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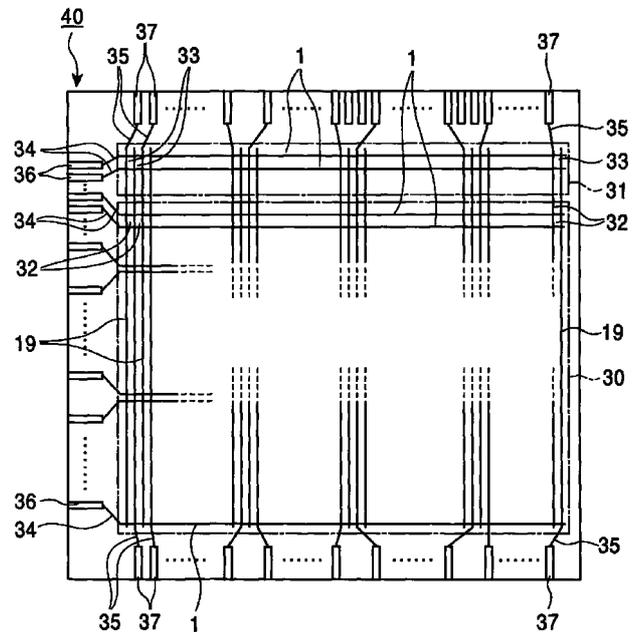
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(54) **Active-matrix liquid-crystal display apparatus which prevents flicker**

(57) Opposed electrodes (13a,13b) are separately provided correspondingly to a main display area (30) and a sub display area (31) in an active-matrix liquid-crystal display apparatus. The most-appropriate voltages are applied to the opposed electrode corresponding to the main display area and to the opposed electrode corresponding to the sub display area, according to the size of each pixel zone disposed in each display area.

FIG. 1



EP 1 093 009 A2

Description

[0001] The present invention relates to active-matrix liquid-crystal display apparatuses, and more particularly, to the structure of opposed electrodes used in an active-matrix liquid-crystal display apparatus which is provided with a main display area and a sub display area having pixel zones different in size from each other.

[0002] Fig. 6 shows a conventional active-matrix liquid-crystal display apparatus. More specifically, Fig. 6 is a plan of a thin-film-transistor (hereinafter called TFT) array substrate 140.

[0003] The TFT array substrate 140 of the conventional active-matrix liquid-crystal display apparatus is formed of a display area 130 where pixel zones 132 constituting pixels are disposed in a matrix manner, scanning-line leads 134 and scanning-line terminals 136 used for connecting scanning lines 101 disposed in the display area 130 to a gate-driver IC provided outside, and signal-line leads 135 and signal-line terminals 137 used for connecting signal lines 119 disposed in the display area 130 to a source-driver IC provided outside.

[0004] In the viewpoint of adding a new function to the conventional active-matrix liquid-crystal display apparatus, it has been proposed that it be necessary to provide, in addition to a display area 30 (hereinafter called a main display area), another display area 31 (hereinafter called a sub display area) used for displaying, for example, character information, as shown in Fig. 1,

[0005] In this case, whereas the size of each pixel zone 32 is made small because high resolution is required for the main display area 30, it is not necessarily required for each pixel zone 33 to have the same size as each pixel zone 32 in the main display area due to its display purpose. Rather, each pixel zone 33 in the sub display area 31 is designed such that it is larger than each pixel zone 32 in the main display area 30 since it is required that, for example, characters be displayed large for easy recognition.

[0006] In a conventional liquid-crystal display apparatus having a sub display area, one opposed electrode 113 common to the whole surface of an opposed substrate 141 is formed, as shown in Fig. 7.

[0007] In each of active-matrix liquid-crystal display apparatuses, a liquid-crystal layer is sandwiched by a pair of substrates disposed oppositely and used as a display medium. An AC voltage on which a DC voltage is not superposed is applied to the liquid-crystal layer so as to prevent image sticking on the liquid-crystal layer. The AC voltage is used as a display voltage, and is applied to pixel electrodes mainly constituting pixel zones from signal lines through TFTs which have been turned on by gate voltages applied from scanning lines. A constant DC voltage is applied to an opposed electrode disposed oppositely to the pixel electrodes through the liquid-crystal layer. With this operation, an electric field is applied to the liquid-crystal layer to change its refractive index, and thus the liquid-crystal layer can be used as a display medium.

[0008] A dynamic voltage drop occurs in the potential V_p of the pixel electrodes when the gate voltages are changed in order to turn off the TFTs because the dielectric constant of the liquid crystal changes according to the electric-field strength, a parasitic capacitor is formed between the gate electrode and the drain electrode of each TFT, and a parasitic capacitor is formed between a scanning line and the pixel electrode.

[0009] Fig. 5 is an outlined view of driving voltages for the liquid-crystal display apparatus. In Fig. 5, (a) shows a voltage V_g applied to the gate electrode of a TFT, (b) shows a voltage V_s applied to the source electrode of the TFT, and (c) shows the voltage V_p of the drain electrode of the TFT, namely, the pixel electrode. In (c) of Fig. 5, V_{sc} indicates the center voltage of an AC voltage applied to the source electrode, and V_{com} indicates a voltage applied to the opposed electrode. Since the voltages V_{com} and V_p are applied to the opposed electrode and the pixel electrode, respectively, an effective potential is given to the liquid-crystal layer and the liquid-crystal layer operates as a display medium. The horizontal axis indicates time in Fig. 5 to show the V_g , V_s , and V_p timing. The TFT is "on" while the voltage shown in (a) of Fig. 5 is high, and the TFT is "off" while the voltage is low.

