US 20140168561A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2014/0168561 A1

(43) Pub. Date: Jun. 19, 2014

CHANG et al.

(54) VERTICAL ALIGNMENT LIQUID CRYSTAL DISPLAY DEVICE AND METHOD FOR DRIVING SAME

(71) Applicant: **InnoLux Corporation**, Miao-Li County (TW)

(72) Inventors: **Yueh-Ping CHANG**, Miao-Li County (TW); **Chao-Yi HUNG**, Miao-Li County (TW)

(73) Assignee: **InnoLux Corporation**, Miao-Li County (TW)

(21) Appl. No.: **14/185,342**

(22) Filed: **Feb. 20, 2014**

Related U.S. Application Data

(63) Continuation of application No. 12/454,450, filed on May 18, 2009, now Pat. No. 8,692,752.

(30) **Foreign Application Priority Data**

May 16, 2008 (CN) 200810067271.3

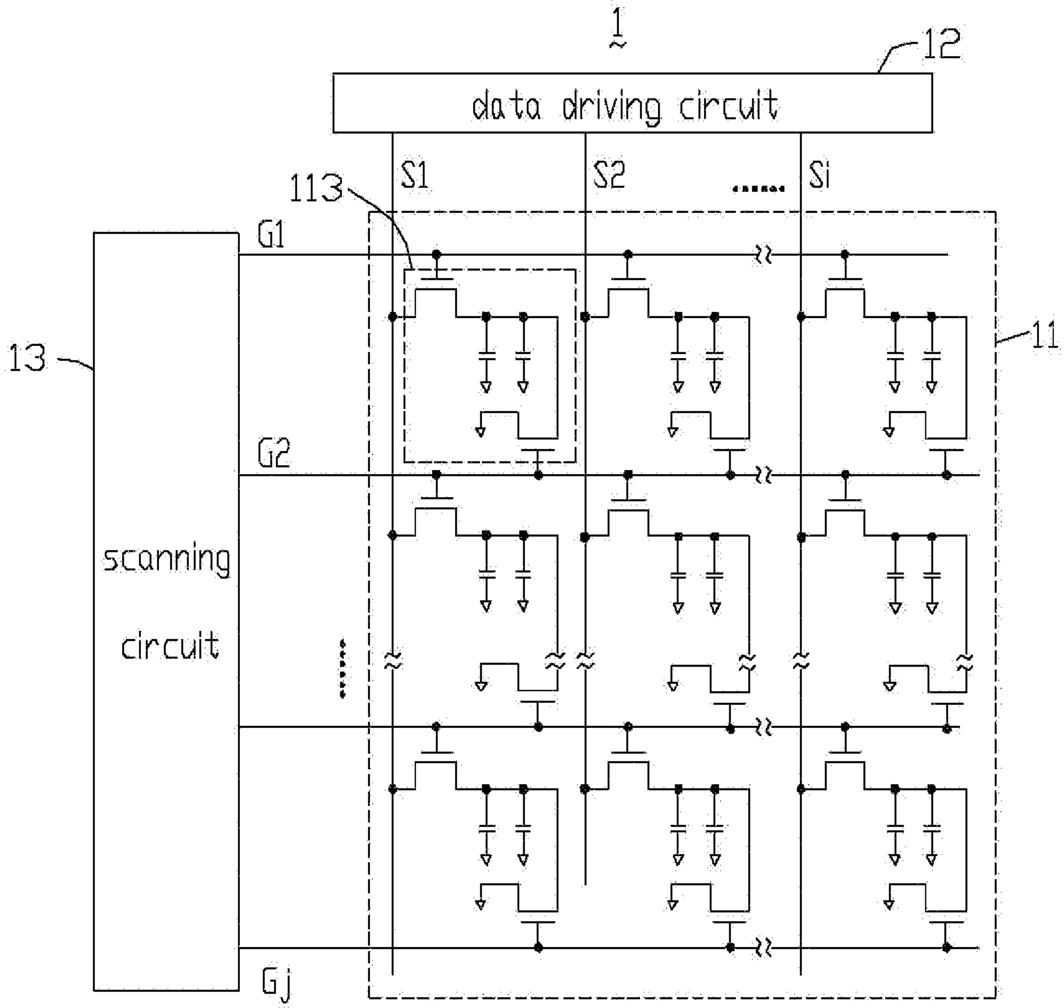
Publication Classification

(51) **Int. Cl.**
G02F 1/1362 (2006.01)

(52) **U.S. Cl.**
CPC *G02F 1/136286* (2013.01)
USPC **349/43**

(57) **ABSTRACT**

A vertical alignment liquid crystal display device (VA-LCD) includes a display panel. The display panel includes a plurality of pixels. Each pixel unit includes a first thin film transistor (TFT), a second TFT, and a liquid crystal capacitor having a pixel electrode and a common electrode. The common electrode is applied with a common voltage, a first gray voltage is applied to the pixel electrode through a first TFT, and a second gray voltage is applied to the pixel electrode through a second TFT different from the first gray voltage, such that liquid crystal capacitor maintains two different gray voltages in a display frame time of the VA-LCD.



