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(54) **LIQUID CRYSTAL DISPLAY**

(76) Inventor: **Hiroshi Komatsu**, Kumi-shi (KR)

Correspondence Address:
LONG ALDRIDGE & NORMAN LLP
Sixth Floor
701 Pennsylvania Avenue, N.W.
Washington, DC 20004 (US)

(57) **ABSTRACT**

A liquid crystal display including: a first transparent sub-
strate coated with a first alignment layer, a second transpar-
ent substrate coated with a second alignment layer, the
second substrate facing the first transparent substrate, a
liquid crystal layer between the substrates, a polarizer
attached on the outer surfaces of the substrates, a pair of
electrodes formed on the first substrates, and a driving
circuit applying signal voltage to the electrodes. The liquid
crystal molecules adjacent to the first substrate is rotated by
applying the voltage, but, the liquid crystal molecule adja-
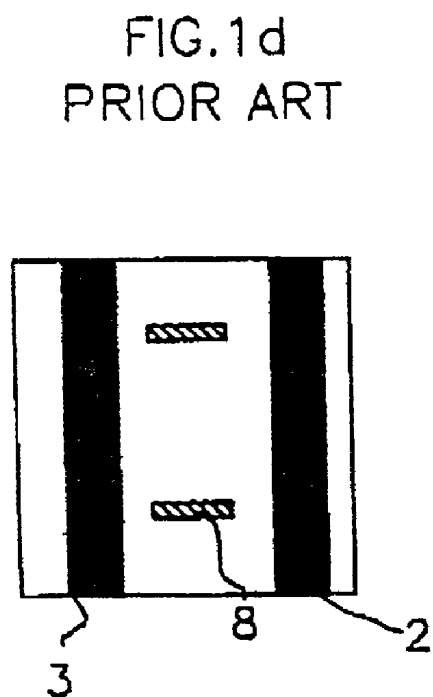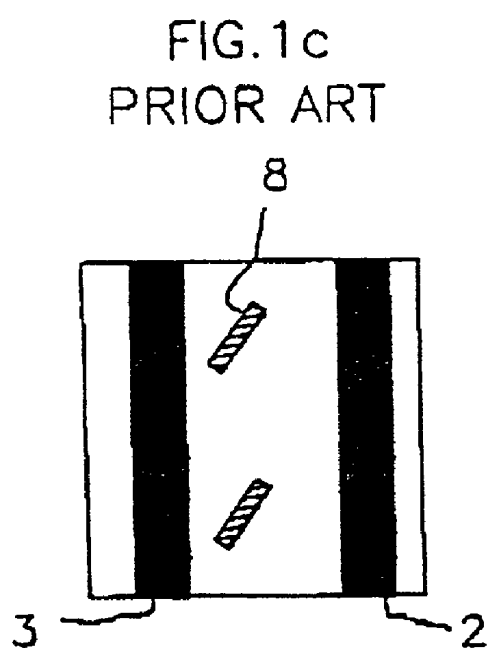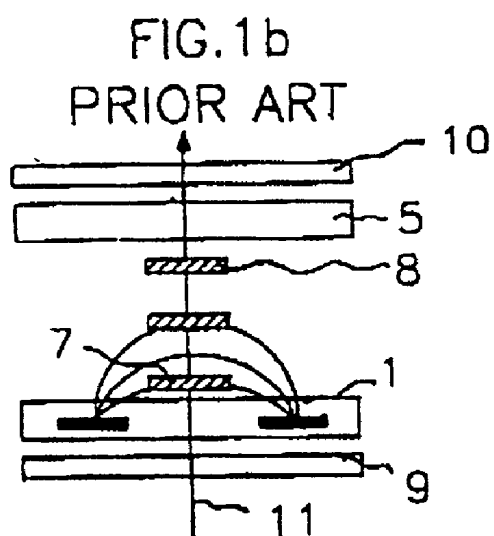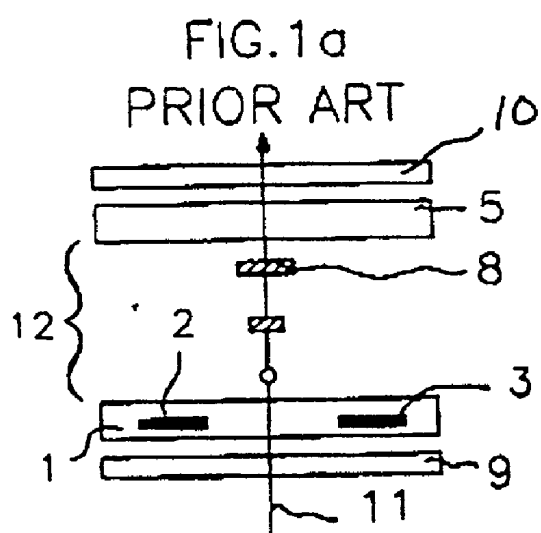cent to the second substrate is fixed regardless of the applied
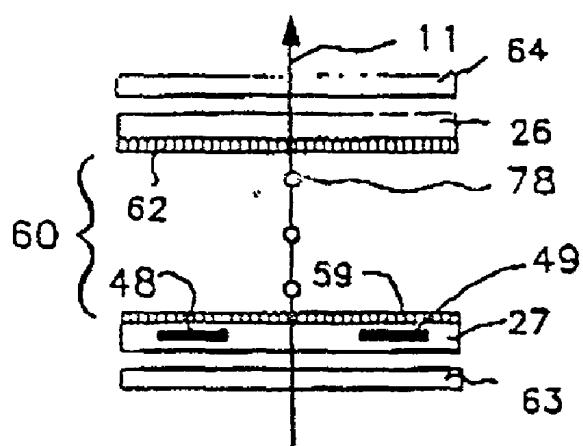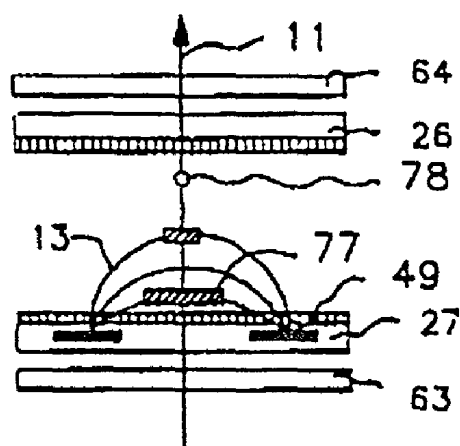voltage.

