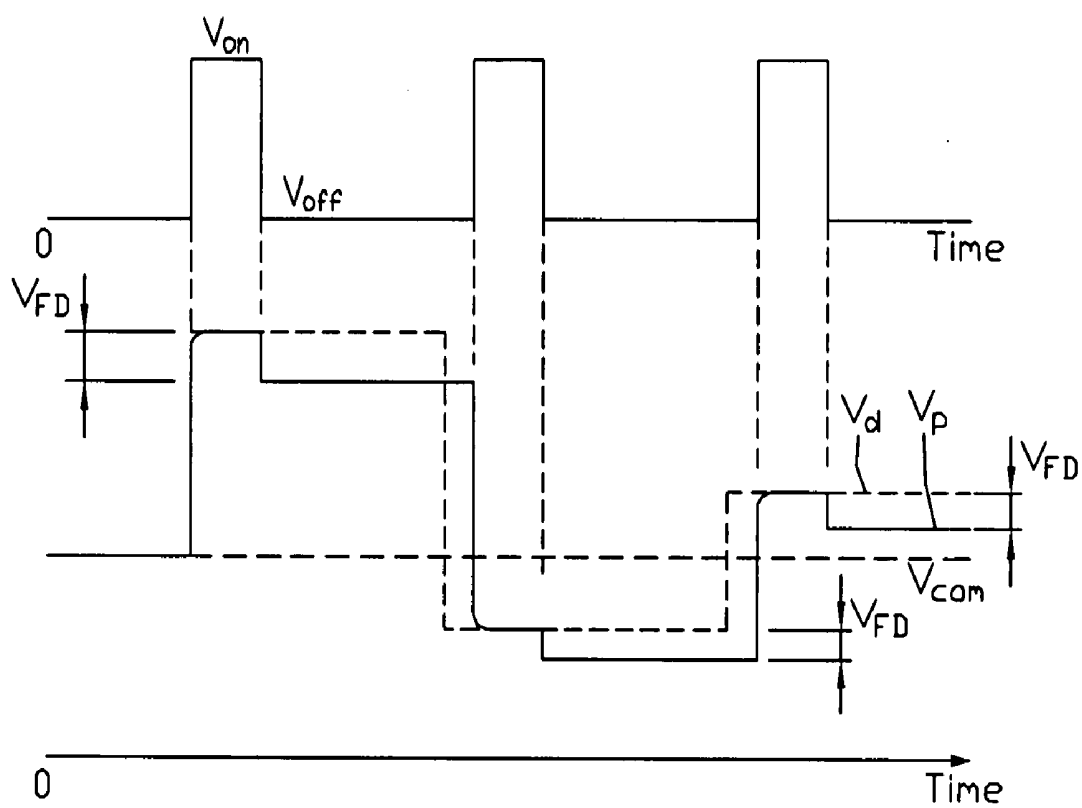


FIG. 8
(RELATED ART)

LIQUID CRYSTAL DISPLAY PANEL HAVING DIELECTRIC COMPENSATING LAYER

FIELD OF THE INVENTION

[0001] The present invention relates to a liquid crystal display (LCD) panel having at least one dielectric compensating layer which can compensate an altering voltage of a pixel capacitor.

GENERAL BACKGROUND

[0002] A typical LCD has the advantages of portability, low power consumption, and low radiation. LCDs have been widely used in various portable information products, such as notebooks, personal digital assistants (PDAs), video cameras and the like. Furthermore, the LCD is considered by many to have the potential to completely replace CRT (cathode ray tube) monitors and televisions.

[0003] Referring to FIG. 5 and FIG. 6, a typical LCD panel 1 includes a color filter (CF) substrate 110, a thin film transistor (TFT) substrate 120 opposite to the CF substrate 110, and a liquid crystal layer 130 sandwiched between the two substrates 110, 120. The LCD panel 1 further includes a gate driver (not shown) and a data driver (not shown) disposed on the TFT substrate 120.

[0004] The CF substrate 110 includes a first glass substrate 111, a common electrode layer 112 formed on the first glass substrate 111 generally facing toward the liquid crystal layer 130, and a first alignment film 113 formed on the common electrode layer 112.