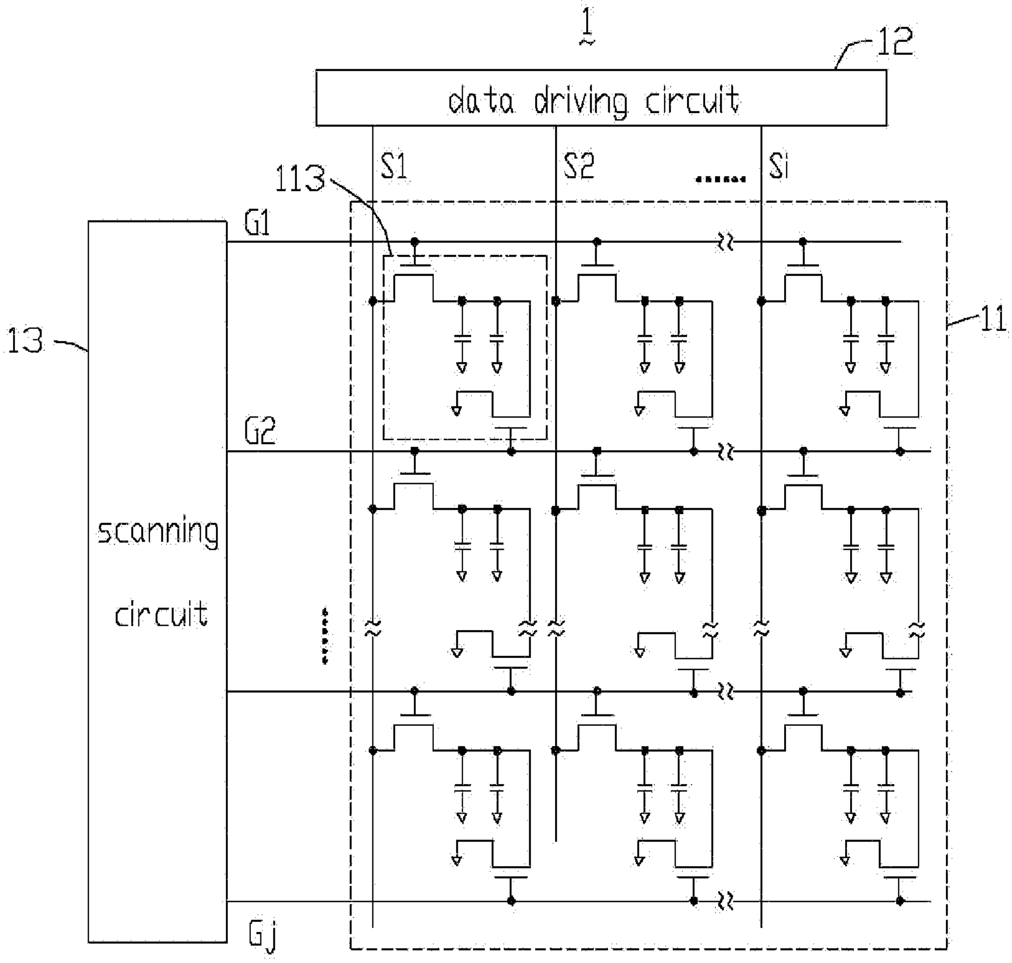

1
12
data driving circuit
S1
S2
Si
113
G1
13
11
G2
scanning
circuit
Gj

FIG. 1

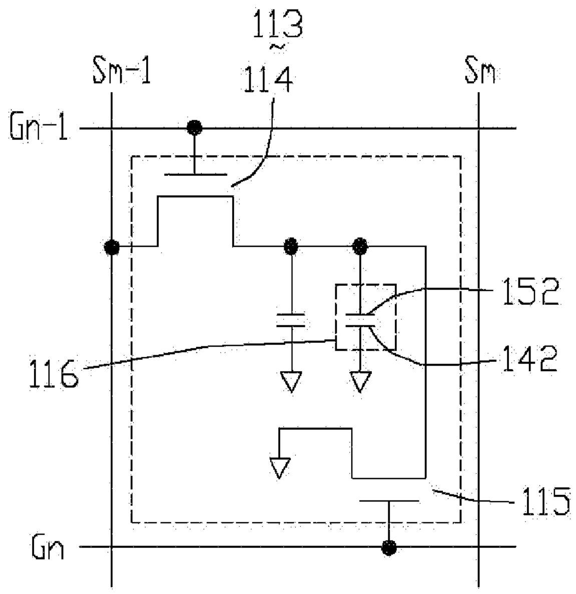

113
114
Sm-1
Sm
Gn-1
152
116
142
115
Gn

FIG. 2