FIG.1a
PRIOR ART

FIG.1b
PRIOR ART

FIG.1c
PRIOR ART

FIG.1d
PRIOR ART

FIG.2a

FIG.2b

FIG.2c
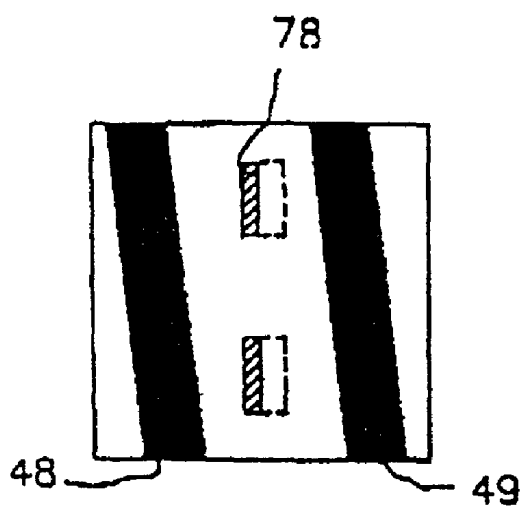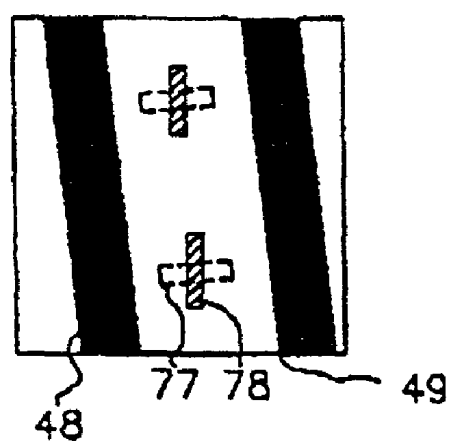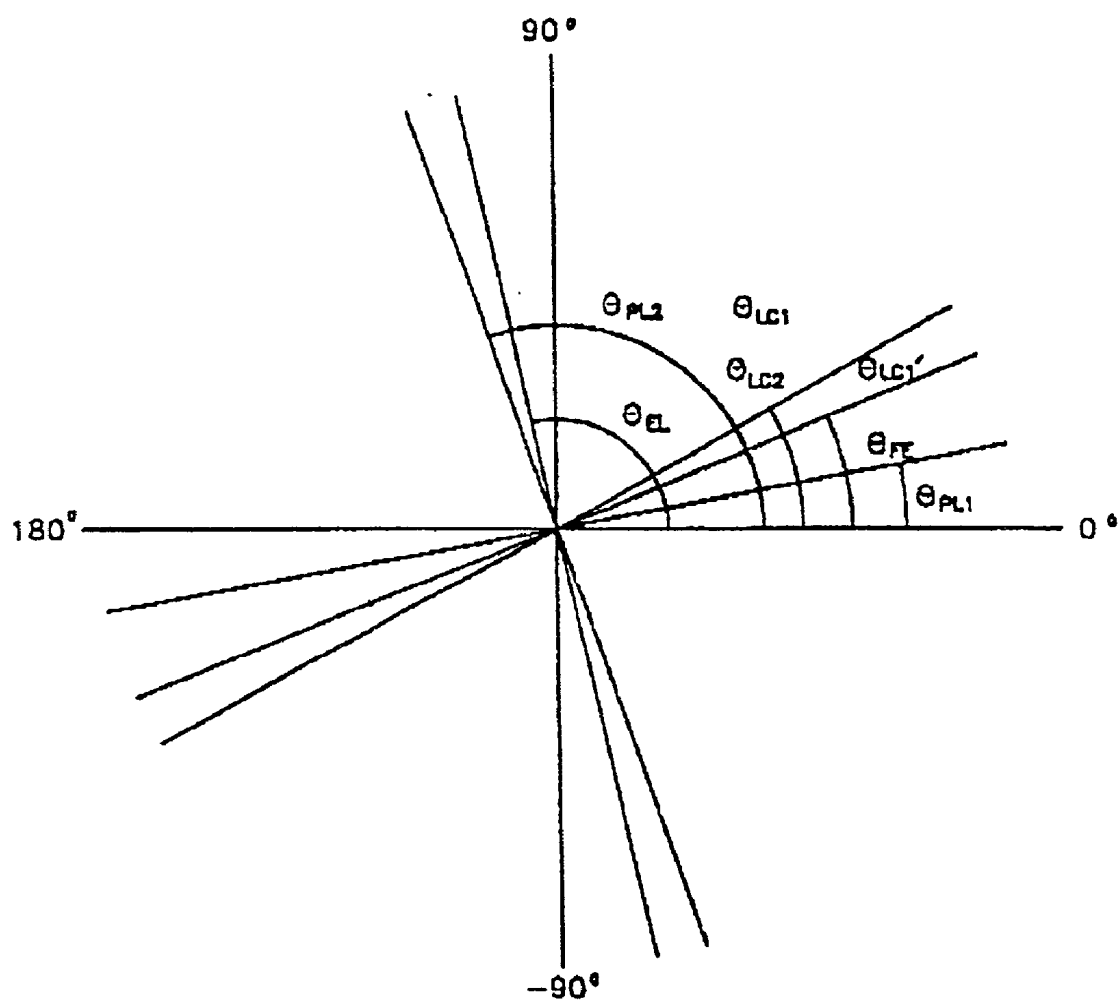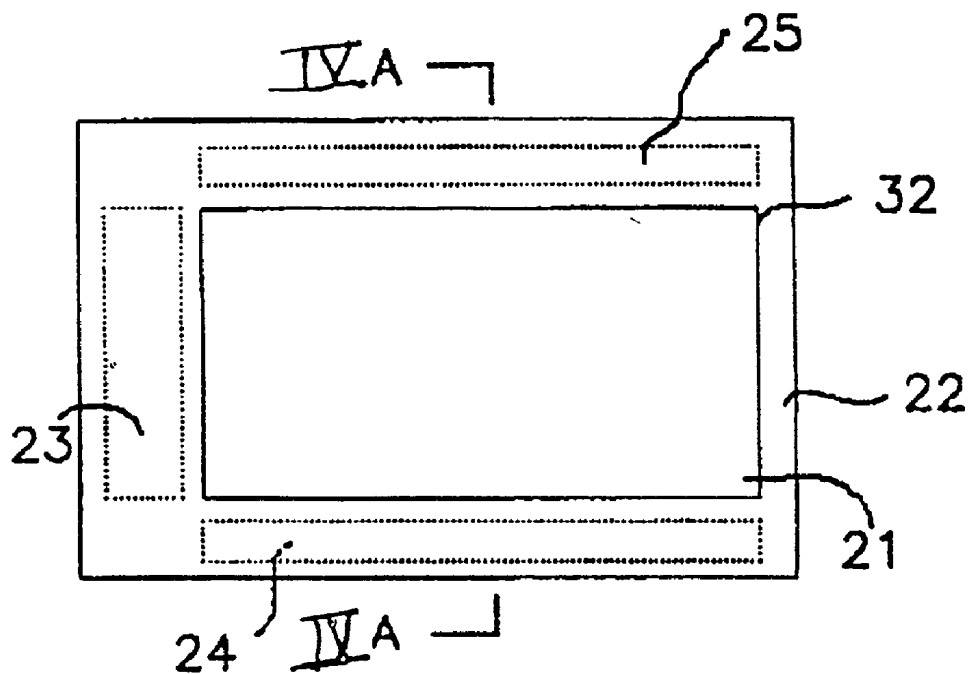
FIG.2d

