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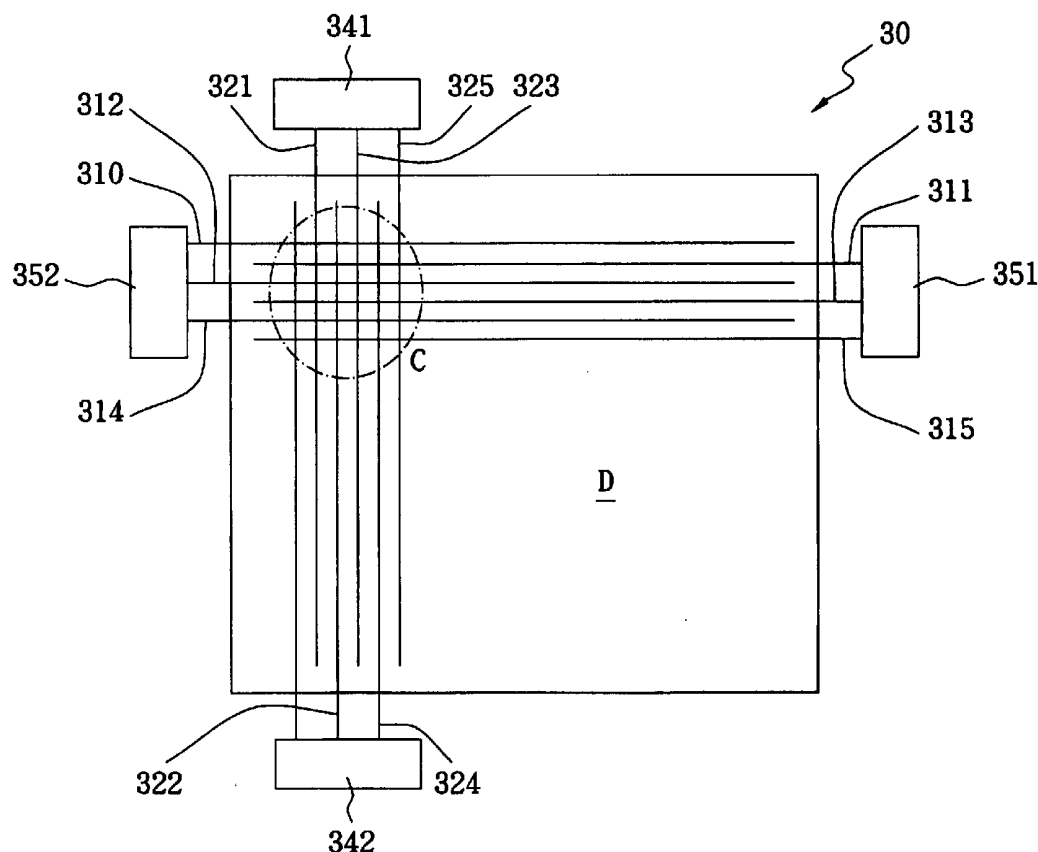
(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0052382 A1**
Lin et al. (43) **Pub. Date: Mar. 10, 2005**(54) **DISPLAY DEVICE AND DRIVING METHOD THEREOF****Publication Classification**(76) Inventors: **Ming-Tien Lin**, Lujou City (TW);
Yi-Lun Chou, Taipei City (TW);
Tea-Sen Jen, Pingjhen City (TW)(51) **Int. Cl.⁷** **G09G 3/36**(52) **U.S. Cl.** **345/87**(57) **ABSTRACT**

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A liquid crystal display is suitable for displaying images with rapid motions, and comprises an active matrix substrate equipped with a plurality of thin film transistors. The active matrix substrate comprises a plurality of pixels that are placed at the encircled areas of a plurality of scanning lines and a plurality of data lines. Each pixel consists of two thin film transistors and one pixel electrode. The data lines connected electrodes of the thin film transistors are connected to two adjoining data lines respectively, whereas the pixel connected electrodes of the two thin film transistors are together connected to the pixel electrode. The gate electrodes of the two thin film transistors are connected to two adjoining scanning lines respectively.

(21) Appl. No.: **10/838,496**(22) Filed: **May 3, 2004**(30) **Foreign Application Priority Data**

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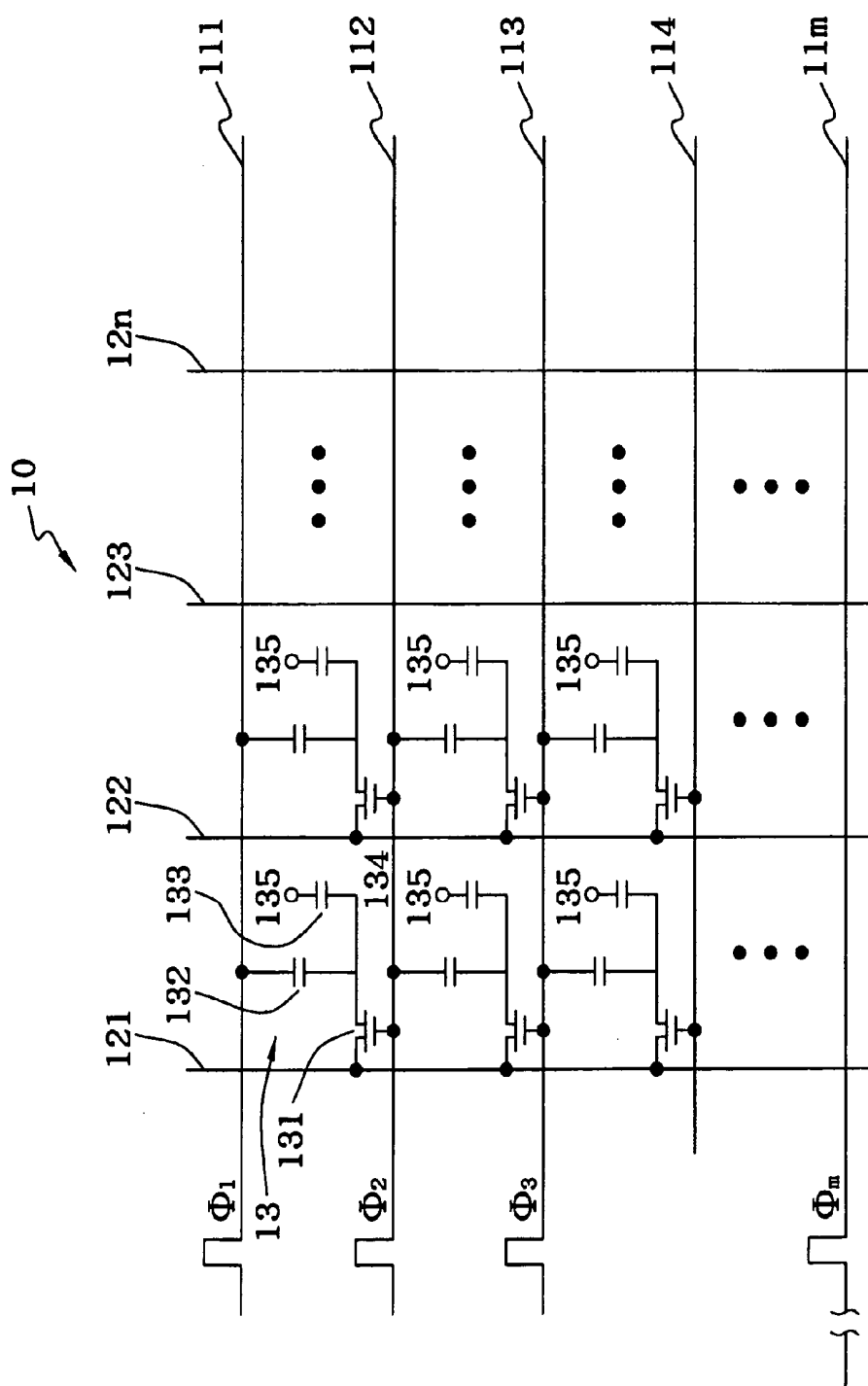