[0005] The TFT substrate 120 includes a second glass substrate 121, a number of gate lines 141 and a number of common lines 123 formed on the second glass substrate 121, an insulating layer 122 formed on the second glass substrate 121 covering the gate lines 141 and the common lines 123, a number of data lines 142 formed on the insulating layer 122, and a number of thin film transistors (TFTs) 140 formed on the insulating layer 122. The gate lines 141 and the common lines 123 are parallel to each other and each extend along a first direction. The data lines 142 are parallel to each other and each extend along a second direction orthogonal to the first direction. The TFTs 140 are formed in the vicinity of intersections of the gate lines 141 and the data lines 142.

[0006] The TFT substrate 120 further includes a plurality of pixel electrodes 124 formed on the insulating layer 122, and a second alignment film 125 adjacent to the liquid crystal layer 130.

[0007] Each TFT 140 includes a gate electrode 1401 connected to the corresponding gate line 141, a source electrode 1402 connected to the corresponding data line 142, and a drain electrode 1403 connected to a corresponding one of the pixel electrodes 124.

[0008] FIG. 7 is an equivalent circuit diagram of one pixel unit of the LCD panel 1. Liquid crystal material sandwiched between the pixel electrode 124 and the common electrode layer 112 on the second glass substrate 121 define a liquid crystal capacitor C_{lc} . C_{gd} is a parasitic capacitor formed between the gate electrode 1401 and the drain electrode 1403 of the TFT 140. C_{st} is a storage capacitor formed between the pixel electrode 124 and the common line 123.

[0009] When the LCD panel 1 works, at each pixel unit, an electric field generated between the pixel electrode 124 and the common electrode layer 112 is applied to the liquid crystal material of the liquid crystal layer 130. Light from a light

source such as a backlight transmits through the TFT substrate 120, the liquid crystal layer 130, and the CF substrate 110. The amount of the light penetrating the LCD panel 1 at each pixel unit is adjusted by controlling the strength of the electric field, in order to obtain a desired optical output for the pixel unit.

[0010] If the electric field between the pixel electrode 124 and the common electrode 112 continues to be applied to the liquid crystal material in one direction, the liquid crystal material may deteriorate. Therefore, in order to avoid this problem, pixel voltages that are provided to the pixel electrode 124 are switched from a positive value to a negative value with respect to a common voltage. This technique is referred to as an inversion drive method.

[0011] FIG. 8 is an abbreviated timing chart illustrating operation of the LCD panel 1. In the chart, the x-axis denotes time, and the y-axis (not shown) denotes voltage. V_{on} denotes a gate-on voltage provided by the gate driver for switching on the TFT 140. V_{off} denotes a gate-off voltage provided by the gate driver for switching off the TFT 140. V_d denotes a number of gradation voltages provided by the data driver. V_p denotes a number of pixel voltages of the pixel electrode 124. V_{com} denotes a common voltage of the common electrode layer 112 and the common line 123 provided by an external circuit (not shown).

[0012] When a gate-on voltage V_{on} is provided to the gate electrode 1401 of the TFT 140 via the corresponding gate line 141, the TFT 140 connected to the gate line 141 turns on. At the same time, a gradation voltage V_d generated by the data driver is provided to the pixel electrode 124 via the data line 142 and the activated TFT 140 in series. The potentials of the common electrode layer 112 are set at a uniform potential V_{com} . Thus, an electric field is generated by the voltage difference between the pixel electrode 124 and the common electrode layer 112. The electric field is used to control the amount of light transmission of the corresponding pixel unit.