[0010] When the gate voltage V_g is changed in order to turn off the TFT, a dynamic voltage drop ΔV_p occurs at the potential V_p of the pixel electrode as shown in (c) of Fig. 5. This is because, when the gate voltage V_g is changed in order to turn off the TFT, charges are distributed among the capacitor formed by the liquid-crystal layer between the pair of substrates; a storage capacitor formed by a scanning line, and a gate insulating film and a capacitor electrode disposed thereabove; and the above-described parasitic capacitors to generate the voltage drop ΔV_p at the potential V_p of the pixel electrode.

[0011] The voltage drop ΔV_p generated at the potential of the pixel electrode 11 is shown by the following expression (1).

$$\Delta V_p = (V_{gh} \times (C_{gdon} + C_{gp}) - V_{gl} \times (C_{gdoff} + C_{gp}) - V_s (C_{gdon} - C_{gdoff})) / (C_s + C_{lc} + C_{gdoff} + C_{gp}) \quad (1)$$

where,

ΔV_p : Voltage drop at the potential of the pixel electrode

V_{gh} : High potential of the gate voltage

Cgdon: Parasitic capacitance obtained when the TFT is "on"

Cgp: Parasitic capacitance obtained between the scanning line and the pixel electrode

Vgl: Low potential of the gate voltage

Cgdo: Parasitic capacitance obtained when the TFT is "off"

5 Vs: Potential of the signal voltage

Cs: Storage capacitance

Clc: Capacitance of the liquid-crystal layer

10 **[0012]** The factors which cause the voltage drop ΔV_p at the potential of the pixel electrode includes the capacitance Clc of the liquid-crystal layer, the parasitic capacitance Cgd of the thin-film transistor, and the storage capacitance Cs, as shown in the expression (1).

15 **[0013]** The dielectric constant of the liquid crystal, which is one factor causing the voltage drop ΔV_p , is changed according to the electric-field strength. This change relates to the characteristics of the liquid crystal and cannot be avoided. In the two parasitic capacitors, that formed between the TFT gate electrode and the TFT drain electrode and that formed between a scanning line and the pixel electrode, which are other factors causing the voltage drop ΔV_p , the parasitic capacitor formed between the TFT gate electrode and the TFT drain electrode is a capacitor generated by the gate insulating film formed between the electrodes, and cannot be avoided in terms of the structure of current active-matrix liquid-crystal display apparatuses.

20 **[0014]** When the voltage drop ΔV_p occurs at the potential V_p of the pixel electrode as described above, the positive and negative voltage amplitudes of the potential V_p of the pixel electrode differ. When an identical-amplitude voltage is applied irrespective of its polarity, liquid crystal shows an identical transmittance. Therefore, in a normally-white active-matrix liquid-crystal display apparatus, which has a high transmittance when a voltage is not applied, for example, the transmittance is lower at a polarity where the voltage amplitude is larger, and the transmittance is higher at a polarity where the voltage amplitude is smaller. Consequently, the repetition of brightness and darkness occurs according to the transmittances, and this pattern is seen as flicker.

25 **[0015]** When voltage amplitudes are not symmetrical for the positive and negative polarities, a DC voltage superposed on an AC voltage is always applied to any of pixel electrodes, and an image remains on the screen, which is so-called image sticking.

30 **[0016]** Therefore, flicker and image sticking are conventionally avoided by adequately adjusting the potential of the opposed electrode such that the voltage amplitudes of the AC voltage driving the liquid crystal are equal at the positive and negative sides and by forming storage capacitors in parallel to the capacitor generated by the liquid-crystal layer.

35 **[0017]** When a sub display area having different pixel zones from those of a main display area is provided in addition to the main display area, since the values of the liquid-crystal capacitance and the parasitic capacitances differ according to the size of pixel zones, the voltage drops ΔV_p at pixel electrodes differ between the main display area and the sub display area. As a result, when the common opposed electrode is used as shown in the conventional case although the most-appropriate potentials applied to the opposed electrode differ between the main display area and the sub display area, the most-appropriate voltage is not applied to the opposed electrode corresponding to one of the main display area and the sub display area. Flicker occurs in either the main display area or the sub display area. In addition, image sticking occurs in either the main display area or the sub display area.

40 **[0018]** Accordingly, it is an object of the present invention to provide an active-matrix liquid-crystal display apparatus having a main display area and a sub display area different in the sizes of pixel zones, which has opposed electrodes for the main display area and the sub display area to allow the most-appropriate voltages to be applied to the opposed electrodes and which is provided with means for preventing flicker and image sticking from occurring.

45 **[0019]** In other words, an object of the present invention is to provide an active-matrix liquid-crystal display apparatus where an appropriate opposed-electrode voltage V_{com} is applied to each opposed electrode when different voltage drops ΔV_p occur at the main display area and the sub display area, so that the voltage amplitudes are made equal at the positive and negative polarities in each display area.