FIG. 1 (Background Art)

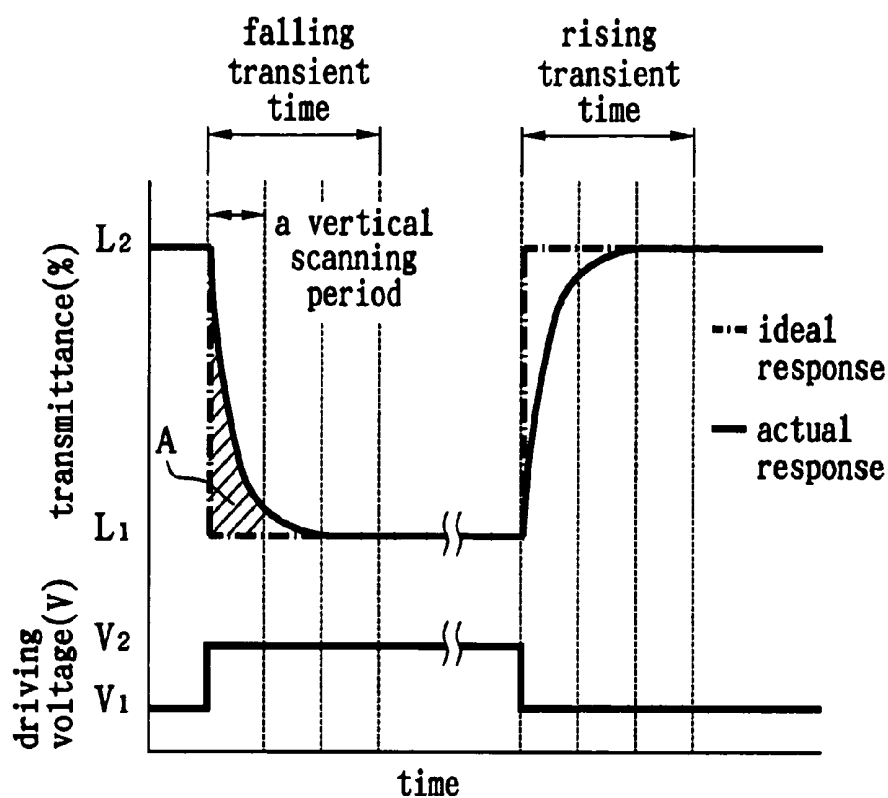


FIG. 2(a) (Background Art)

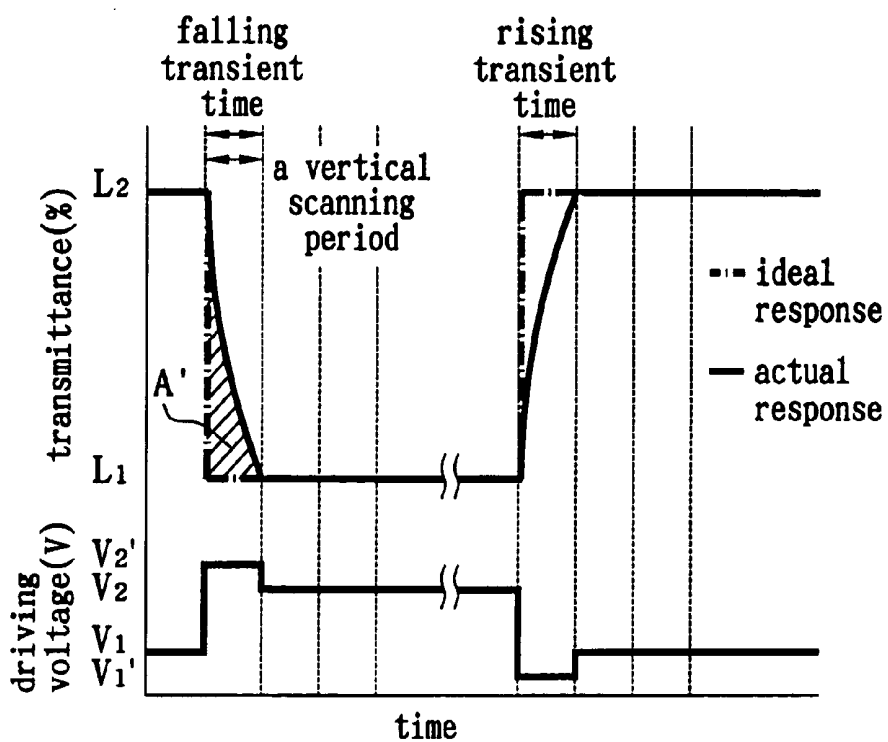


FIG. 2(b) (Background Art)