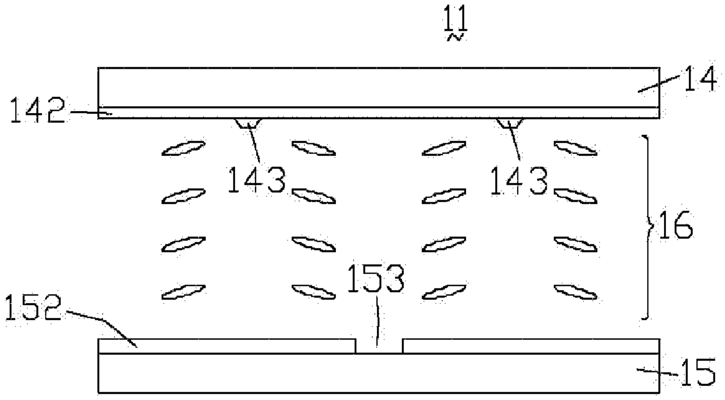


FIG. 3

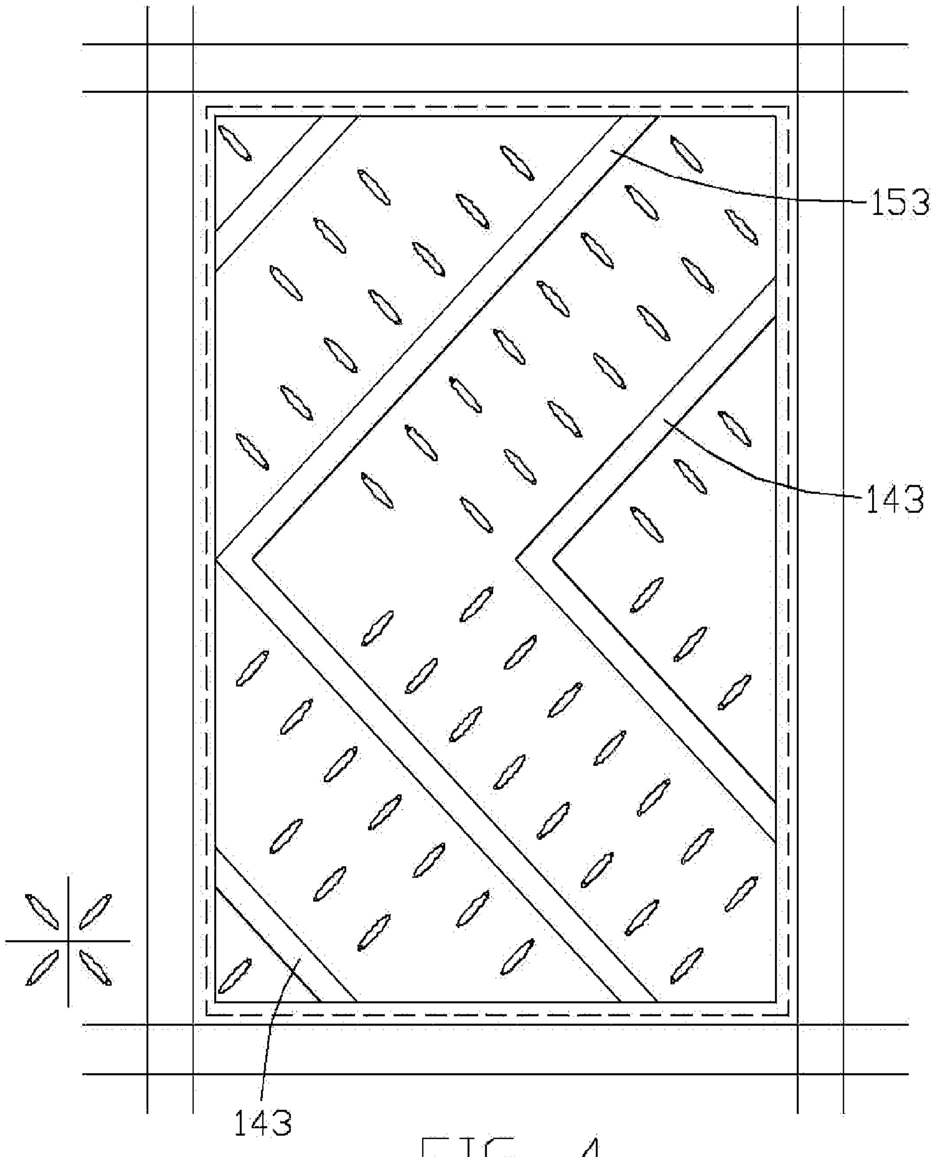


FIG. 4

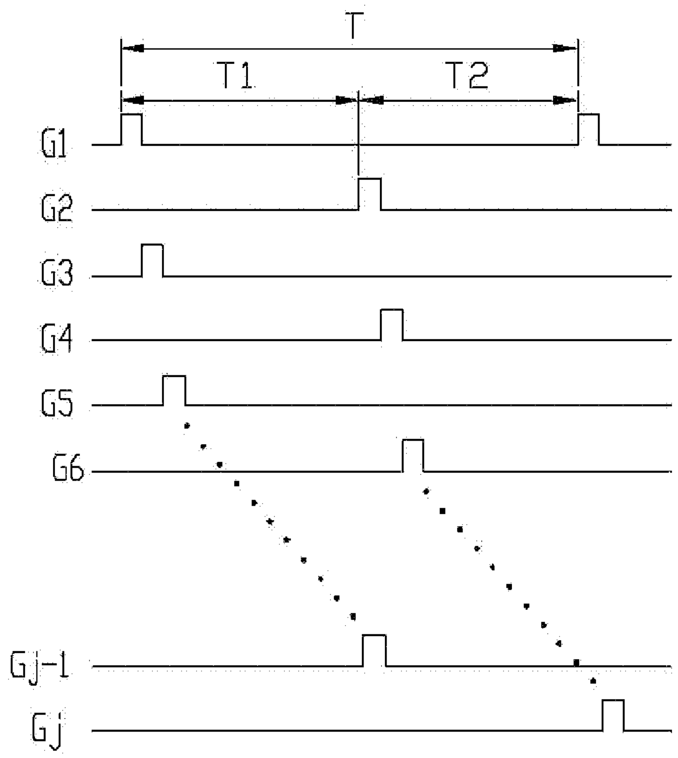


FIG. 5

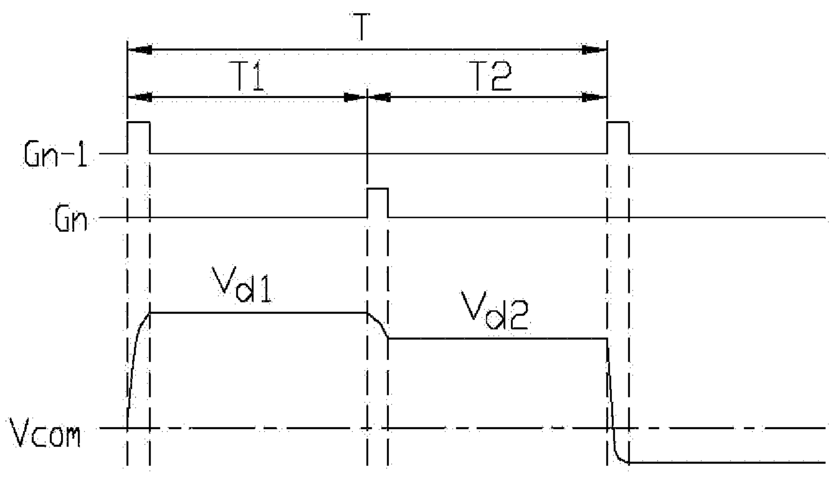


FIG. 6

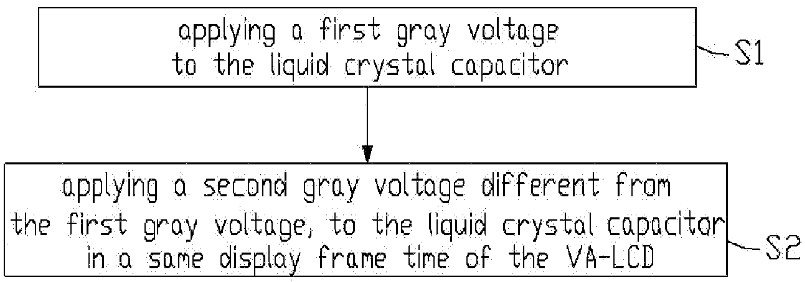

applying a first gray voltage to the liquid crystal capacitor
S1
applying a second gray voltage different from the first gray voltage, to the liquid crystal capacitor in a same display frame time of the VA-LCD
S2