50 **[0020]** The foregoing object is achieved in one aspect of the present invention through a provision of an active-matrix liquid-crystal display apparatus including: a pair of substrates disposed oppositely; a liquid-crystal layer sandwiched by the pair of substrates; a plurality of scanning lines and a plurality of signal lines formed in a matrix manner in a two-level-crossing fashion on one of the pair of substrates; thin-film transistors having gate electrodes connected to the plurality of scanning lines, and pixel electrodes and storage capacitors connected to the thin-film transistors, all of which disposed in the vicinity of two-level-crossing portions formed by the plurality of scanning lines and the plurality of signal lines; a main display area and a sub display area having different-size pixel zones enclosed by the plurality of scanning lines and the plurality of signal lines; and opposed electrodes formed on the surface close to the liquid-crystal layer, of the other, serving as an opposed substrate, of the pair of substrates, wherein one opposed electrode is disposed oppositely to the main display area and the other opposed electrode is disposed oppositely to the sub area.

55 **[0021]** The active-matrix liquid-crystal display apparatus may be configured such that the size of each pixel zone in

the main display area is smaller than that of each pixel zone in the sub display area.

[0022] The active-matrix liquid-crystal display apparatus may further include voltage applying means for applying different voltages to the opposed electrode disposed oppositely to the main display area and to the opposed electrode disposed oppositely to the sub display area.

5 **[0023]** In this case, the active-matrix liquid-crystal display apparatus may be configured such that the size of each pixel zone in the main display area is smaller than that of each pixel zone in the sub display area, and the voltage applying means applies a lower voltage to the opposed electrode disposed oppositely to the main display area than a voltage applied to the opposed electrode disposed oppositely to the sub display area.

10 **[0024]** When the size of each pixel zone in the main display area differs from that of each pixel zone in the sub display area, separate voltage applying units are provided as the voltage applying means in order to apply different voltages to the opposed electrodes disposed oppositely to the main display area and the sub display area, according to the size of each pixel zone. One voltage applying unit may be provided in order to apply different voltages to the opposed electrodes.

15 **[0025]** When the main display area is required to have high resolution for displaying images, and the sub display area is used for displaying characters and resolution is not much concerned, for example, the size of each pixel zone in the main display area is made smaller than that of each pixel zone in the sub display area and a lower voltage is applied to the opposed electrode disposed oppositely to the main display area than a voltage applied to the opposed electrode disposed oppositely to the sub display area.

20 **[0026]** In other words, in the expression (1), since the size of each pixel zone in the sub display area is larger, the capacitance C_{lc} of the liquid-crystal layer is large and therefore the voltage drop ΔV_p is small. To make voltage amplitudes in the positive and negative polarities equal in (c) of Fig. 5, it is necessary to set a voltage applied to the opposed electrode disposed oppositely to the sub display area higher. With this operation, the most-appropriate voltages are applied to the opposed electrodes according to the size of each pixel zone, and thus flicker and image sticking are avoided.

25 **[0027]** Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

Fig. 1 is a plan of a TFT array used in an active-matrix liquid-crystal display apparatus according to an embodiment of the present invention.

30 Fig. 2 is an enlarged plan of a vicinity of one pixel zone in a sub display area disposed on the TFT array substrate shown in Fig. 1.

Fig. 3 is a sectional view taken on line III-III in Fig. 2.

Fig. 4 is a plan of opposed electrodes according to the present invention.

Fig. 5 is a view showing driving voltages of the liquid-crystal display apparatus.

35 Fig. 6 is a plan of a conventional TFT-array substrate.

Fig. 7 is a plan showing a conventional opposed electrode.

[0028] In Fig. 1, a number of pixel zones 32 and 33 are arranged in a matrix in a main display area 30 and a sub display area 31 on the TFT array substrate 40. The pixel zones are enclosed by scanning lines 1 and signal lines 19. The size of each pixel zone disposed in the main display area 30 is different from that of each pixel zone disposed in the sub display area 31.

[0029] More specifically, the size of each pixel zone 32 disposed in the main display area 30 is 40 μm in width and 120 μm in height, and the size of each pixel zone 33 disposed in the sub display area 31 is 40 μm in width and 400 μm in height.

45 **[0030]** In the present embodiment, the sub display area, which includes the pixel zones 33 having a larger size than the pixel zones 32 disposed in the main display area 30, is formed next to the main display area 30 such that the widths of their pixel zones match in the scanning-line direction.

[0031] In these pixel zones, the scanning lines 1 for scanning the pixel zones and the signal lines 19 for sending signals are formed in a lattice manner. The signal lines 19 are continuously disposed without any disconnection in the main display area 30 and the sub display area 31, where the sizes of the pixel zones differ.

50 **[0032]** On an opposed substrate 41 disposed oppositely to the TFT array substrate 40, opposed electrodes 13a and 13b opposite to the main display area 30 and the sub display area 31, respectively, are disposed, and different voltages are applied to the opposed electrodes.

55 **[0033]** Around the main display area 30 and the sub display area 31, leads 34 for connecting the scanning lines 1 to scanning-line terminals 36 in order to connect the scanning lines 1 disposed in the display areas 30 and 31 to a gate-driver IC provided outside are provided, and leads 35 for connecting the signal lines 19 to signal-line terminals 37 in order to connect the signal lines 19 disposed in the display areas 30 and 31 to a source-driver IC provided outside are provided. When a driving circuit is built in the TFT array substrate, which is a different case from the present embodi-

ment, the leads for the scanning lines and those for the signal lines may be connected to the outputs of the driving circuit.