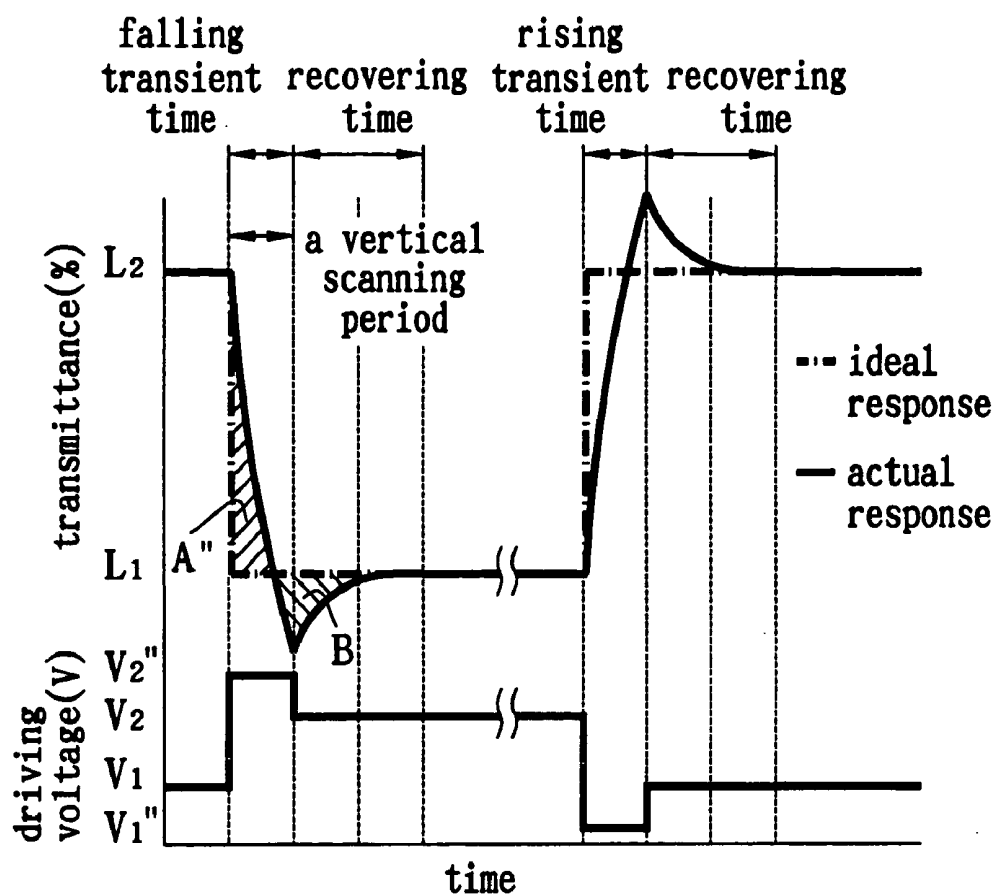
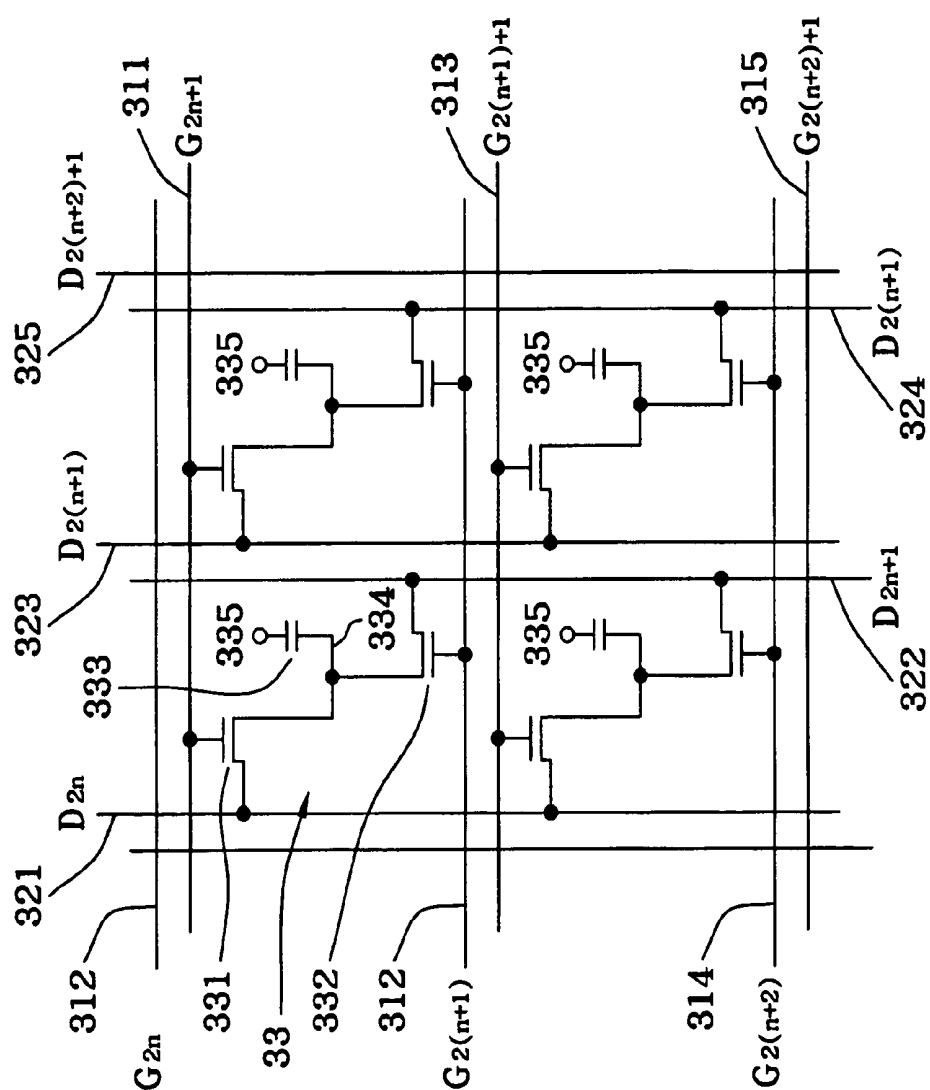