FIG. 7

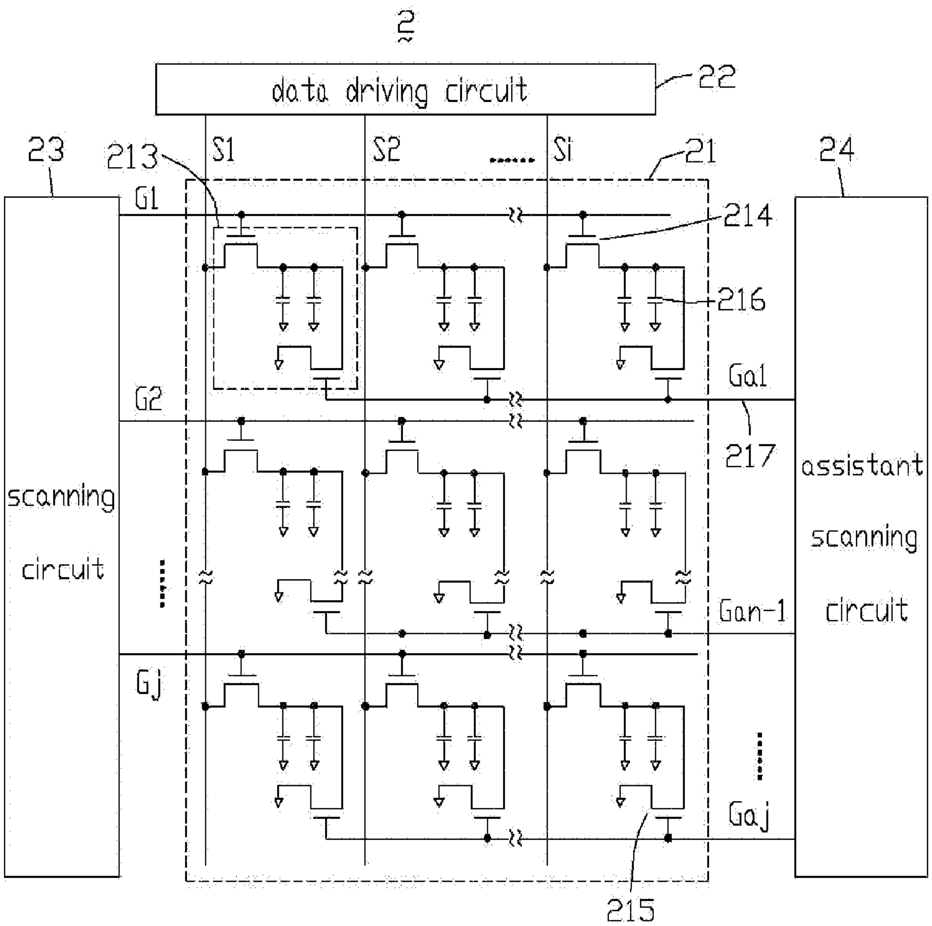

2
data driving circuit
22
23
213
S1
S2
Si
21
24
G1
214
216
Ga1
G2
217
scanning
circuit
assistant
scanning
circuit
Gan-1
Gj
Gaj
215

FIG. 8

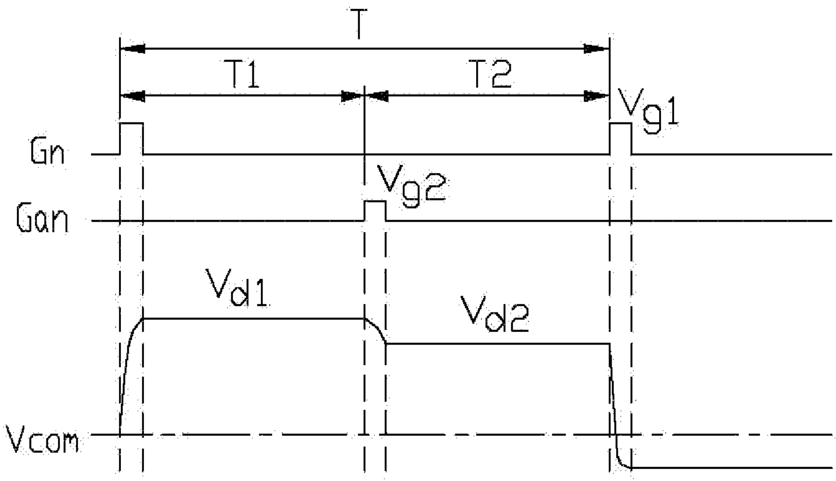


FIG. 9

VERTICAL ALIGNMENT LIQUID CRYSTAL DISPLAY DEVICE AND METHOD FOR DRIVING SAME

CROSS REFERENCES TO THE RELATED APPLICATIONS

[0001] This is a continuation application of U.S. application Ser. No. 12/454,450, filed on May 18, 2009, which claims priority to Chinese Application No. 200810067271.3, filed on May 16, 2008, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present disclosure relates to a liquid crystal display device, and more particularly to a vertical alignment liquid crystal display (VA-LCD) device and a method for driving the VA-LCD device.

[0004] 2. Description of Related Art

[0005] Since liquid crystal molecules in a liquid crystal display device emit no light themselves, illumination by a light source is necessary to display clear and sharp text and images. By controlling the torsion of liquid crystal molecules in the liquid crystal display device with gray voltages, the liquid crystal display device can control the transmission of light beams emitted from a light source, so that the liquid crystal display device can display images.

[0006] Twist-nematic type liquid crystal display (TN-LCD) devices, while commonly used, are limited by a correspondingly narrow viewing angle, such that different colors are viewed from different angles. To overcome the problem, a multi-domain vertical alignment liquid crystal display (MVA-LCD) device and a patterned vertically aligned liquid crystal display (PVA-LCD) device have been developed. By disposing a plurality of "<" shaped protrusions or grooves on the inner surfaces of substrates, each pixel of the MVA-LCD device or PVA-LCD device is divided into a plurality of domains. The liquid crystal molecules of each domain are aligned at different angles, so as to widen the viewing angle of the LCD device.

[0007] However, a long optical axis of the liquid crystal molecule has a refractive index different from that of a short optical axis of the liquid crystal molecule, generating color shift when viewed from different angles, thus the MVA-LCD device still has limited display quality.

[0008] What is needed, is a liquid crystal display device that can overcome the described limitations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present VA-LCD device and a method for driving the VA-LCD device. In the drawings, like reference numerals designate corresponding parts throughout various views, and all the views are schematic.

[0010] FIG. **1** is a schematic circuit diagram of a first embodiment of a VA-LCD device according to the present disclosure, the VA-LCD including a plurality of pixels.

[0011] FIG. **2** is an enlarged view of a pixel of the VA-LCD device of FIG. **1**.