[0013] When a gate-off voltage V_{off} is provided to the gate electrode 1401 of the TFT 140 via the corresponding gate line 141, the TFT 140 turns off. The gradation voltage V_d applied to the liquid crystal capacitor C_{lc} while the TFT 140 was turned on should be maintained after the TFT 140 turns off. However, due to the parasitic capacitance C_{gd} between the gate electrode 1401 and the drain electrode 1403 of the TFT 140, the gradation voltage V_d applied to the pixel electrode 124 is distorted. This kind of voltage distortion is known as a feed-through voltage V_{FD} , and the feed-through voltage is obtained by the following formula (1):

$$V_{FD} = \frac{C_{gd}(V_{on} - V_{off})}{C_{gd} + C_{lc} + C_{st}} \quad (1)$$

[0014] The voltage distortion V_{FD} always tends to reduce the pixel voltage V_p regardless of the polarity of the data voltage, as shown in FIG. 8.

[0015] In an ideal LCD panel 1 as shown by a dashed line V_d in FIG. 8, when the gate-on voltage V_{on} is provided to turn on the TFT 140, the gradation voltage V_d is applied to the pixel electrode 124, and thereby, when the gate-off voltage V_{off} is provided to turn off the TFT 140, the applied gradation voltage V_d should be maintained as the pixel voltage. But in an actual LCD panel 1 as shown by a solid line V_p in FIG. 8, when the gate-off voltage V_{off} is provided to the TFT 140, the pixel voltage V_p is reduced by the feed-through voltage V_{FD} .

[0016] An actual value of the voltage supplied to the liquid crystal material is obtained from the area between the pixel voltage V_p line and the common voltage V_{com} line in FIG. 8. In one time frame, the pixel voltage V_p is greater than the common voltage V_{com} , and this area can be considered to be a 'positive' area. In an adjacent frame, the pixel voltage V_p is less than the common voltage V_{com} , and this area can be considered to be a 'negative' area. When the LCD panel 1 is driven by an inversion drive method, the level of the common voltage V_{com} must be adjusted to keep the positive area of the one frame equal to the negative area of the adjacent frame. Therefore, a common voltage V_{com} satisfying the above-mentioned condition needs to be supplied to the common electrode layer 112 in order to suppress the so-called flicker phenomena of a display screen of the LCD panel 1.

[0017] Generally, a dielectric constant of the liquid crystal material increases with increasing of the gradation voltage V_d provided to the liquid crystal layer 130. In other words, a capacitance of the liquid crystal capacitor C_{lc} of each pixel unit changes according to the gradation voltage V_d provided to the corresponding pixel electrode 124. Thus the feed-through voltage V_{FD} calculated according to formula (1) is changed with the gradation voltage V_d provided to the corresponding pixel electrode 124. Therefore a constant common voltage that can make the above-described positive and negative areas equal to each other is difficult to attain because of the changing of the feed-through voltage V_{FD} .

[0018] It is desired to provide an LCD which can overcome the above-described deficiencies.

SUMMARY

[0019] In one preferred embodiment, an LCD includes a first substrate, a second substrate, and a liquid crystal layer sandwiched between the two substrates. The LCD further includes a common electrode layer formed at an inner side of the first substrate; a dielectric compensating layer formed at an inner side of the common electrode layer; and a plurality of pixel electrodes formed at an inner side of the second substrate. The dielectric compensating layer is configured to compensate changes in the dielectric constant of the liquid crystal layer which occur according to gradation voltages provided to the liquid crystal layer.

[0020] Other novel features and advantages will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. 1 is a schematic, side cross-sectional view of part of an LCD panel according to an exemplary embodiment of the present invention, the LCD panel including a TFT substrate.

[0022] FIG. 2 is a top plan view of four adjacent pixel units of the TFT substrate of FIG. 1.

[0023] FIG. 3 is an equivalent circuit diagram of one pixel unit of the LCD panel of FIG. 1.

[0024] FIG. 4 is a timing chart illustrating operation of the LCD panel of FIG. 1.

[0025] FIG. 5 is a schematic, side cross-sectional view of part of a conventional LCD panel, the LCD panel including a TFT substrate.

[0026] FIG. 6 is a top plan view of four adjacent pixel units of the TFT substrate of FIG. 5.

[0027] FIG. 7 is an equivalent circuit diagram of one pixel unit of the LCD panel of FIG. 5.

[0028] FIG. 8 is a timing chart illustrating operation of the LCD panel of FIG. 5.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0029] Reference will now be made to the drawings to describe various embodiments of the present invention in detail.