FIG. 2(c) (Background Art)



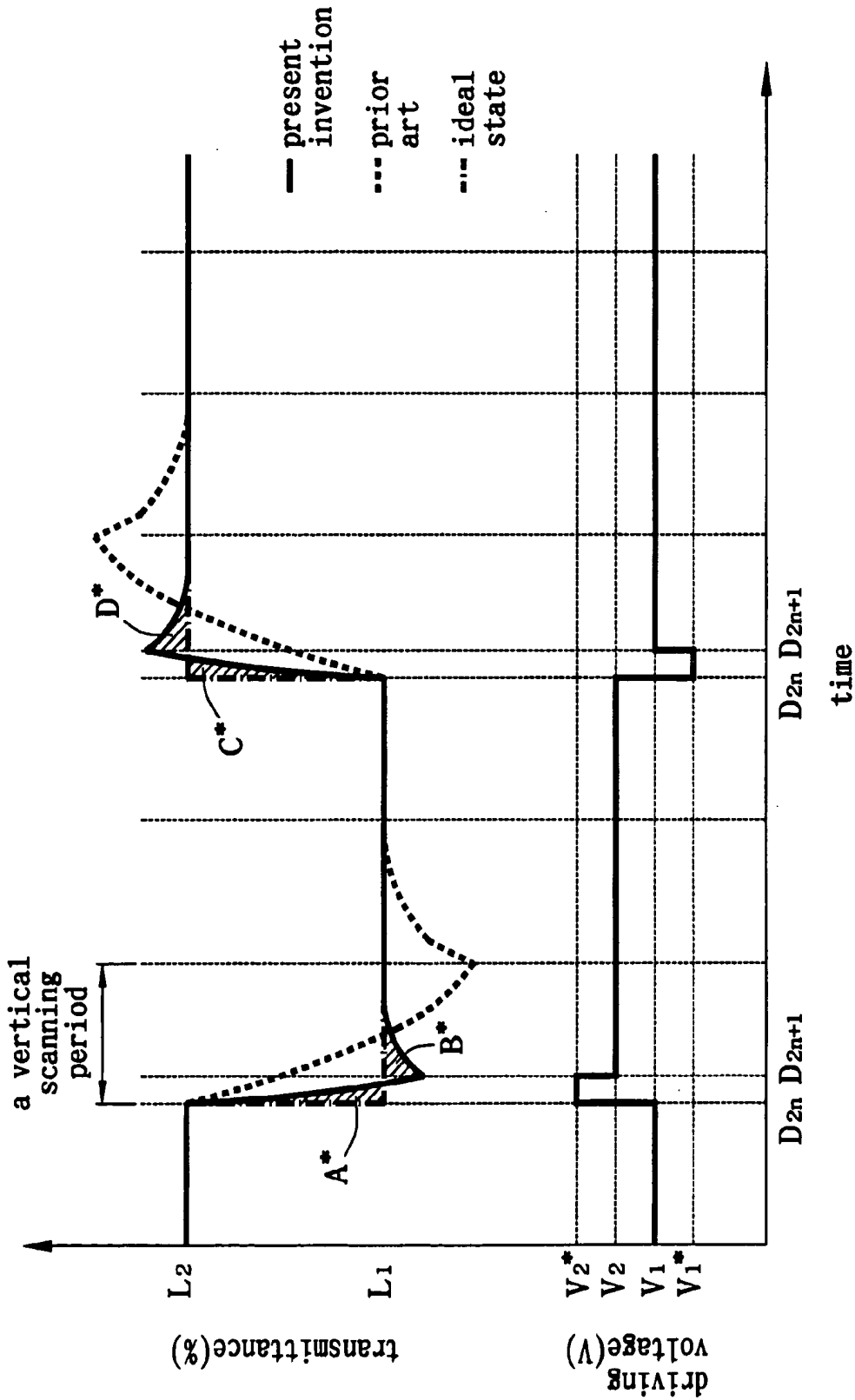


FIG. 5

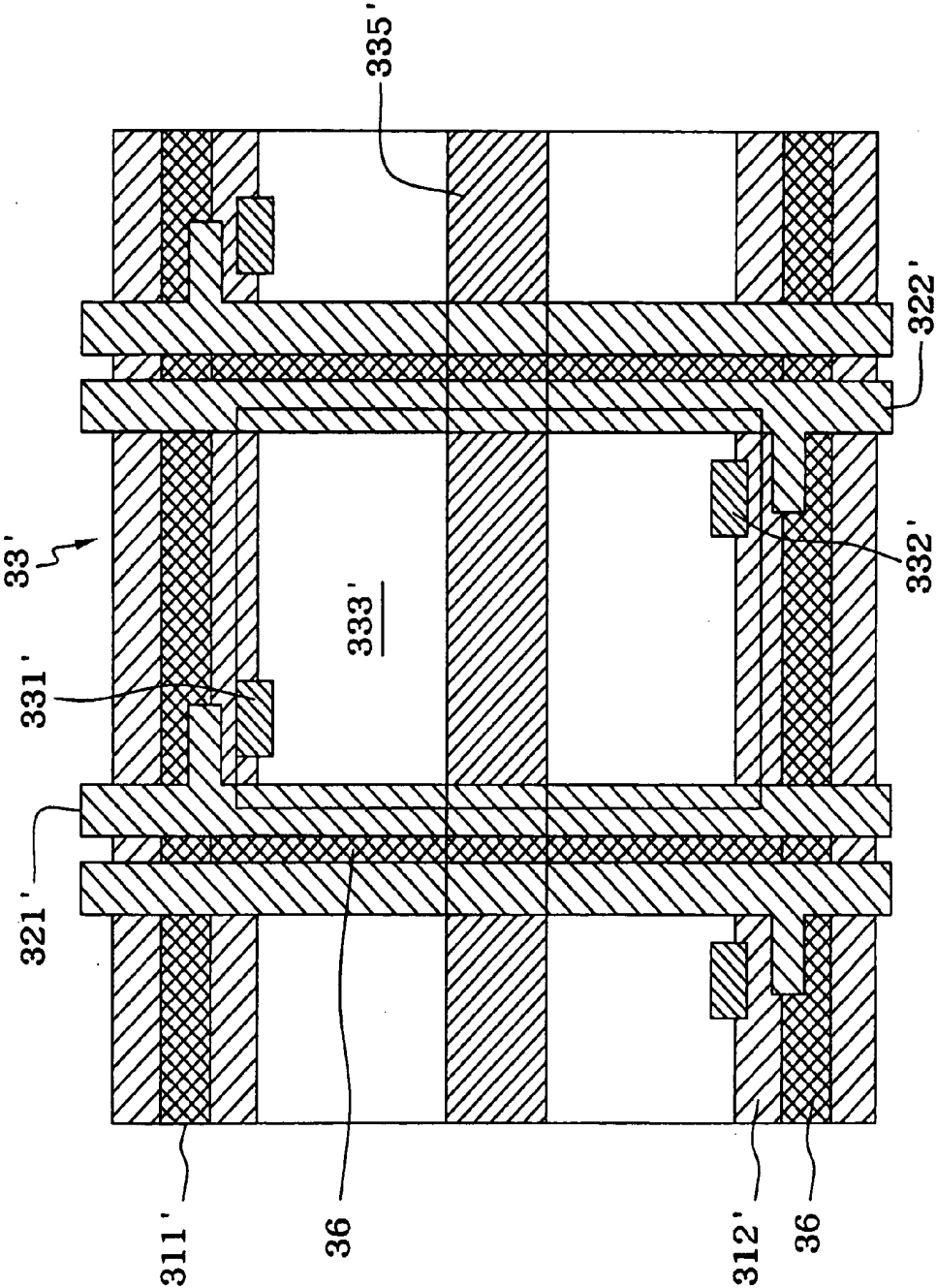


FIG. 7

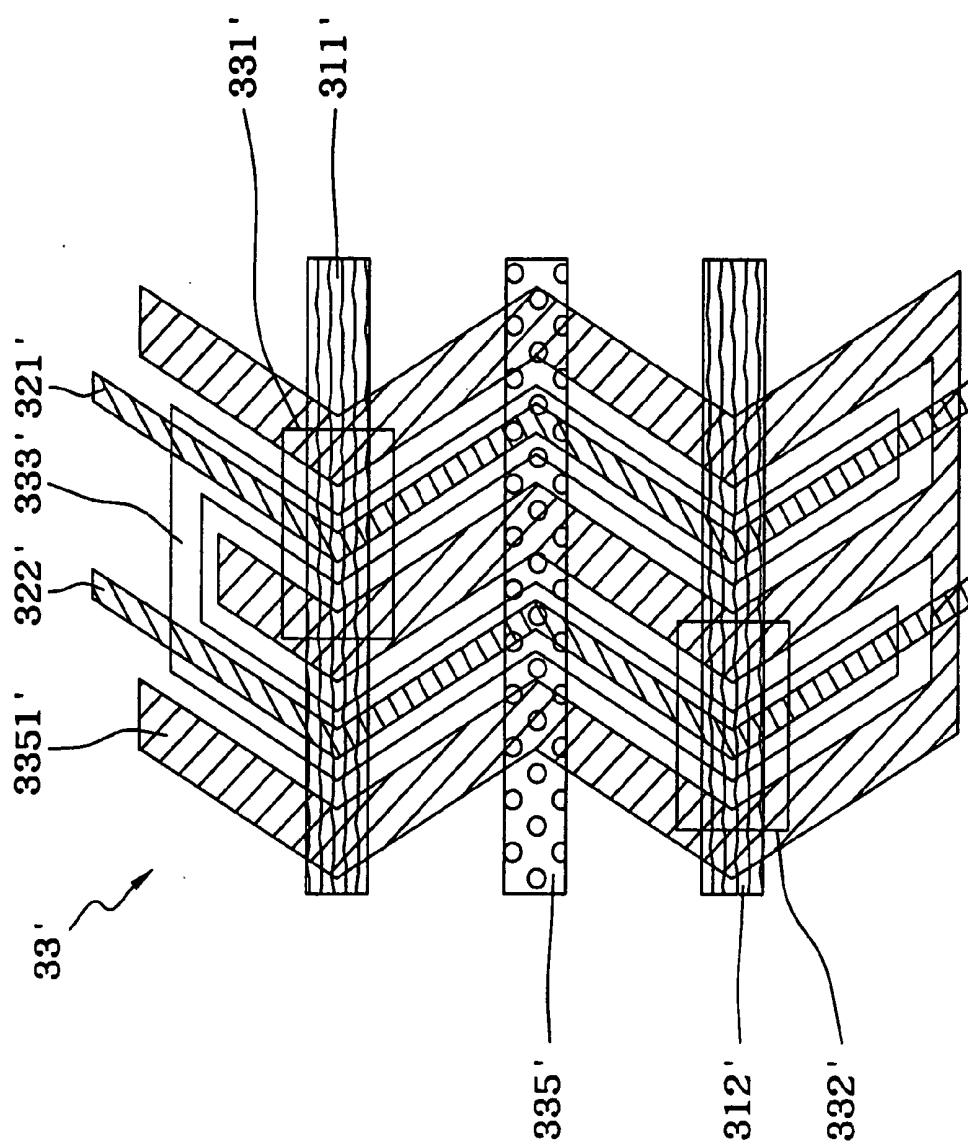


FIG. 8

DISPLAY DEVICE AND DRIVING METHOD THEREOF

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a display, such as a liquid crystal display (LCD) panel and more particularly to a display device and a driving method thereof that speeds up optical response and is suitable for displaying continuous images with rapid motions.