[0012] FIG. **3** is a schematic side view of a pixel of a display panel of the VA-LCD device of FIG. **1**.

[0013] FIG. **4** is a schematic plan view of the pixel of the display panel of the VA-LCD device of FIG. **3**.

[0014] FIG. **5** is a waveform graph of scanning signals of the VA-LCD device of FIG. **1**.

[0015] FIG. **6** is a waveform graph of driving signals of the VA-LCD device of FIG. **1**.

[0016] FIG. **7** is a flowchart of an exemplary method for driving the VA-LCD device of FIG. **1**.

[0017] FIG. **8** is a schematic circuit of a second embodiment of a VA-LCD device according to the present disclosure.

[0018] FIG. **9** is a waveform graph of driving signals of the VA-LCD device of FIG. **8**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] Reference will now be made to the drawings to describe exemplary embodiments of the present disclosure in detail.

[0020] FIG. **1** is a schematic circuit diagram of a first embodiment of a VA-LCD device **1** according to the present disclosure. The VA-LCD device **1** includes a display panel **11**, a data driving circuit **12**, and a scanning circuit **13**.

[0021] The display panel **11** includes a plurality of parallel scan lines G**1**~Gj, and a plurality of data lines S**1**~Si parallel to each other and orthogonal to the scan lines G**1**~Gj. The scan lines G**1**~Gj and the data lines S**1**~Si cooperatively define a plurality of pixels **113**.

[0022] FIG. **2** is an enlarged view of a pixel **113** of the VA-LCD device **1** of FIG. **1**. The data line Sm−1 and the data line Sm together with the scan line Gn−1 and the scan line Gn define the m×n'th pixel **113**, m and n represent any natural number, 1≤m≤i, 1≤n<j, and so the m×n'th pixel **113** represents any pixel **113** of the VA-LCD device **1**.

[0023] The m×n'th pixel **113** includes a first thin film transistor (TFT) **114**, a pixel electrode **152**, a common electrode **142** opposite to the pixel electrode **152** and a second TFT **115**. The common electrode **142** is electrically connected to a common voltage Vcom. A drain of the first TFT **114** is electrically connected to the pixel electrode **152**, a source thereof is electrically connected to the data line Sm−1, and a gate thereof is electrically connected to the scan line Gn−1. A drain of the second TFT **115** is electrically connected to the pixel electrode **152**, a source thereof is electrically connected to the common voltage Vcom, and a gate thereof is electrically connected to the scan line Gn. The pixel electrode **152** together with the common electrode **142** forms a liquid crystal capacitor **116** maintaining gray voltages.

[0024] The electrical characteristic of the second TFT **115** is different from that of the first TFT **114**. A switch-on resistance of the second TFT **115** is greater than that of the first TFT **114**, While the same gate voltage is applied to the gates of the first TFT **114** and the second TFT **115**, and the same voltage is applied to the drains and the sources of the first TFT **114** and the second TFT **115**, current through the first TFT **114** is greater than that through the second TFT **115**.

[0025] FIG. **3** shows a schematic side view of a pixel **113** of the display panel **11** of the VA-LCD device **1** of FIG. **1**. FIG. **4** shows a schematic plan view of the pixel **113**. The display panel **11** further includes a first substrate **14**, a second substrate **15**, and a liquid crystal layer **16** disposed between the first substrate **14** and the second substrate **15**. The common electrode **142** is disposed on a surface of the first substrate **14** that faces the liquid crystal layer **16**. A plurality of "<" shaped protrusions **143** are disposed on a surface of the common electrode **142** that faces the liquid crystal layer **16**. The pixel electrode **152** is disposed on a surface of the second substrate **15** that faces the liquid crystal layer **16**. A plurality of "<" shaped grooves **153** are formed in the pixel electrode **152**. Each "<" shaped groove **153** is disposed between two "<" shaped protrusions **143**, and each "<" shaped protrusion **143** is disposed between two "<" shaped grooves **153**.

[0026] FIG. **5** is a waveform graph of scanning signals of the VA-LCD device **1** of FIG. **1**. An interlacing scanning method is employed in the VA-LCD device **1**. In detail, one display frame time T of the VA-LCD device **1** is divided into two sequential substantially equal sub-display frame times T1, T2. In sub-display frame time T1, the scanning circuit **13** sends scanning signals to the odd row scanning lines G1~Gj−1 one after another; and in sub-display frame time T2, the scanning circuitl **3** sends scanning signals to the even row scan lines G2~Gj one after another. Thus, for the m×n'th pixel **113**, in the display frame time 'T', the time between the scanning circuit **13** sending a scanning signal to the scan line Gn−1 and sending a scanning signal to the scan line Gn is substantially half a display frame time T.

[0027] FIG. **6** is a waveform graph of driving signals of the VA-LCD device **1** of FIG. **1**. FIG. **7** is a flow chart of an exemplary method for driving the VA-LCD device **1**, The method for driving the VA-LCD device **1** is described as below.