FIG.3

FIG.4a

FIG.4b

FIG.5

FIG.6

FIG.7

FIG.8

Data Voltage Amplitude V_D
(volts)
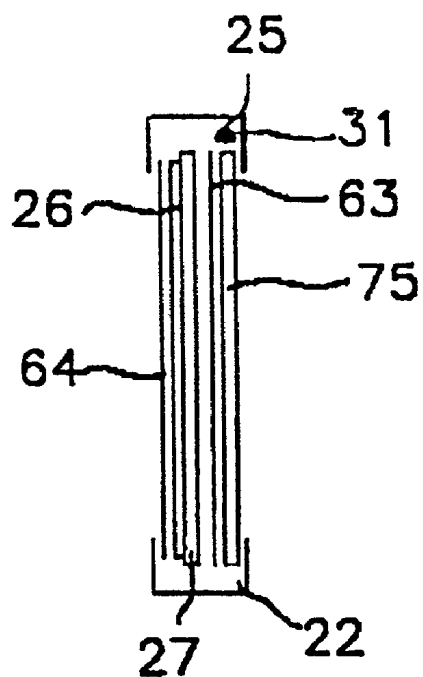
LIQUID CRYSTAL DISPLAY

[0001] This application claims the benefit of Korean Application No. 10152/1996 filed on Apr. 4, 1996, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a liquid crystal display, and more particularly to an IPS(In-Plane Switching) liquid crystal display that is large in area and exhibits a wide viewing angle.

[0004] Conventional TFT LCD (thin film transistor liquid crystal display) has a drawback known as a viewing angle dependency, that is, the contrast ratio is changed according to the viewing angle. This has made it difficult to apply the technology to a large size display.

[0005] To solve this problem, various liquid crystal displays are proposed such as a retardation attaching TNLCD (twisted nematic liquid crystal display) and a multi-domain liquid crystal display. These LCDs still have other technical problems such as complicated production process and shifting color tones.