[0003] 2. Description of the Related Art

[0004] Progress has been ceaselessly made in the manufacturing technique for liquid crystal displays regarding high contrast displays with a wide view angle. However, continuous images with rapid motions are displayed at the expense of blurred images, as an image change takes place later than variations in motions do. So far various related driving techniques have been put forth in an attempt to shorten the time liquid crystal displays take to respond. Of these, the capacitively coupled driving (CCD) method puts forth by the Japanese Matsushita Electric Industrial Co., Ltd. shortens the time pixel electrodes take to respond to variations in voltage best, and in consequence it speeds up changes in the electric field of a liquid crystal capacitor.

[0005] FIG. 1 is an equivalent circuit diagram of a conventional liquid crystal display. The liquid crystal display 10 is composed of a plurality of parallel data lines 121-12n and a plurality of scanning lines 111-11m disposed perpendicular to the data lines, which further comprises a plurality of pixels 13 are placed at the encircled areas of the data lines 121-12n and the scanning lines 111-11m. Each pixel 13 comprises a thin film transistor 131 and a liquid crystal capacitor 133, which control the direction in which liquid crystal molecules tilt. For instance, the thin film transistor 131 is controlled by a pulse Φ_2 of the scanning line 112 to be turned on or turned off, whereas the two electrodes of the liquid crystal capacitor 133 are connected to a pixel electrode 134 and a common electrode 135, respectively. In addition, each of the pixels 13 comprises a storage capacitor 132 whose two electrodes are connected to the pixel electrode 134 and the scanning 111, respectively. With the storage capacitor 132, the operating voltage of the pixel electrode 134 is kept within a preferred voltage range so as to reduce the leakage resulting from the properties of liquid crystal materials and other stray capacitance.

[0006] Furthermore, a coupled voltage is induced on the pixel electrode 134 by employing the scanning signals Φ_1 - Φ_m , with four gate voltage levels. Given the coupled voltage, the electric field of the liquid crystal capacitor 133 varies faster. However, real changes of gray levels always occur later than variations in the electric field, as liquid crystal molecules tilt slower than the electric field varies.

[0007] FIG. 2(a) is a conventional waveform diagram of the optical responses of pixels and data signals. The waveforms of the driving voltage applied to a pixel electrode are shown in the lower half of the figure. In the upper half of the figure, the dotted line indicates the theoretical optical responses of pixels, whereas the solid line indicates the actual optical responses of pixels. If a second default voltage V_1 applied to the pixel electrode changes into a first default voltage V_2 , the actual positions or states of the liquid crystal

molecules vary and thus the transmittance of rays from a backlight source decreases, compared with the ideal state, which is a true white display without any applied voltage. It takes about two vertical scanning periods to pass through a transient time where transmittance decreases from L_2 to L_1 , thus the conventional technology is unfit for displaying continuous images with rapid motions.

[0008] The concept of fast response driving is put forth to speed up optical responses, as shown in FIG. 2(b). The default voltages V_2 and V_1 applied to the pixel electrode are replaced with V_2' and V_1' , where $V_2 < V_2'$ and $|V_1| < |V_1'|$. Hence, the time taken to pass through a transient time in which transmittance decreases from L_2 to L_1 can be reduced to approximately one vertical scanning period, indicating that the fast response driving method surpasses the driving method described in FIG. 2(a) in displaying continuous images with rapid motions. Furthermore, the deviation area A' (that is, the hatched area enclosed by the solid line and the dotted line) of the fast response driving method is less than the hatched area A in FIG. 2(a), thus the fast response driving method seldom brings about blurred motion images.

[0009] FIG. 2(c) is a diagram about the waveforms of the optical responses resulting from the Dynamic Contrast Compensating Driving method put forth by Japanese Hitachi Ltd. Wherein the driving voltages $V_2' > V_2$ and $|V_1'| > |V_1|$, an actual optical response ends up with an overshooting waveform during a vertical scanning period and results in the return of the default transmittance L_2 or L_1 during the following period. The overshooting-related area B is roughly equal to the area A' so as to compensate for a lack of dynamic contrast in motion images. Nevertheless, it still takes longer time than one vertical scanning period to bring about an overshooting waveform with the dynamic contrast compensating driving method, making it impossible to apply the dynamic contrast compensating driving method to motion images, which take less than 16.7 ms to give an optical response.

SUMMARY OF THE INVENTION

[0010] The first objective of the present invention is to provide a liquid crystal display and a driving method for thereof capable of giving fast optical responses, wherein two thin film transistors together function as the switches of each pixel; one of the thin film transistors allows normal driving voltage to a pixel electrode; meanwhile, the other thin film transistor allows overdriving voltage to be applied to the pixel electrode; as a result, the liquid crystal display gives optical responses much sooner. The second objective of the present invention is to provide a liquid crystal display compatible with existing driving devices, so that the circuit of the liquid crystal display works without any newly developed driving devices.

[0011] In order to achieve the aforesaid objectives, the present invention discloses a liquid crystal display that is suitable for displaying images with rapid motions and comprises an active matrix substrate equipped with a plurality of thin film transistors. The active matrix substrate comprises a plurality of pixels that are placed at the encircled areas of a plurality of scanning lines and a plurality of data lines. Each pixel consists of two thin film transistors and one pixel electrode.

[0012] The data lines connected electrodes of the thin film transistors are connected to two adjoining data lines respec-

tively, whereas the pixel connected electrodes of the two thin film transistors are together connected to the pixel electrode. The gate electrodes of the two thin film transistors are connected to two adjoining scanning lines respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention will be described according to the appended drawings in which:

[0014] FIG. 1 is an equivalent circuit diagram of a conventional liquid crystal display;

[0015] FIGS. 2(a)-2(c) are waveform diagrams of the optical responses of pixels and data signals in accordance with prior arts;

[0016] FIG. 3 is a schematic diagram of the circuit layout for the active matrix substrate of the liquid crystal display in accordance with the present invention;

[0017] FIG. 4 is a magnification of the circuit layout of portion C in FIG. 3;

[0018] FIG. 5 is a waveform diagram of the optical response of a pixel and a data signal in accordance with the present invention;

[0019] FIG. 6 is a waveform diagram of the optical responses during several consecutive vertical scanning periods in accordance with the present invention;

[0020] FIG. 7 is a schematic diagram of the circuit layout of the pixel applied to an active matrix substrate employing the color filter on array technology in accordance with the present invention; and

[0021] FIG. 8 is a schematic diagram of the circuit layout of the pixel applied to an active matrix substrate employing the Advanced-Super IPS technology in accordance with the present invention.