[0028] In step S1, for the m×n'th pixel **113**, the scanning circuit **13** sends a scanning signal to the scan line Gn−1. The scanning signal drives the first TFT **114** to be switched on. Then the data driving circuit **12** outputs a first gray voltage Vd1. The first gray voltage Vd1 charges the liquid crystal capacitor **116** through the data line Sm and the first TFT **114**. As the first TFT **114** is switched off, the liquid crystal capacitor **116** maintains the first gray voltage Vd1. Driven by the first gray voltage Vd1, the electric field formed between the pixel electrode **152** and the common electrode **142** inclines to four different orientations because of the "<" shaped protrusions **143** and grooves **153** disposed in the pixel **113** and one protrusion **143** being disposed between every two grooves **153**. The declining electric field make liquid crystal molecules of the m×n'th pixel **113** align to four different orientations. A four-domain display is achieved.

[0029] In step S2, half a display frame time T After the scanning circuit **13** sending a scanning signal to the scan line Gn−1, the scanning circuit **13** sends a scanning signal to the scan line Gn. When the scanning signal switches the second TFT **115** on, the liquid crystal capacitor **116** discharges through the second TFT **115**. As the switch-on resistance of the second TFT **115** is greater than that of the first TFT **114**, when the second TFT **115** is switched on by the scanning signal, the liquid crystal capacitor **116** discharges incompletely. As the second TFT **115** is switched off, the liquid crystal capacitor **116** maintains a second gray voltage Vd2 lower than the first gray voltage Vd1. Thus, another four-domain display is achieved. Therefore, in the display frame time T of the VA-LCD device, the m×n'th pixel **113** achieves an eight-domain display.

[0030] In summary, for each pixel **113** of the VA-LCD device **1**, in the sub-display frame time T1, the liquid crystal capacitor **116** maintains the first gray voltage Vd1, and in the sub-display frame time T2, the liquid crystal capacitor **116** maintains the second gray voltage Vd2. Then, the four-domain VA-LCD device **1** achieves an eight-domain display. Therefore, the VA-LCD device **1** reduces color shift, and achieves a higher display quality.

[0031] FIG. **8** is a schematic circuit diagram of a VA-LCD device according to a second embodiment of the present disclosure, differing from the VA-LCD device **1** of the first embodiment in the further inclusion of an assistant scanning circuit **24**. The display panel **21** further includes a plurality of assistant scan lines Ga**1**~Gaj electrically connected to the assistant scanning circuit **24**. The electrical characteristic of the first TFT **214** and the second TFT **215** are the same. In each pixel **213**, a gate of the second TFT **215** is electrically connected to a corresponding assistant scan line Gan.

[0032] FIG. **9** is a waveform graph of driving signals of the VA-LCD device **2** of FIG. **8**. In operation of the VA-LCD device **2**, in a display frame time T of the VA-LCD device, the scanning circuit **23** sends a first scanning signal Vg**1** to the scan line On, and switches the first TFT **214** on. The liquid crystal capacitor **216** maintains a first gray voltage Vd1. After half a display frame time T, the assistant scanning circuit **24** sends a second scanning signal Vg**2** lower than the first scanning signal Vg**1** to the corresponding assistant scan line Gan. The second scanning signal Vg**2** switches the second TFT **215** on, and the liquid crystal capacitor **216** discharges through the second TFT **215**. Since the second scanning signal Vg**2** is lower than the first scanning signal Vg**1**, the liquid crystal capacitor **216** maintains a second gray voltage Vd2 different from the first gray voltage Vd1.

[0033] In summary, the four-domain VA-LCD device **2** can achieve an eight-domain display, such that the VA-LCD device **2** can reduce color shift and improve display quality. The electrical characteristics of the first TFT **214** and the second TFT **215** are the same, making the VA-LCD device **2** easier to fabricate.

[0034] Alternatively, the VA-LCD device **1**, **2** can be any PVA-LCD device, or any MVA-LCD device. A threefold or fourfold interlacing scanning method can also be applied in the VA-LCD device **1**. In the VA-LCD device **2**, the assistant scanning circuit **24** can also send a scanning signal having ⅓ display frame time delay to that sent by the scanning circuit **23**. The time between the assistant scanning circuit **24** sending a scanning signal and that sent by the scanning circuit **23** can be between about ¼ display frame time to about ¾ display frame time

[0035] 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 within the principles of the present disclosure 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 vertical alignment liquid crystal display (VA-LCD) device, comprising:

a display panel comprising a plurality of pixels, a plurality of data lines, and a plurality of scan lines intersecting the plurality of data lines, the plurality of scan lines and the plurality of data lines defining the plurality of pixels, a first pixel of the plurality of pixels comprising a first thin film transistor (TFT), a second TFT, and a liquid crystal capacitor having a pixel electrode and a common electrode, the first TFT and the second TFT being directly connected to the same liquid crystal capacitor, wherein in the first pixel, the common electrode is electrically connected to a source of the second TFT, a drain of the second TFT is electrically connected to the pixel electrode directly, a source of the first TFT is electrically connected to the first data line, a drain of the first TFT is electrically connected to the pixel electrode directly, and a switch-on resistance of the second TFT is greater than that of the first TFT, as the switch-on resistance of the second TFT is greater than that of the first TFT and an absolute value of second gray voltage is lower than that of the first gray voltage,

wherein in a display frame time of the VA-LCD, the common electrode is applied with a common voltage, and the pixel electrode is applied with a first gray voltage and a second gray voltage, the first gray voltage being different from the second gray voltage.