[0030] Referring to FIG. 1 and FIG. 2, an LCD panel 2 according to an exemplary embodiment of the present invention includes a CF substrate 210, a TFT substrate 220 opposite to the CF substrate 210, and a liquid crystal layer 230 sandwiched between the two substrates 210, 220. The LCD panel 2 further includes a gate driver (not shown) and a data driver (not shown) disposed on the TFT substrate 220. The liquid crystal layer 230 can be made of twisted nematic liquid crystal molecules.

[0031] The CF substrate 210 includes a first glass substrate 211, a common electrode layer 212 formed on the first glass substrate 211 generally facing toward the liquid crystal layer 230, a first dielectric compensating layer 213 formed on the common electrode layer 212, and a first alignment film 214 formed on the first dielectric compensating layer 213.

[0032] The TFT substrate 220 includes a second glass substrate 221, a number of gate lines 241 and a number of common lines 223 formed on the second glass substrate 221, an insulating layer 222 formed on the second glass substrate 221 covering the gate lines 241 and the common lines 223, a number of data lines 242 formed on the insulating layer 222, and a number of thin film transistors (TFTs) 240 formed on the insulating layer 222. The gate lines 241 and the common lines 223 are parallel to each other and each extend along a first direction. The data lines 242 are parallel to each other and each extend along a second direction orthogonal to the first direction. The TFTs 240 are formed in the vicinity of intersections of the gate lines 241 and the data lines 242.

[0033] The TFT substrate 221 further includes a plurality of pixel electrodes 224 formed on the insulating layer 222, a second dielectric compensating layer 225 covering the TFTs 240 and the pixel electrodes 224, and a second alignment film 226 covering the second dielectric compensating layer 225. The first and second dielectric compensating layers 213, 225 can be made of dielectric material such as piezoelectric ceramic, ferroelectric ceramic, or ferroelectric polymer. Dielectric constants of the first and second dielectric compensating layers 213, 225 decrease with an increase in the gradation voltage V_d provided to the liquid crystal layer 230. A thickness of the first dielectric compensating layer 213 is approximately equal to a thickness of the second dielectric compensating layer 225.

[0034] Each TFT transistor 240 includes a gate electrode 2401 connected to the corresponding gate line 241, a source electrode 2402 connected to the corresponding data line 242, and a drain electrode 2403 connected to a corresponding one of the pixel electrodes 224.

[0035] FIG. 3 is an equivalent circuit diagram of one pixel unit of the LCD panel 2. Liquid crystal material of the liquid crystal layer 230, the first and second dielectric compensating layers 213, 225 sandwiched between the pixel electrode 224, and a common electrode layer 212 cooperatively define a first compensating capacitor C_{p1} , a liquid crystal capacitor C_{lc} , and a second compensating capacitor C_{p2} connected in series.

C_{gd} is a parasitic capacitor formed between the gate electrode **2401** and the drain electrode **2403** of the TFT **240**. C_{st} is a storage capacitor formed between the pixel electrode **224** and the common line **223**.

[0036] FIG. 4 is an abbreviated timing chart illustrating operation of the LCD panel **2**. In the chart, the x-axis denotes time, and the y-axis (not shown) denotes voltage. V_{on} denotes a gate-on voltage provided by the gate driver for switching on the TFT **240**. V_{off} denotes a gate-off voltage provided by the gate driver for switching off the TFT **240**. V_d denotes a number of gradation voltages provided by the data driver. V_p denotes a number of pixel voltages of the pixel electrode **224**. V_{com} denotes a common voltage of the common electrode layer **212** and the common line **223** provided by an external circuit (not shown).

[0037] When a gate-on voltage V_{on} is provided to the gate electrode **2401** of the TFT **240** via the corresponding gate line **241**, the TFT **240** connected to the gate line **241** turns on. At the same time, a gradation voltage V_d generated by the data driver is provided to the pixel electrode **224** via the corresponding data line **242** and the activated TFT **240** in series. The potential of the common electrode layer **212** is set at a uniform potential V_{com} . Thus, an electric field is generated by the voltage difference between the pixel electrode **224** and the common electrode layer **212**. The electric field is used to control the amount of light transmission of the corresponding pixel unit.