PREFERRED EMBODIMENT OF THE PRESENT INVENTION

[0022] FIG. 3 is a schematic diagram of the circuit layout for the active matrix substrate of the liquid crystal display in accordance with the present invention. The active matrix substrate 30 comprises not only a first data driving device 341 that drives first data lines 321, 323 and 325, but also a second data driving device 342 that controls second data lines 322 and 324. The first data driving device 341 and the second data driving element 342 can be disposed on the two opposite sides of the active area D where the pixels exist. Similarly, a first gate driving device 351 controls first scanning lines 311, 313 and 315, whereas a second gate driving device 352 controls second scanning lines 310, 312 and 314. The first gate driving device 351 and the second gate driving device 352 can be disposed on the two opposite sides of the active area D respectively.

[0023] FIG. 4 is a magnification of the circuit layout of portion C in FIG. 3. A pixel 33 comprises a first thin film transistor 331 and a second thin film transistor 332, and the two thin film transistors together function as switches, allowing the overdriving signals on the first data line 321 and the data signals on the second data line 322 to be written in a liquid crystal capacitor 333, wherein the first data line 321 is connected to a first electrode of first thin film

transistor 331 and a third electrode the second thin film transistor 332 is connected to the second data line 322.

[0024] The first gate electrode of the first thin film transistor 331 is controlled by the first scanning line 311, whereas the second gate electrode of the second thin film transistor 332 is controlled by the second scanning line 312. Both the first thin film transistor 331 and the second thin film transistor 332 are connected together to a pixel electrode 334 electrically, wherein the pixel electrode 334 is connected to the second electrode of the first thin film transistor 331 and the fourth electrode of the second thin film transistor 332.

[0025] Further, the pixel electrode 334 and a common electrode 335 are the two electrodes of the liquid crystal capacitor 333. Positions or postures of liquid crystal molecules (not shown in the figure) in the liquid crystal capacitor 333 change while the liquid crystal molecules are driven by the electric field of the liquid crystal capacitor 333.

[0026] As shown in FIG. 5, since the first thin film transistor 331 is solely controlled by the first scanning line 311 to be turned on or turned off and a first overdriving voltage V_2^* ($V_2^* > V_2$) or a second overdriving voltage V_1^* (and $|V_1^*| > |V_1|$) is applied to the pixel electrode 334, the optical response based on the disclosure of the present invention is superior to the optical response based on conventional technology described in FIG. 2(c). Since the overshooting waveform of the transmittance always recovers the default transmittance L_1 during the same period, the merit of the present invention is even more distinct.

[0027] The description of a driving method for the present invention needs to refer to FIG. 4 and FIG. 5:

[0028] The first overdriving voltage V_2^* is written into the first thin film transistor 331 and the pixel electrode 334 via the first data line 321, and the first default voltage V_2 is written into the second thin film transistor 332 and the pixel electrode 334 for a start. Then the second overdriving voltage V_1^* is written into the first thin film transistor 331 and the pixel electrode 334 via the first data line 321, and the second default voltage V_1 is written into the second thin film transistor 332 and the pixel electrode 334. The value of suggestion range between the first default voltage V_2 and the second default voltage V_1 depends on the mode of liquid crystal display. For example, the value of suggestion range for TN mode is 0.5-8.5 Volts, but for AS-IPS mode is 0.5-15.5 Volts.

[0029] The first overdriving voltage V_2^* is written during a first vertical scanning period, and a first overshooting waveform of transmittance resulting from the first overdriving voltage V_2^* returns to the first default transmittance L_1 during the first vertical scanning period. On the other hand, the second overdriving voltage V_1^* is written during a second vertical scanning period, and a second overshooting waveform of transmittance resulting from the second overdriving voltage V_1^* returns to the second default transmittance L_2 during the second vertical scanning period.

[0030] The difference between the first overdriving voltage V_2^* and first default voltage V_2 depends on the first overshooting waveform of transmittance resulting, which further comprises a first hatched area A^* and a second hatched area B^* are enclosed by the first overshooting waveform of transmittance and a first default waveform of transmittance, and the measure of the first hatched area A^*

is equal to the measure of the second hatched area B*. Further, the suggestion range of the difference value is 0-0.5 Voltages.

[0031] The difference between the second overdriving voltage V_1^* and second default voltage V_1 depends on the second overshooting waveform of transmittance resulting, which further comprises a third hatched area C* and a fourth hatched area D* are enclosed by the second overshooting waveform of transmittance and a second default waveform of transmittance, and the measure of the third hatched area C* is equal to the measure of the fourth hatched area D*. Further, the suggestion range of the difference value is 0-0.5 Voltages.

[0032] FIG. 6 is a waveform diagram of the optical responses during several consecutive vertical scanning periods in accordance with the present invention. As illustrated with FIG. 6, in terms of optical response speed and dynamic contrast compensation, the present invention is more suitable for displaying continuous images with rapid motions, as the present invention ensures the recovery of the default transmittance during every vertical scanning period and meets the dynamic contrast compensation requirement. In addition, the circuit layout put forth in accordance with the present invention may be applied to various types of liquid crystal displays, such as twisted nematic (TN), super TN (STN), in-plane switching (IPS), advanced-super IPS (AS-IPS) and multi-domain vertical alignment (NVA). The present invention is also applied to liquid crystal displays characterized by a high aperture ratio (HAR) technology or a color filter on array (COA) technology.