[0006] 2. Discussion of the Related Art

[0007] Recently, IPS LCD has been introduced to obtain a wide viewing angle. This technology is discussed in JAPAN DISPLAY 92, p547, Japanese patent application No. 7-36058, Japanese patent application No. 7-225538, and ASIA DISPLAY 95, p707. As shown in **FIG. 1**a and **FIG. 1**c, in the liquid crystal layer **12** the molecules are aligned at a 45° angle. The principle transmittance axis of a polarizer **9** attached to the first substrate **1** is the same direction as the alignment direction of the liquid crystal **12**, and the principle transmittance direction of an analyzer **10** attached to the second substrate **5** is perpendicular to the alignment direction of the liquid crystal layer **12**. A pair of electrodes **2,3** is formed on the first substrate **1**.
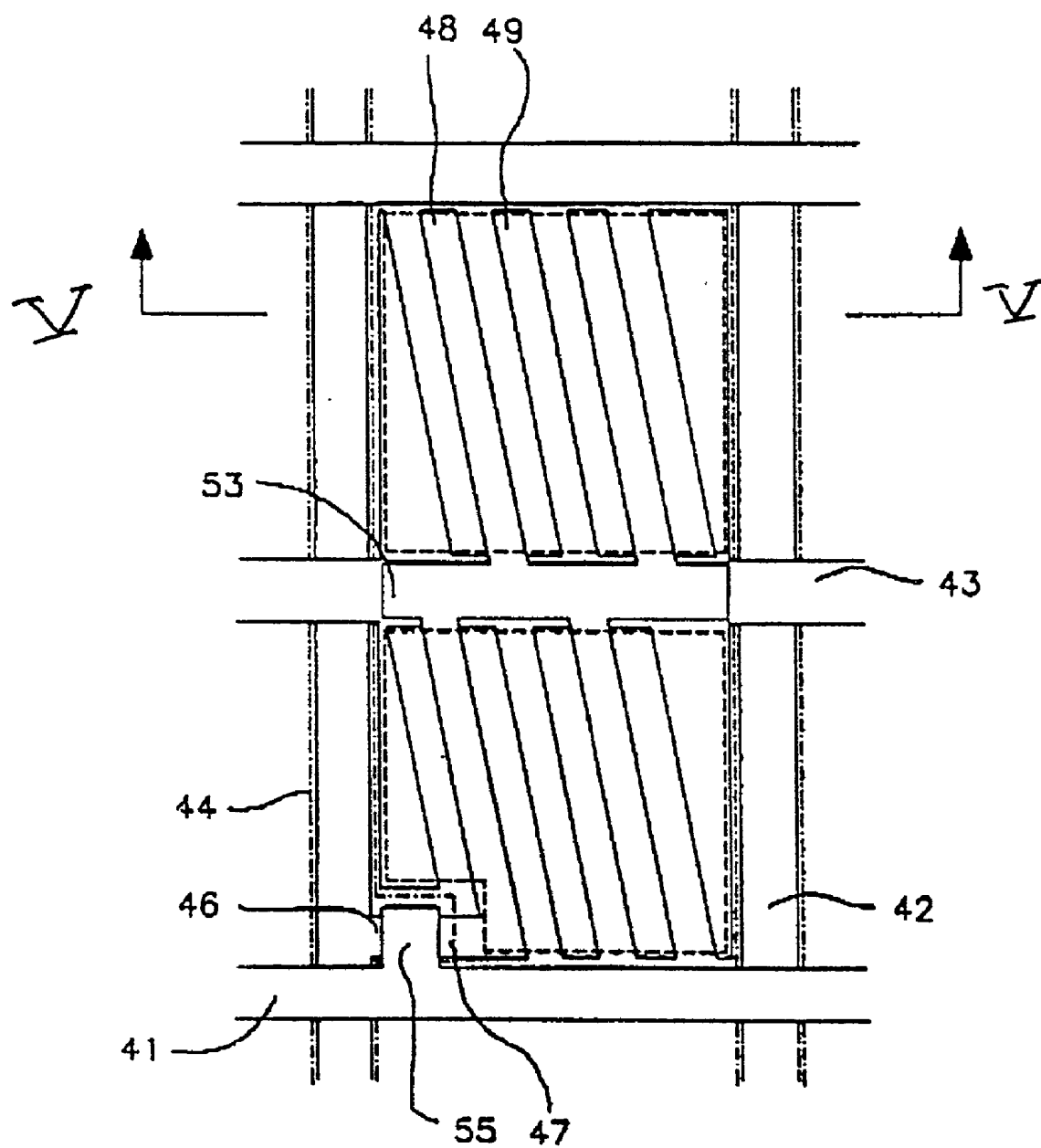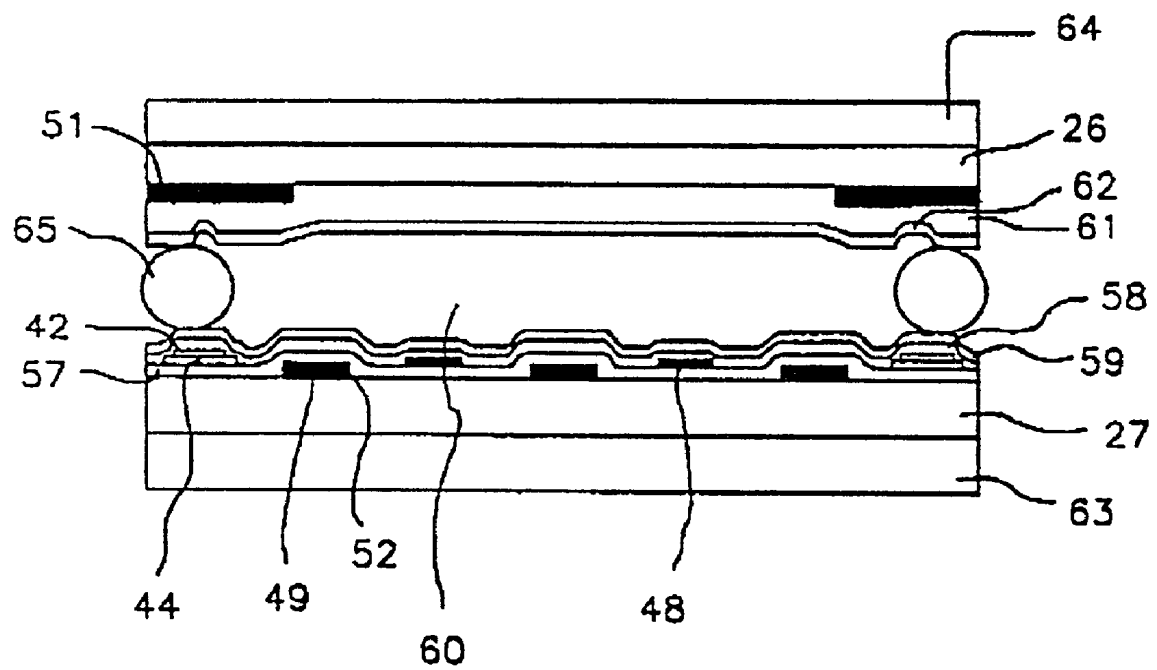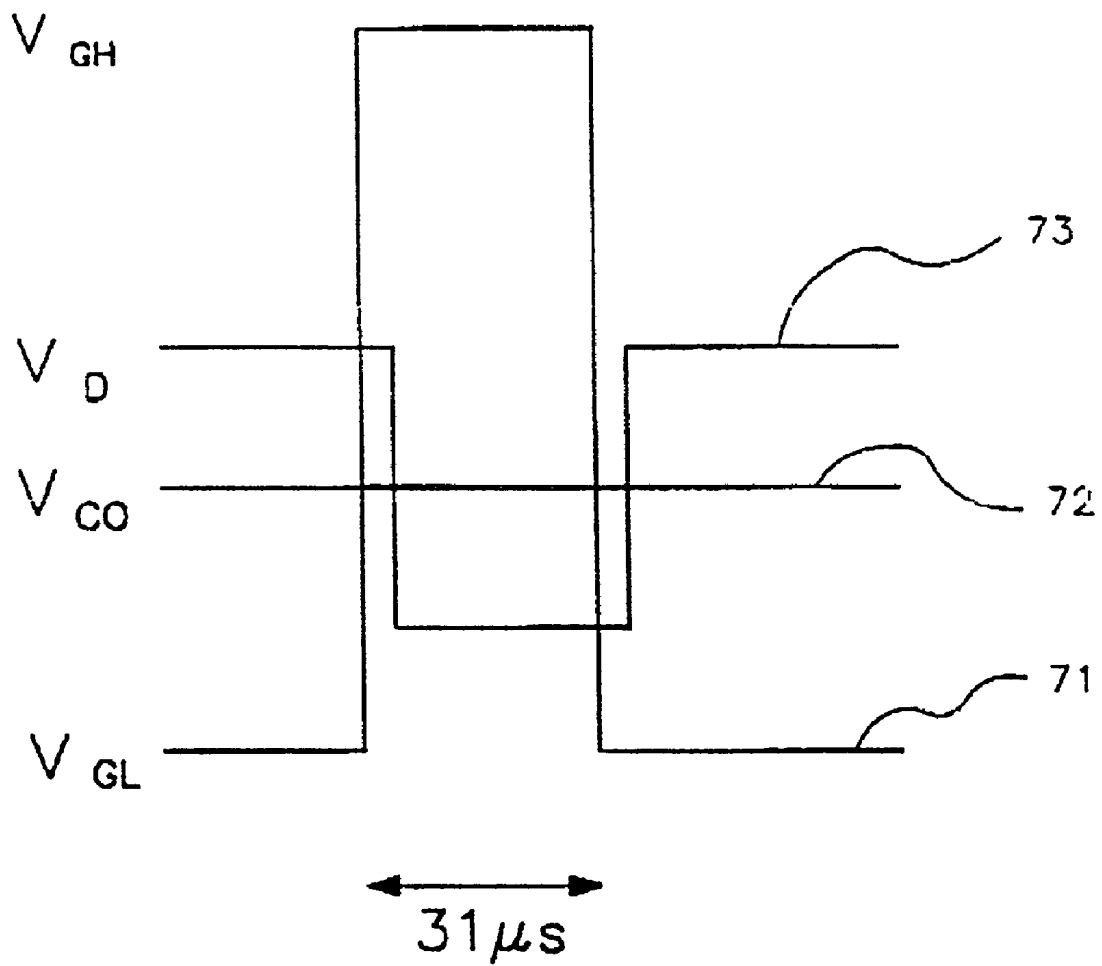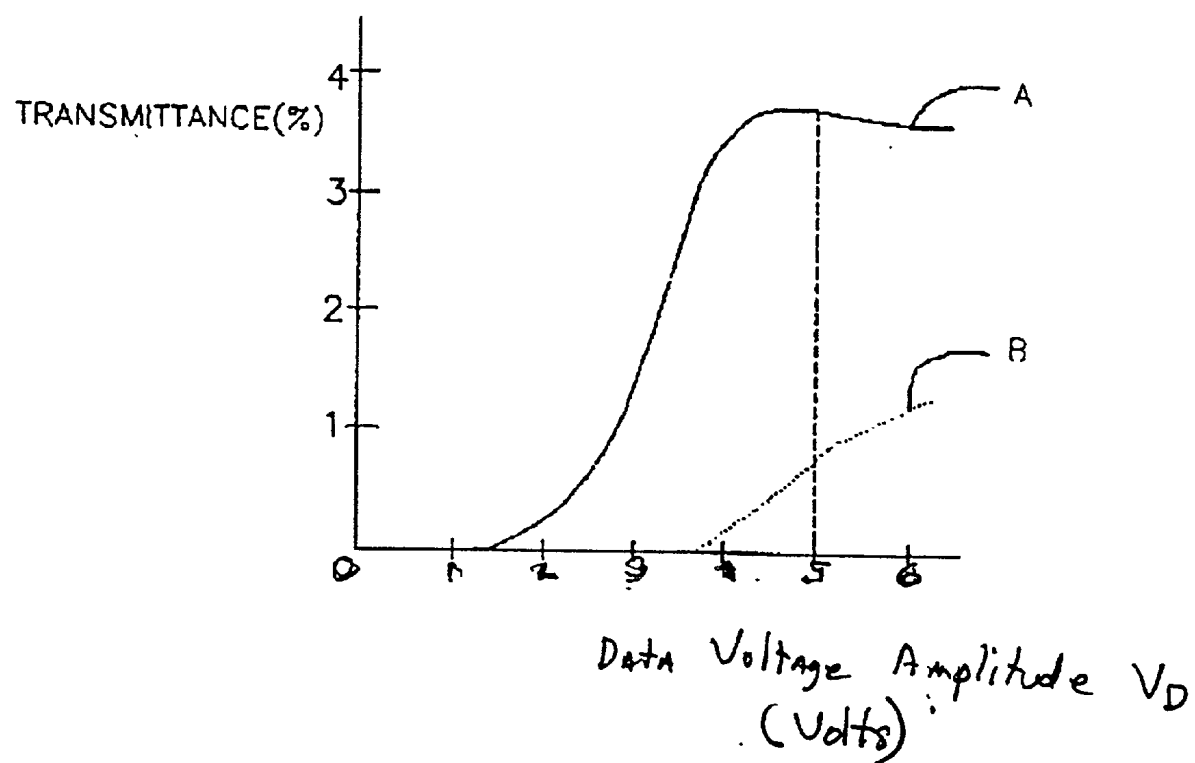
[0008] In **FIG. 1**b and **FIG. 1**d, when the voltage is applied between two electrodes, a horizontal electric field is created. Therefore, the transmittance is controlled by causing the liquid crystal molecules to be rotated to be parallel with the electric field. When the rotation angle of the liquid crystal molecules is 45° in the normally black mode, the retardation value(And) is about $\lambda/2$(**0.21-0.36** μm) for a maximum transmittance.