[0038] When a gate-off voltage V_{off} is provided to the gate electrode **2401** of the TFT **240** via the corresponding gate line **241**, the TFT **240** turns off. The gradation voltage V_d applied to the liquid crystal capacitor C_{lc} while the TFT **240** was turned on should be maintained after the TFT **240** turns off. However, due to the parasitic capacitance C_{gd} between the gate electrode **2401** and the drain electrode **2403** of the TFT **240**, the gradation voltage V_d applied to the pixel electrode **224** is distorted. This kind of voltage distortion is known as a feed-through voltage V_{FD} , and the feed-through voltage V_{FD} is obtained by following formula (2):

$$V_{FD} = \frac{C_{gd}(V_{on} - V_{off})}{C_{gd} + C'_{lc} + C_{st}} = \frac{C_{gd}(V_{on} - V_{off})}{\frac{1}{\frac{C_{gd}}{C_{lc} + C_{p1} + C_{p2}} + C_{st}}}. \quad (2)$$

[0039] In formula (2) above, C'_{lc} is a capacitance of a sum capacitor C'_{lc} between the pixel electrode **224** and a common electrode layer **212**. Because the dielectric constant of the liquid crystal material increases with an increase in the gradation voltage V_d provided to the liquid crystal layer **130**, the dielectric constants of the first and second dielectric compensating layers **213**, **225** decreases with the increase in the gradation voltage V_d provided to the liquid crystal layer **230**. Thus the capacitance of the sum capacitor C'_{lc} can be controlled to be a constant.

[0040] In other words, when a capacitance of the liquid crystal capacitor C_{lc} of each pixel increases according to an increase in the gradation voltage V_d , the capacitances of the first and second compensating capacitors C_{p1} , C_{p2} decreases according to the corresponding gradation voltage V_d . Thus the feed-through voltage V_{FD} calculated according to formula (2) is a constant. Therefore a constant common voltage can be obtained according to the constant feed-through voltage V_{FD} . When a constant common voltage is attained, this suppresses

or even eliminates the so-called flicker phenomenon of a display screen of the LCD panel **2**.

[0041] In an alternative embodiment, the first and second dielectric compensating layers **213**, **225** can be replaced by other voltage controlled variable capacitors. In another alternative embodiment, one of the first and second dielectric compensating layers **213**, **225** can be omitted.

[0042] It is to be further understood that even though numerous characteristics and advantages of preferred and exemplary embodiments have been set out in the foregoing description, together with details of the structures and functions of the embodiments, the disclosure is illustrative only; and that changes may be made in detail, especially in matters of arrangement of parts within the principles of the present invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A liquid crystal display (LCD) comprising:

- a first substrate, a second substrate, and a liquid crystal layer sandwiched between the two substrates;
 - a common electrode layer formed at an inner side of the first substrate;
 - a plurality of pixel electrodes formed at an inner side of the second substrate; and
 - a dielectric compensating layer formed at an inner side of the common electrode layer or formed at an inner side of pixel electrodes;
- wherein the dielectric compensating layer is configured to compensate changes in the dielectric constant of the liquid crystal layer which occur according to gradation voltages provided to the liquid crystal layer.

2. The LCD as claimed in claim 1, wherein the dielectric compensating layer is made of piezoelectric ceramic.

3. The LCD as claimed in claim 1, wherein the dielectric compensating layer is made of ferroelectric ceramic.

4. The LCD as claimed in claim 1, wherein the dielectric compensating layer is made of ferroelectric ceramic.

5. The LCD as claimed in claim 1, wherein further comprising a first alignment film and a second alignment film respective formed on the first substrate and the second substrate opposite to the liquid crystal layer.