[0033] FIG. 7 is a schematic diagram of the circuit layout of the pixel applied to an active matrix substrate employing the color filter on array technology in accordance with the present invention. In this embodiment, a first thin film transistor 331' and a second thin film transistor 332' are disposed at two diagonal corners of a pixel 33', respectively. The first gate electrode of the first thin film transistor 331' is connected to a first scanning line 311', whereas its two other electrodes are connected to a first data line 321' and a pixel electrode 333' respectively. The second gate electrode of the second thin film transistor 332' is connected to a second scanning line 312', whereas its two other electrodes are connected to a second data line 322' and the pixel electrode 333' respectively. An in-plane or horizontal electric field exists between a common electrode 335' and the pixel electrode 333' to drive liquid crystal molecules to rotate for an optical response. An opaque black matrix 36 which functions as a partition is disposed at the periphery of the pixel 33' in order to prevent light rays from be leaked through the edge of the pixel 33'.

[0034] FIG. 8 is a schematic diagram of the circuit layout of the pixel applied to an active matrix substrate employing the Advanced-Super IPS technology in accordance with the present invention. In this embodiment, a first thin film transistor 331' and a second thin film transistor 332' are disposed at two diagonal corners of a pixel 33', respectively. The first gate electrode of the first thin film transistor 331' is connected to a first scanning line 311', whereas its two other electrodes are connected to a first data line 321' and a pixel electrode 333' respectively. The second gate electrode of the second thin film transistor 332' is connected to a second scanning line 312', whereas its two other electrodes are

connected to a second data line 322' and the pixel electrode 333' respectively. A common electrode 335' is electrically connected to its comb-like portion 3351', thus an in-plane electric field exists between the comb-like portion 3351' and the pixel electrode 333' to drive liquid crystal molecules to rotate for an optical response.

[0035] The above-described embodiments of the present invention are intended to be illustrative only. Numerous alternative embodiments may be devised by persons skilled in the art without departing from the scope of the following claims.

What is claimed is:

1. A display, comprising:

a substrate;

a plurality of first scanning lines on the substrate, connected a first gate driving device;

a plurality of second scanning lines parallel and interlaced with the first scanning lines, connected a second gate driving device;

a plurality of first data lines intersecting to the second scanning lines, connected a first data driving device; and

a plurality of second data lines parallel and interlaced with the first data lines, connected a second data driving device.

2. The display of claim 1, wherein the first gate driving device, the second gate driving device, the first data driving device, and the second data driving device are disposed on the sides of the substrate.

3. The display of claim 1, which further comprises a plurality of pixel units on the substrate, each pixel unit enclosed by the first scanning line, the second scanning line, the first data line and the second data line.

4. The display of claim 3, wherein the pixel unit further comprises a first transistor, a second transistor, a pixel electrode, and a liquid crystal capacitor connected to the pixel electrode and a common electrode on the substrate.

5. The display of claim 4, wherein the first transistor having a first gate electrode connected to one of the first scanning lines, a first electrode connected to one of the first data lines and a second electrode.

6. The display of claim 5, wherein the second transistor having a second gate electrode connected to one of the second scanning lines, a third electrode connected to one of the second data lines and a fourth electrode.

7. The display of claim 6, wherein the pixel electrode connected to the second electrode of the first transistor and the fourth electrode of the second transistor.

8. A pixel unit of a display, comprising:

a first transistor having a first gate electrode connected to a first scanning line, a first electrode connected to a first data line and a second electrode; and

a second transistor having a second gate electrode connected to a second scanning line, a third electrode connected to a second data line and a fourth electrode electrically connected the second electrode.

9. The pixel unit of claim 8, which further comprises:

a pixel electrode between the second electrode and the fourth electrode; and

a liquid crystal capacitor connected to the pixel electrode and a common electrode.

10. A method driving a pixel unit of a display, wherein the pixel unit comprises a first transistor and a second transistor:

writing a first voltage via a first data line into the first transistor and a pixel electrode during a first period; and

writing a second voltage via a second data line into the second transistor and the pixel electrode during a second period.

11. The driving method of claim 10, which further comprises a first waveform of transmittance resulting from the first voltage returns to a first default transmittance during the first period.

12. The driving method of claim 11, wherein the difference between the first voltage and the second voltage is 0-0.5 Voltagess.

13. The driving method of claim 11, wherein the difference between the first voltage and second voltage depends on the first waveform of transmittance resulting.

14. The driving method of claim 13, which further comprises a first area and a second area enclosed by the first waveform of transmittance and a second waveform of transmittance, wherein the measure of the first area is equal to the measure of the second area.

15. The driving method of claim 10, which further comprises steps of:

writing a third voltage via a first data line into a first transistor and the pixel electrode during a third period; and

writing a fourth voltage via a second data line into a second transistor and the pixel electrode during a fourth period.

16. The driving method of claim 15, which further comprises a third waveform of transmittance resulting from the third voltage returns to a second default transmittance during the third period.

17. The driving method of claim 16, wherein the difference between the third voltage and the fourth voltage is 0-0.5 Voltagess.

18. The driving method of claim 16, wherein the difference between the third voltage and the fourth voltage depends on the third waveform of transmittance resulting.

19. The driving method of claim 18, which further comprises a third area and a fourth area enclosed by the third waveform of transmittance and a fourth waveform of transmittance, wherein the measure of the third area is equal to the measure of the fourth area.

20. The driving method of claim 15, wherein the difference between the second voltage and fourth voltage is 0.5-15.5 Voltagess.

* * * * *

专利名称(译)	显示装置及其驱动方法		
公开(公告)号	US20050052382A1	公开(公告)日	2005-03-10
申请号	US10/838496	申请日	2004-05-03
[标]申请(专利权)人(译)	林铭田 邱毅LUN JEN天安SEN		
申请(专利权)人(译)	林铭田 邱毅-LUN JEN天安森		
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[标]发明人	LIN MING TIEN CHOU YI LUN JEN TEAN SEN		
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其他公开文献	US7336248		
外部链接	Espacenet USPTO		

摘要(译)

液晶显示器适合于以快速运动显示图像，并且包括配备有多个薄膜晶体管的有源矩阵基板。有源矩阵基板包括多个像素，这些像素位于多条扫描线和多条数据线的环绕区域。每个像素由两个薄膜晶体管和一个像素电极组成。连接薄膜晶体管的电极的数据线分别连接到两条相邻的数据线，而两个薄膜晶体管的像素连接电极一起连接到像素电极。两个薄膜晶体管的栅极分别连接到两条相邻的扫描线。