2. The VA-LCD device of claim **1**, wherein a gate of the first TFT and a gate of the second TFT are electrically connected to the scan lines.

3. The VA-LCD device of claim **2**, wherein a same gate voltage is applied to the gate of the first TFT and the gate of the second TFT, and a same voltage is applied to the drain and the source of the first TFT and the drain and the source of the second TFT, a current through the first TFT is greater than that through the second TFT.

4. The VA-LCD device of claim **1**, wherein a plurality of grooves are formed in the pixel electrode and the liquid crystal molecules are aligned to different orientations.

5. The VA-LCD device of claim **4**, wherein the liquid crystal molecules are aligned to four different orientations.

6. The VA-LCD device of claim **1**, wherein the VA-LCD device is a multi-domain vertical alignment liquid crystal display device.

7. The VA-LCD device of claim **1**, wherein the VA-LCD device is a patterned vertically aligned liquid crystal display device.

8. A vertical alignment liquid crystal display (VA-LCD) device, comprising: a plurality of parallel scan lines, a plurality of data lines parallel to each other and orthogonal to the scan lines, and a plurality of pixels cooperatively defined by the plurality of scan lines and the plurality of data lines, a first pixel of the plurality of pixels comprising a first thin film transistor (TFT), a second TFT, and a liquid crystal capacitor having a pixel electrode and a common electrode, a source electrode of the first TFT being connected to a first data line of the plurality of data lines, a drain electrode of the first TFT being connected to the pixel electrode, a source electrode of the second TFT being connected to the common electrode, a drain electrode of the second TFT being connected to the pixel electrode, the first TFT and the second TFT being directly connected to the same liquid crystal capacitor, a switch-on resistance of the second TFT being greater than a switch-on resistance of the first TFT, as the switch-on resistance of the second TFT is greater than that of the first TFT and an absolute value of second gray voltage is lower than that of the first gray voltage,

wherein in a first period of a display frame time of the VA-LCD, the common electrode is applied with a common voltage, and the first data line applies a first gray voltage to the pixel electrode via the first TFT, and in a second period of the display frame time of the VA-LCD, the common electrode is applied with the common voltage such that the liquid crystal capacitor maintains a second gray voltage through the second TFT different from the first gray voltage in the second period.

9. The VA-LCD device of claim **8**, wherein a gate of the first TFT and a gate of the second TFT are electrically connected to the scan lines.

10. The VA-LCD device of claim **8**, wherein a same gate voltage is applied to the gate of the first TFT and the gate of the second TFT, and a same voltage is applied to the drain and the source of the first TFT and the drain and the source of the second TFT, a current through the first TFT being greater than that through the second TFT.

11. The VA-LCD device of claim **8**, wherein a plurality of grooves are formed in the pixel electrode and the liquid crystal molecules are aligned to different orientations.

12. The VA-LCD device of claim **11**, wherein the liquid crystal molecules are aligned to four different orientations.

13. The VA-LCD device of claim **8**, wherein the VA-LCD device is a multi-domain vertical alignment liquid crystal display device.

14. The VA-LCD device of claim **8**, wherein the VA-LCD device is a patterned vertically aligned liquid crystal display device.

* * * * *

专利名称(译)	垂直取向液晶显示装置及其驱动方法		
公开(公告)号	[US20140168561A1](US20140168561A1)	公开(公告)日	2014-06-19
申请号	US14/185342	申请日	2014-02-20
[标]申请(专利权)人(译)	群创光电股份有限公司		
申请(专利权)人(译)	群创光电		
当前申请(专利权)人(译)	群创光电		
[标]发明人	CHANG YUEH PING HUNG CHAO YI		
发明人	CHANG, YUEH-PING HUNG, CHAO-YI		
IPC分类号	G02F1/1362		
CPC分类号	G02F1/134309 G02F1/133707 G02F1/136213 G02F1/13624 G02F1/136286 G02F1/1368 G02F2203/30 G09G3/2025 G09G3/3659 G09G2300/0426 G09G2300/0447 G09G2300/0842 G09G2310/0224 G09G2310/0251 G09G2320/028		
优先权	200810067271.3 2008-05-16 CN		
其他公开文献	US9217898		
外部链接	Espacenet USPTO		

摘要(译)

垂直配向液晶显示装置（VA-LCD）包括显示面板。显示面板包括多个像素。每个像素单元包括第一薄膜晶体管（TFT），第二TFT和具有像素电极和公共电极的液晶电容器。公共电极施加有公共电压，第一灰度电压通过第一TFT施加到像素电极，第二灰度电压通过不同于第一灰度电压的第二TFT施加到像素电极，使得液体晶体电容器在VA-LCD的显示帧时间内保持两种不同的灰度电压。