[0034] Fig. 2 is an enlarged plan of one pixel zone 33 disposed in the sub display area 31 of the liquid-crystal display apparatus according to the present embodiment. Fig. 3 is a sectional view taken on line III-III, which passes through a TFT 21, a contact hole 18a, and a capacitor electrode 9 in Fig. 2. Each pixel zones 32 of the main display area 30 have the same structure as each pixel zones 33 of the sub display area 31 except for the size.

[0035] As shown in Fig. 2, the pixel zone 33 of the sub display area 31 is enclosed by scanning lines 1 and signal lines 19. The TFT 21 is formed at the lower left portion of Fig. 2, and a storage capacitor 22 is formed at the upper portion. At the center of Fig. 2, the pixel electrode 11 is disposed.

[0036] In the liquid-crystal display apparatus using the TFT array substrate 40, the opposed substrate 41 is disposed oppositely to the TFT array substrate 40 through the liquid-crystal layer 20, as shown in Fig. 3. The opposed substrate 41 is provided with a light-shielding black matrix 15, a color filter 14, and a transparent opposed electrode 136 made from indium-tin oxide (hereinafter called ITO), which is also used for the pixel electrode 11. On a surface contacting the liquid crystal 20, an alignment layer 12 is formed. Therefore, when a voltage is applied between the pixel electrode 11 and the opposed electrode 136, an electric field is applied to the liquid-crystal layer 20 and alignment control can be applied to liquid-crystal molecules. This structure can be regarded as a capacitor (hereinafter called a liquid-crystal capacitor) because the liquid-crystal layer 20, which is a dielectric, is sandwiched by the pixel electrode 11 and the opposed electrode 136.

[0037] In a TFT, as shown in Fig. 2 and Fig. 3, a gate electrode 2 connected to a scanning line 1 is provided, a gate insulating film 3 made from silicon nitride is formed thereon, a semiconductor film 4 made from amorphous silicon is formed further thereon, an ohmic-contact film 5 made from n+ amorphous silicon where phosphorus is added to amorphous silicon is formed still further thereon, and a drain electrode 7 and a source electrode 8 both made from a conductor are formed yet further thereon. The source electrode 8 is led from the signal line 19. On the drain electrode 7 and the source electrode 8, a passivation film 10 made from silicon nitride is formed in a cover manner. A contact hole 18a is formed in the passivation film 10 disposed on the drain electrode 7. The drain electrode 7 is connected to the transparent pixel electrode 11 made from ITO through the contact hole 18a.

[0038] In the storage capacitor 22, the scanning line 1 serves as an electrode, the gate insulating film 3 formed thereon serves as a dielectric, and a capacitor electrode 9 is formed further thereon to serve as the other electrode. The capacitor electrode 9 is made from the same conductor as the drain electrode 7 and the source electrode 8. In the same way as in the TFT 21, a passivation film 10 is formed on the capacitor electrode 9. A contact hole 18b is formed in the passivation film 10. The pixel electrode 11 made from ITO is led above the capacitor electrode 9, and is connected to the capacitor electrode 9 through the contact hole 18b. The storage capacitor 22 is connected to the liquid-crystal capacitor in parallel. Both serves as load capacitors of the TFT 21.

[0039] In the present embodiment, the main display area 30 having the pixel zones each 40 μm wide and 120 μm high, and the sub display area 31 having the pixel zones each 40 μm wide and 400 μm high are formed on the same TFT array substrate 40. Opposed electrodes 13a and 13b disposed oppositely to the above display areas are disposed separately on the opposed substrate 41 as shown in Fig. 4. The opposed electrodes 13a and 13b are made from the same ITO film as the pixel electrode 11. The sizes of the opposed electrodes 13a and 13b are made almost equal to the sizes of the main display area 30 and the sub display area 31.

[0040] To apply the most-appropriate voltages to the opposed electrodes separately provided, two DC/DC converters (not shown) for generating DC voltages are prepared as voltage applying means. Each DC/DC converter generates the most-appropriate voltage to the corresponding opposed electrode and applies it to the electrode.

[0041] One voltage applying unit may be used to apply the most-appropriate voltages to the opposed electrodes.

[0042] In the present embodiment, since the size of each pixel zone 32 of the main display area 30 is smaller than that of each pixel zone 33 of the sub display area 31, the voltage applied to the opposed electrode 13a of the main display area 30 is made lower than that applied to the opposed electrode 13b of the sub display area 31. In the present embodiment, for example, the voltage applied to the opposed electrode 13a of the main display area 30 is set to 3.7 V, and the voltage applied to the opposed electrode 13b of the sub display area 31 is set to 4.0 V.

[0043] As described above, different voltages are applied to the two opposed electrodes corresponding to two display areas having different-size pixel zones. In other words, in (c) of Fig. 5, V_{com} is changed according to the size of each pixel zone disposed in a display area to cancel out a difference between the voltage amplitudes in the positive and negative polarities.

Claims

1. An active-matrix liquid-crystal display apparatus comprising:

a pair of substrates disposed oppositely;

5 a liquid-crystal layer sandwiched by said pair of substrates;
a plurality of scanning lines and a plurality of signal lines formed in a matrix manner in a two-level-crossing
fashion on one of said pair of substrates;
thin-film transistors having gate electrodes connected to said plurality of scanning lines, and pixel electrodes
and storage capacitors connected to said thin-film transistors, all of which disposed in the vicinity of two-level-
crossing portions formed by said plurality of scanning lines and said plurality of signal lines;
10 a main display area and a sub display area having different-size pixel zones enclosed by said plurality of scan-
ning lines and said plurality of signal lines; and
opposed electrodes formed on the surface close to said liquid-crystal layer, of the other, serving as an opposed
substrate, of said pair of substrates,
15 wherein one opposed electrode is disposed oppositely to said main display area and the other opposed elec-
trode is disposed oppositely to said sub area.