[0009] In conventional IPS LCDs as described above, the transmittance is controlled by birefringence, and a retardation film is necessary to compensate for the viewing angle which increases the manufacturing cost.

[0010] In addition, a viewing angle inverted area appears in the central portion of the outer lines of the display.

SUMMARY OF THE INVENTION

[0011] Accordingly, the present invention is directed to a liquid crystal display that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

[0012] An object of the present invention is an IPS mode liquid crystal display having a wide viewing angle and improved picture quality.

[0013] Another object of the present invention is an IPS mode liquid crystal display that can be fabricated at low cost by using a low voltage driving IC and by eliminating the need for a retardation film.

[0014] Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0015] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, the liquid crystal display device of the present invention includes a first substrate having a first surface and a second surface, a first alignment layer formed on the second surface of the first substrate, a second substrate having a first surface and a second surface, a second alignment layer formed on the second surface of the second substrate, a molecular liquid crystal layer between the second surface of the first substrate and the second surface of the second substrate, a pair of electrodes formed in parallel on the second surface of the first substrate, a polarizer formed on the first surface of the first substrate and having a transmittance axis, and an analyzer formed on the second surface of the second substrate and having a transmittance axis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention. In the drawings:

[0017] **FIGS. 1**a, **1**b, **1**c, and **1**d schematically show cross-section and plan views of a pixel of a conventional liquid crystal display;

[0018] **FIGS. 2**a, **2**b, **2**c, and **2**d schematically show cross-section and plan views of a pixel of a liquid crystal display according to the present invention;

[0019] **FIG. 3** shows the optical axes of the liquid crystal display according to the present invention;

[0020] **FIG. 4**a shows a plan view of the liquid crystal display according to the present invention, and **FIG. 4**b shows a cross-section of the device taken along the line IVA-IVA of **FIG. 4**a;

[0021] **FIG. 5** shows a pixel electrode pattern according to the present invention;

[0022] **FIG. 6** shows a cross-sectional view taken along the line V-V of **FIG. 5**;

[0023] **FIG. 7** shows a driving wave pattern of a TFT LCD according to the present invention; and

[0024] **FIG. 8** shows the relationship between the wave length of data voltage and the transmittance of a TFT LCD according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

[0026] The liquid crystal display device of the present invention, as described below, comprises a first transparent substrate, a second transparent substrate facing the first transparent substrate, an alignment layer coated on the substrates, a liquid crystal layer injected between the substrates, a polarizer attached on the outer surfaces of the substrates; a pair of electrodes formed on the first substrates, and a driving circuit applying a signal voltage to the electrodes. Liquid crystal molecules adjacent to the first substrate are rotated by applying the voltage, however, liquid crystal molecules adjacent to the second substrate are fixed regardless of the applied voltage.

[0027] An embodiment of the display according to the present invention is shown in **FIGS. 2a-2d.** **FIG. 2a** and **FIG. 2c** are a cross-sectional view and a plan view, respectively, when a driving voltage is not applied to the display and **FIGS. 2b** and **2d** are a cross-sectional view and a plan view, respectively, when the driving voltage is applied.

[0028] When the driving voltage is not applied, the liquid crystal molecules adjacent to the first substrate **27** are aligned with the liquid crystal molecules near the second substrate **26** as shown in **FIGS. 2a** and **2c**. The liquid crystal molecules adjacent to the substrates are aligned by the alignment directions induced on alignment layers **59, 62.**

[0029] The liquid crystal molecules **60** will be twisted between the two substrates **26, 27** by applying the driving voltage to the electrodes **48, 49.** The distance between two adjacent electrodes **48, 49** is less than the thickness of the liquid crystal layer **60.** The retardation value is calculated by following formula:

$$\lambda/2 < \Delta nd < \lambda.$$

[0030] Wherein, Δn is the dielectric anisotrophy, d is the thickness of the liquid crystal layer, and λ is referred as a wave length.

[0031] In addition, when the horizontal line of the liquid crystal display is 0° the angle of the electric field(θ_{FE}) applied by the electrodes is according to the following formula:

[0032] $$0° < \theta_{FE} < 90°,$$

$$0° < \theta_{FE} < -90°$$

[0033] **FIG. 3** shows optical axes of the liquid crystal display according to the present invention. θ_{EL} is represented as the extension direction of the electrodes **48** and **59,** θ_{FE} is the electric field direction applied by the electrodes, θ_{LC1} is the optical axis direction of the liquid crystal molecules adjacent to the first substrate and θ_{LC2} is the optical axis direction of the liquid crystal molecules adjacent to the second substrate when the voltage is not applied. θ_{PL1} is the principle transmission axis of a polarizer, θ_{PL2} is the principle transmission axis of an analyzer, θ_{LC1}' is the optical axis direction of the liquid crystal molecules adjacent to the first substrate when the voltage is applied. The alignment direction θ_{LC1} of the first substrate is anti-parallel to the alignment direction θ_{LC1} of the second substrate, and the

principle transmission axis θ_{PL2} of the analyzer is parallel to the alignment directions θ_{LC1}, θ_{LC2}. In addition, the principle transmission axis θ_{PL1} of the polarizer is perpendicular to the principle transmission axis θ_{PL2} of the analyzer.

[0034] The extension direction of the electrodes, θ_{EL}, is slightly slanted compared to the conventional extension direction which is 90° relative to the horizontal line 0° of the substrate as shown in **FIG. 3**.

[0035] By forming the electrodes on the slant, when the voltage is not applied, all of the liquid crystal molecules between the two alignment layers **59, 62** are aligned parallel to the substrates **26, 27** and to the principle transmission axis θ_{PL2} of analyzer. Therefore, the viewing angle inverted areas appear at the corners of the display so that the inverted phenomenon is not remarkable. The liquid crystal is nematic without the need to mix a chiral dopant. The LCD shown in **FIG. 2(a)** is a normally black mode because the polarizer and the analyzer are crossed and the liquid crystal molecules between them are parallel to one another.