6. A liquid crystal display (LCD) comprising:

- a first substrate, a second substrate, and a liquid crystal layer sandwiched between the two substrates;
- a common electrode layer formed at an inner side of the first substrate;
- a first dielectric compensating layer formed at an inner side of the common electrode layer;
- a plurality of pixel electrodes formed at an inner side of the second substrate; and
- a second dielectric compensating layer formed at inner sides of the pixel electrodes;

wherein the first and second dielectric compensating layers are configured to compensate changes in the dielectric constant of the liquid crystal layer which occur according to gradation voltages provided to the liquid crystal layer.

7. The LCD as claimed in claim 6, wherein further comprising a first alignment film and a second alignment film respective formed on the first substrate and the second substrate opposite to the liquid crystal layer.

8. The LCD as claimed in claim 6, wherein the liquid crystal layer is made of twisted nematic liquid crystal molecular.

9. The LCD as claimed in claim 6, wherein a thickness of the first dielectric compensating layer and the second dielectric compensating layer are approximately equal to each other.

10. The LCD as claimed in claim 6, wherein further comprising a plurality of common electrode and an insulating layer form between the the second substrate and the pixel electrode, the pixel electrode, the common electrode, and the insulating layer sandwiched between the the pixel electrode and the common electrode defining a plurality of storage capacitors.

11. A liquid crystal display (LCD) comprising:

a first substrate, a second substrate, and a liquid crystal layer between the two substrates, the liquid crystal layer comprising liquid crystal material;

a common electrode layer formed at an inner side of the first substrate;

a plurality of pixel electrodes formed at an inner side of the second substrate, wherein each of the pixel electrodes, a portion of the common electrode layer corresponding to the pixel electrode, and liquid crystal material sandwiched between the pixel electrode and said portion of the common electrode layer cooperatively define a liquid crystal capacitor; and

a first dielectric compensating layer provided at an inner side of the first substrates, wherein the pixel electrodes, the common electrodes, and the first dielectric compensating layer define a plurality of first compensating capacitors, each first compensating capacitors connected in series to the liquid crystal capacitor for compensating a capacitance change of the liquid crystal capacitor according to gradation voltages between the pixel electrode and the common electrode.

12. The LCD as claimed in claim 11, wherein a capacitance of the first compensating capacitor decreases with increasing of the gradation voltages between the pixel electrode and the common electrode.

13. The LCD as claimed in claim 12, wherein the first dielectric compensating layer is formed at an inner side of the common electrode.

14. The LCD as claimed in claim 13, wherein further comprising a second dielectric compensating layer provided at an inner side of the second substrates, wherein the pixel electrodes, the common electrodes, and the second dielectric compensating layer define a plurality of second compensating capacitors, each the second compensating capacitor connected in series to the liquid crystal capacitor for compensating the capacitance change of the liquid crystal capacitor according to gradation voltages between the pixel electrode and the common electrode.

15. The LCD as claimed in claim 14, wherein a capacitance of the second compensating capacitor decreases with increasing of the gradation voltages between the pixel electrode and the common electrode.

16. The LCD as claimed in claim 15, wherein the second dielectric compensating layer is formed at an inner side of the pixel electrodes.

17. The LCD as claimed in claim 11, wherein the first dielectric compensating layer is made of piezoelectric ceramic.

18. The LCD as claimed in claim 11, wherein the first dielectric compensating layer is made of ferroelectric ceramic.

19. The LCD as claimed in claim 11, wherein the first dielectric compensating layer is made of ferroelectric ceramic.

* * * * *

专利名称(译)	具有介电补偿层的液晶显示板		
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IPC分类号	G02F1/1333		
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优先权	095144724 2006-12-01 TW		
其他公开文献	US7880841		
外部链接	Espacenet USPTO		

摘要(译)

示例性液晶显示器 (LCD) (1) 包括第一基板 (211) , 第二基板 (221) 和夹在两个基板之间的液晶层 (230) 。 LCD还包括形成在内侧的公共电极层 (212) ;介电补偿层 (213) 形成在公共电极层内侧的内侧;多个像素电极 (224) 形成在第二基板的内侧。介电补偿层被配置为补偿根据提供给液晶层的灰度电压而发生的液晶层的介电常数的变化。