2. An active-matrix liquid-crystal display apparatus according to Claim 1, wherein the size of each pixel zone in said
20 main display area is smaller than that of each pixel zone in said sub display area.

3. An active-matrix liquid-crystal display apparatus according to Claim 1 or 2, further comprising voltage applying
means for applying different voltages to the opposed electrode disposed oppositely to said main display area and
to the opposed electrode disposed oppositely to the sub display area.

4. An active-matrix liquid-crystal display apparatus according to Claim 1, 2 or 3,
25 wherein the size of each pixel zone in said main display area is smaller than that of each pixel zone in said sub dis-
play area, and

said voltage applying means applies a lower voltage to the opposed electrode disposed oppositely to said main
display area than a voltage applied to the opposed electrode disposed oppositely to said sub display area.

FIG. 1

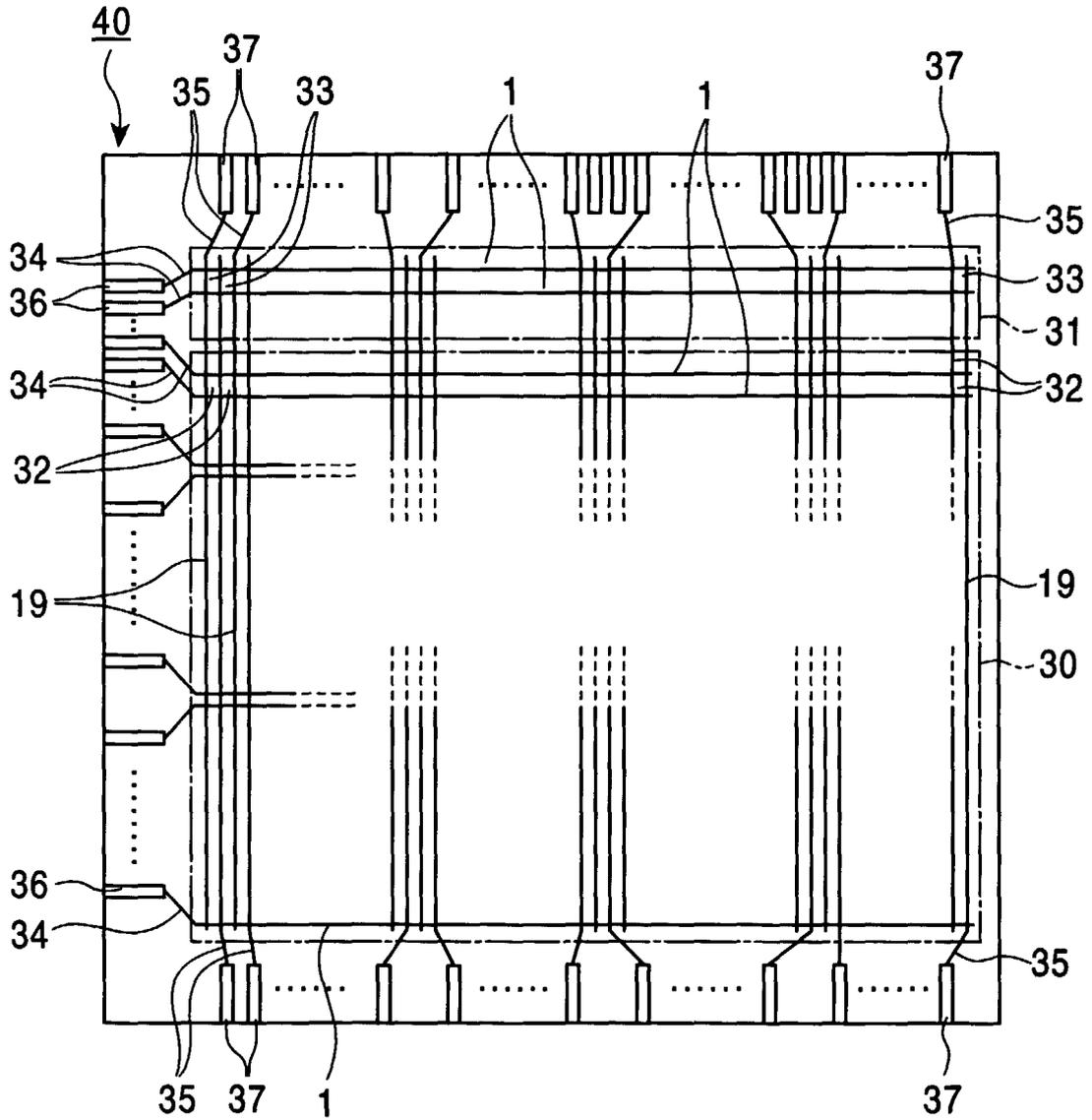


FIG. 2

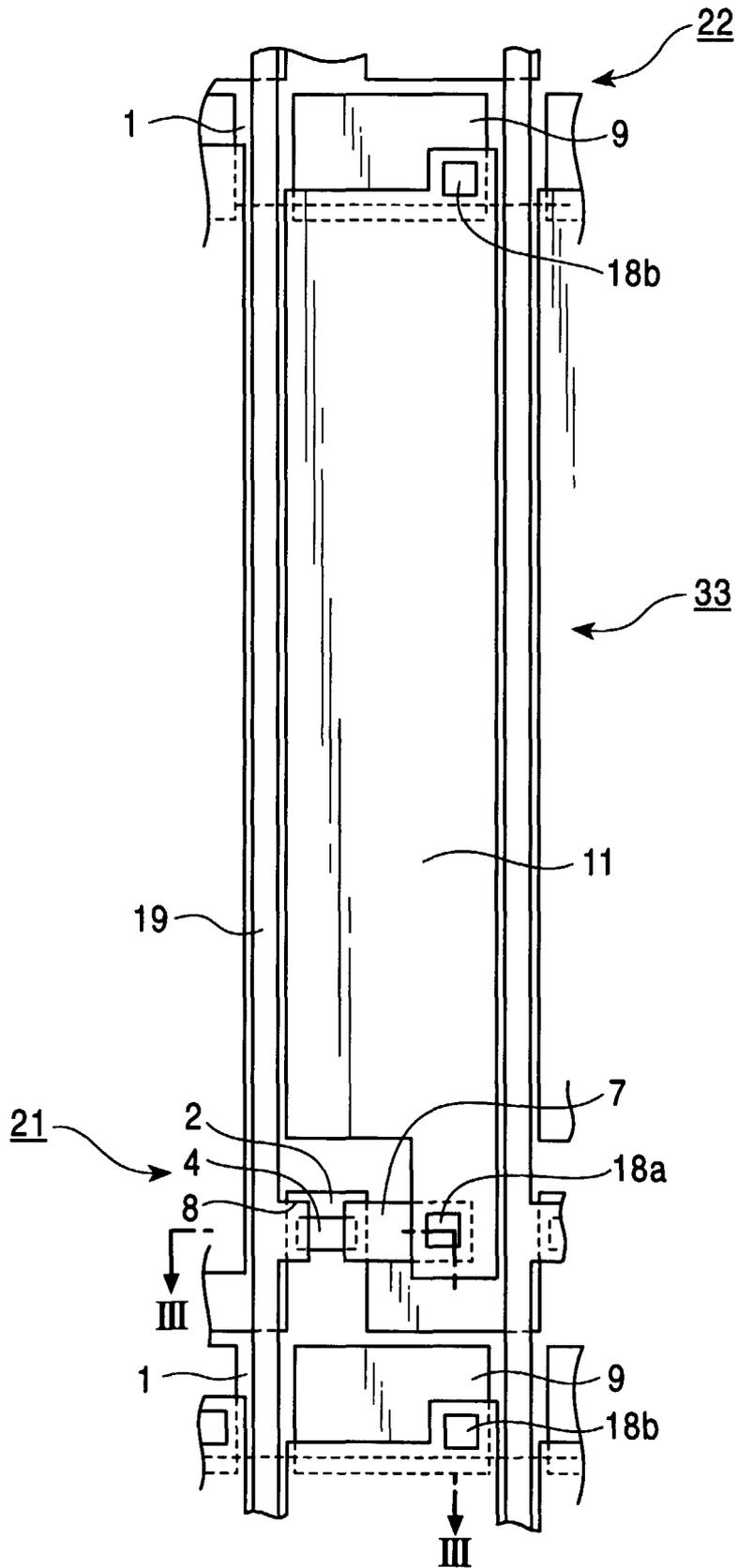


FIG. 4

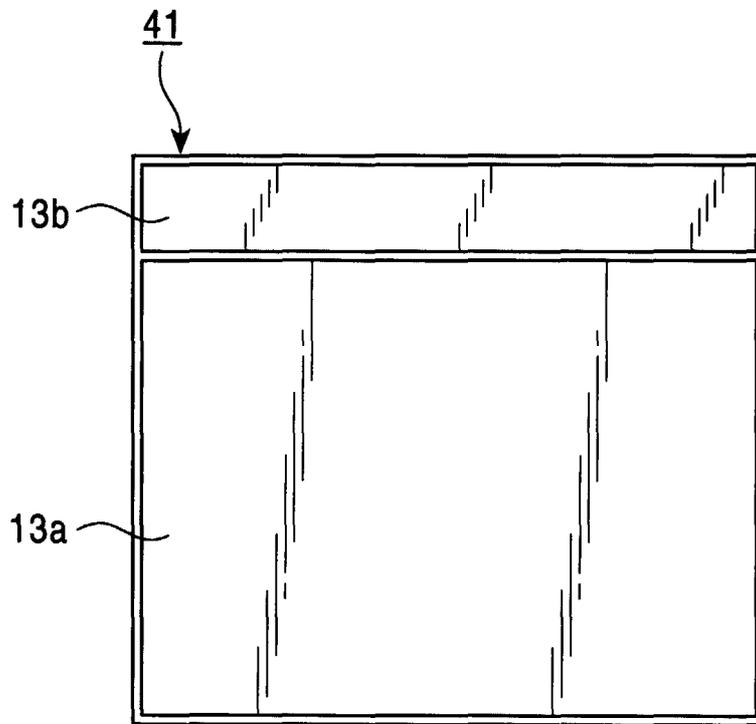


FIG. 5

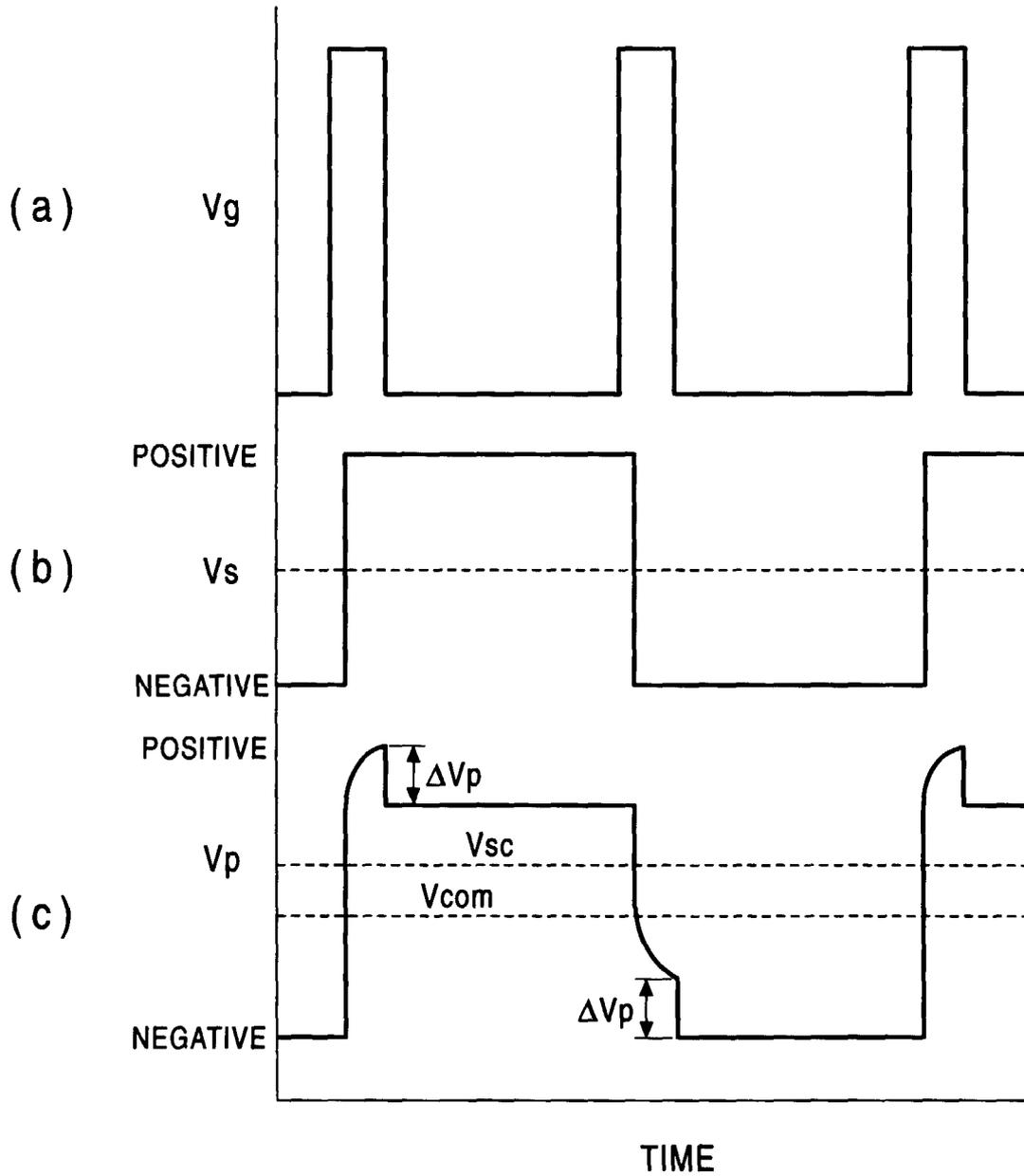


FIG. 6
PRIOR ART

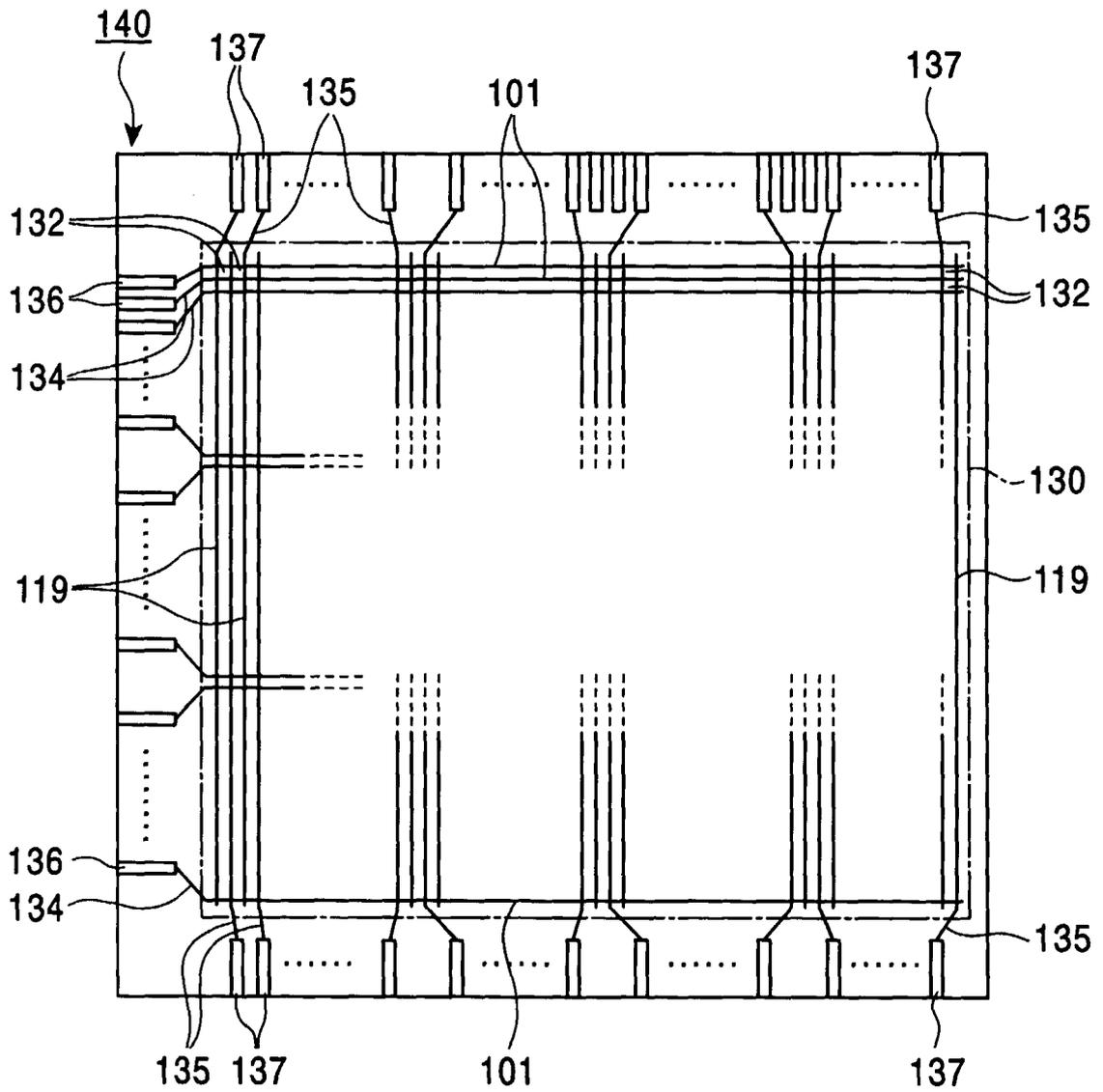
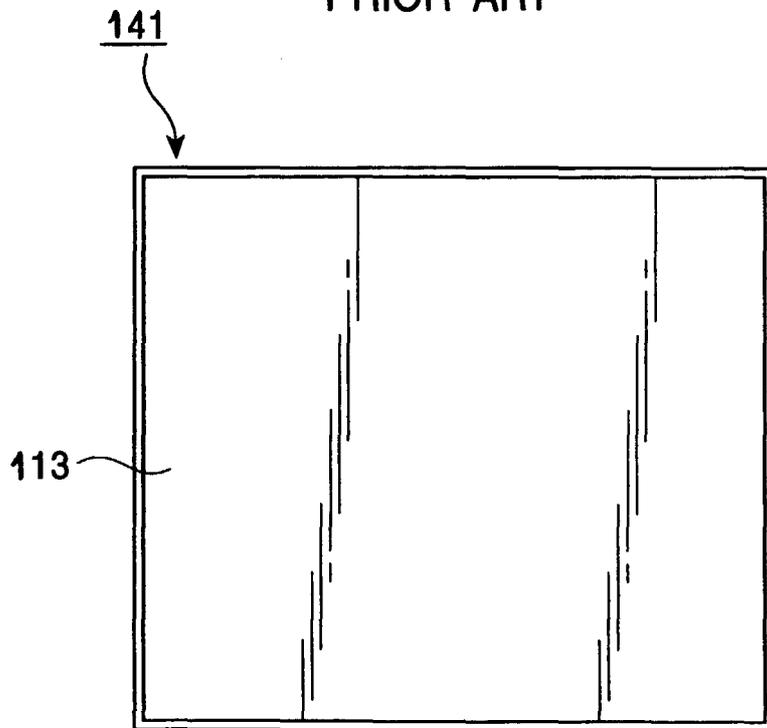


FIG. 7
PRIOR ART



专利名称(译)	有源矩阵液晶显示装置，可防止闪烁		
公开(公告)号	EP1093009A2	公开(公告)日	2001-04-18
申请号	EP2000306528	申请日	2000-07-31
[标]申请(专利权)人(译)	阿尔卑斯电气株式会社		
申请(专利权)人(译)	ALPS ELECTRIC CO., LTD.		
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发明人	NAKANO, AKIRA		
IPC分类号	G02F1/133 G02F1/1343 G02F1/136 G02F1/1368 G09F9/30 G09G3/20 G09G3/36 G02F1/1362		
CPC分类号	G02F1/134336 G02F1/13306 G02F2001/133391 G02F2201/121 G02F2201/123 G09G3/3655 G09G3/3666 G09G2320/0219 G09G2320/0247 G09G2320/0257		
优先权	1999292967 1999-10-14 JP		
其他公开文献	EP1093009A3		
外部链接	Espacenet		

摘要(译)

相对于有源矩阵液晶显示装置中的主显示区域 (30) 和子显示区域 (31) 分别设置相对的电极 (13a , 13b)。根据设置在每个显示区域中的每个像素区域的尺寸，将最合适的电压施加到对应于主显示区域的对置电极和对应于子显示区域的对置电极。