[0036] One of the two electrodes **48** and **49** is called a data electrode and the other electrode is called a common electrode. The parallel electric field **13** is formed in the θ_{FE} direction by a signal voltage between the data electrode, e.g., electrode **48**, and the common electrode, e.g., the electrode **49.** The parallel electric field **13** has a maximum strength adjacent to the first substrate **27,** and a minimum strength adjacent to the second substrate **26.** In the middle of the liquid crystal layer **60,** the parallel electric field **13** has a mean strength defined by($E_M = (E_1 + E_2)/2$). The electric field is weaker as the distance increases from the first substrate formed with electrodes **48** and **49.** Irregularities in the electric field can be avoided by making the thickness of the liquid crystal layer greater than the interval between two electrodes.

[0037] The liquid crystal molecules **77** adjacent to the first substrate **27** are rotated to the electric field direction θ_{FE} by the maximum electric field. The rotation angle θ_{RT1} is determined by following formula: $\theta_{RT1} = \theta_{LC1} - \theta LC_1'$ and the maximum rotation angle is $\theta_{LC1} - \theta_{FE}$.

[0038] The liquid crystal molecules **78** adjacent to the second substrate **26** are subject to an electric field that is below the threshold electric field so that the molecules retain the original direction θ_{LC2}. In this manner, the liquid crystal molecules are continuously twisted between the two substrates **26, 27.** Polarized light having a polarized direction θ_{PL1} of polarizer **63** is guided by the twisted liquid crystal molecules **60** to the perpendicular direction parallel with the principle transmittance axis θ_{PL2} of the analyzer **64.** As a result, a white state is obtained by transmitting polarized light through the polarizer **63** and the analyzer **64.**

[0039] The transmittance is dependent on the twisted angle $\theta_{TW} = \theta_{LC2} - \theta_{LC1}'$, that is, the transmittance is increased in proportion to the degree of the twisted angle. A grey level of the liquid crystal display is controlled by the signal voltage inducing the liquid crystal molecules to be twisted.

[0040] To improve the viewing angle, the transmittance axis of the polarizer **63** is perpendicular to the transmittance axis of the analyzer **64** ($\theta_{PL1} = 0°$, $\theta_{PL2} = 90°$), and the alignment direction θ_{LC1} of the liquid crystal molecule **77** adjacent to the first substrate **27** is anti-parallel with the

alignment direction θ_{LC2} of the liquid crystal molecule **78** adjacent to the second substrate **26** (θ_{LC1}=90°, θ_{LC2}=−90°). In addition, the extension direction θ_{EL} is angularly offset (for example, θ_{EOL}=95°) from the electric field direction θ_{FE}, which is in a direction perpendicular thereto (for example θ_{FE}=5°) such that extensive direction θ_{EL} is slanted. The liquid crystal molecules **77** adjacent to the first substrate **27** are rotated from 90° to 5°, while the liquid crystal molecules **78** adjacent to the second substrate **26** are fixed, so that the rotation angle between the first substrate **27** and the second substrate **26** is 85°.

[0041] The retardation value Δnd, which provides a maximum transmittance to the liquid crystal layer **60**, is calculated according to the following formula: Δnd=0.74λ. The dielectric anisotrophy An and the thickness d of the liquid crystal are appropriately arranged. The dielectric anisotrophy of the liquid crystal generally used in TN mode is **0.06-0.08**, and the wave length of the light is 0.56 μm. When the values are substituted in the above formula, the thickness d should be **5.0-7.0** μm.

[0042] **FIG. 4a** shows a plan view of a liquid crystal display according to the present invention, and **FIG. 4b** shows a cross-sectional view taken along the line IVA-IVA of **FIG. 4a**. The area outside of the viewing area **21** is protected by a metal frame **22**, an area deposited with a driving circuit **23** for a gate line, a driving circuit **24** for a data line, and a back light housing **25** including a back light **31**. The viewing area or presentation unit **21** is shown in **FIG. 4b** to successively comprise a photoguide plate **75** including a photo-diffusion plate, a polarizer **63**, a first substrate **27**, a second substrate **26**, and an analyzer **64**. To compensate for the contrast ratio of the liquid crystal display, a retardation film can be deposited either between the polarizer **63** and the first substrate **27** or between the second substrate **26** and the analyzer **64**.

[0043] This invention can be adopted for use with a diode mode LCD using diodes instead of TFT, or a simple matrix LCD using a simple matrix substrate, as well as the TFT mode LCD which includes the first substrate **27** formed with a thin film transistor and the second substrate **26** formed with a color filter. In addition, this invention can be adopted to monochrome type LCD or TFT mode LCD, which includes the first substrate **27** formed with a color filter and the second substrate **26** formed with a thin film transistor.

[0044] **FIG. 5** is a plan view showing an electrode pattern for a pixel of the first substrate **27**. **FIG. 6** is a cross-sectional view of a liquid crystal display taken a line V-V of **FIG. 5**.

[0045] The liquid crystal panel is composed of two substrates **26, 27**, a liquid crystal layer **60** and a spacer **65** supporting the thickness of the liquid crystal layer. The substrates **26, 27** are coated with alignment layers **62, 59** on their respective inner surfaces and attached with polarizers **64, 63** on their respective outer surfaces. TFT **55** is formed between the first substrate **27** and alignment layer **59**, and a color filter **61** is formed between the second substrate **26** and the alignment layer **62**.

[0046] TFT **55** is formed in the intersection of a gate line **41** and a data line **42**, the gate line **41** extends horizontally (for example 0°) and the data line extends vertically (for example 90°). A common line **43** passes through the center of the pixel in a direction parallel to the gate line **41**. A

common electrode **49** extends from the common line **43** to the interior inside of the pixel area in a slanted direction relative to the data line **42**. The data electrode **48** is provided parallel to common electrode **49** in the pixel area and is connected to a drain electrode **47** of TFT **55**.

[0047] A AlTa thin layer (for example Ta content about 3%) with a thickness of about 0.3 μm thick is photo etched to pattern the gate line **41**, common line **43** and common electrode **49**. Then, an AlTa oxidation layer **52** is formed to a thickness of about 0.1 μm by anodizing the surface of the AlTa thin layer. Both a gate insulation thick film layer **57** of about a 0.3 μm of SiNx and an amorphous silicon (a-Si) layer **44** are patterned by a plasma chemical vapor deposition method. A Cr thin layer about 0.1 μm thick is deposited by a sputtering method and photoetched to form the data line **42**, a source electrode **46**, and a drain electrode **47** of the TFT **55**, and the data electrode **48**. The TFT **55** is completed by removing the N+ silicon layer within the channel of the TFT **55**. The intersection of the common line **43** and data electrode **48** forms a storage capacitor **53**, to support an electric charge (voltage) for each pixel. Finally, a SiNx passivation layer **58** (0.2 μm thickness) is deposited on the entire surface.

[0048] A black matrix **51** and a color filter **61** are formed on the second substrate **26**. It is also possible to deposit an overcoat layer on the black matrix **51** and the color filter **61** to provide stability and flatness for the surface. The black matrix **51** is formed with a thin layer of width less than 10 μm, for example, 0.1 μm thick Cr/CrOx, on the area of the gate line **41**, the data line **42**, and common line **43** to prevent leakage of light therefrom. The color filter **61** is repeatedly formed with R,G,B layers in each pixel area.

[0049] In the above structure, the extension line θ_{EL} is disposed 95° relative to the horizontal line (0°), such that the electric field direction θ_{FE} is 5°. The extension line is extended from the 5 μm width data electrode **48** and the 5 μm width common electrode **49**, which are parallel to each other with a 5 μm space therebetween.

[0050] The alignment layers **59, 62** coated on the first and second substrates **27, 26** are obtained by coating, for example, RN1024 (produced in NISSAN CHEMICAL CO.) to a thickness of about 0.08 μm and baking. The alignment layer **59** coated on the first substrate **27** is rubbed in the −90° direction, and the alignment layer **62** coated on the second substrate **26** is rubbed in the 90° direction. The spacer **65** can be formed from Micropal(produced in SEKISUI FINE CHEMICAL CO.) with an exemplary 6.4 μm diameter, to maintain the liquid crystal layer **60** with a mean thickness of 6.2 μm. The liquid crystal material can be ZGS 5025(Δn= 0.067; Δε=6.0; produced by CHISSO CO.). The pretilt angle of the liquid crystal is 4.8°, and the retardation value Δnd is 0.41.

[0051] The principle transmittance axis of the polarizer **63** attached on the first substrate **27** is the horizontal direction (θ_{PL1}=0°) and that of the analyzer **64** attached on the second substrate **26** is the vertical direction (θ_{PL2}=90°).

[0052] The interval (horizontal spacing) between the data electrode **48** and common electrode **49** is less than the

thickness of liquid crystal layer **60**. The retardation value of the liquid crystal layer is satisfied with the following formula:

$$\lambda/2 < \Delta nd \leq \lambda,$$

[0053] wherein, Δn is a dielectric anisotrophy of the liquid crystal, d is the thickness of the liquid crystal, and λ is the wave length of the light.

[0054] The electric field direction is satisfied with the following formula:

$$0° < \theta_{FE} < 90°.$$

[0055] The electro optical characteristics of the above mentioned described TFT LCD are evident with reference to **FIG. 7** and **FIG. 8**.

[0056] **FIG. 7** shows the driving voltage pulse of the LCD fabricated according to the present invention, wherein, the LCD has a 12.1 inch screen, a 480×640 (R.G.B) array of pixels. The gate voltage V_G **71** is V_{GH}=20V, V_{GL}=0V, the width of the pulse=31 μs, and the common voltage V_{CO} **72** is 8V direct voltage. In addition, the data voltage V_D **73** is a monowave signal with a pulse width of 31 μs, of which the maximum voltage is 6V, the minimum voltage is 1V, and 5V is controlled in the signal area.

[0057] **FIG. 8** is a graph showing the relationship between the amplitude of the data voltage V_D and the transmittance of the liquid crystal panel. The transmittance has a maximum value of 3.6% near the 5V data voltage amplitude. The dotted line shows the transmittance of the LCD in which the interval (spacing) between two electrodes is 10 μm and the thickness of the LC layer is 6.5 μm (the interval>the thickness). The transmittance is increasing at 6V, and is ¼of that illustrated by a solid line corresponding to the LCD of the present invention as described herein. Therefore, the LCD according to the present invention has a high transmittance despite the use of a low driving voltage.

[0058] The rotation angle of the liquid crystal layer is detected by an evaluator for LCD (produced in NIHON DENSHI CO.). The results show that the liquid crystal molecules adjacent the second substrate **26** have a transmittance axis of 88°, and the liquid crystal molecules adjacent to the first substrate **27** have a transmittance axis of 19°. It can be understood that the alignment direction of the liquid crystal molecules near the second substrate **26** is almost fixed, but the alignment direction of the liquid crystal molecules near the first substrate **27** is rotated about the anticipated angle of 16°. Therefore, the liquid crystal molecule is twisted in the liquid crystal layer.

[0059] The driving voltage is in the range of 1.8V-5.0V, the viewing angle is over ±70° in the vertical direction and over ±70° in the horizontal direction, wherein the contrast ratio is over 5:1, In this range, the gray level is not inverted. Accordingly, this LCD is remarkably improved in both vertical and horizontal viewing, can be used with a standard 5V driving IC, and has a front contrast ratio of 120:1.

[0060] The embodiments of the present invention have been described as having a 95° electric field extension line as a example. However, the direction can be selected according to the viewing angle characteristics that are required.

[0061] In addition, the alignment layers for the substrates need not be the same. For example, the alignment layer for the first substrate **27** can be materials that have a low anchoring energy to allow easy rotation of the adjacent liquid crystal molecules according to the applied driving voltage. The alignment layer for the second substrate **26** can be a polyamic-based material having a high anchoring energy liquid crystal molecules to inhibit rotation under the influence on applied electric field.

[0062] The present invention provides an LCD in which the data line and the common line are deposited in a slanted orientation so that the viewing angle is improved. This provides a large rotation angle for the liquid crystal molecules to permit the thickness of the liquid crystal layer to be increased, so that a standard (low voltage) driving IC can be used. In addition, a twisted nematic structure can be easily used in an IPS mode LCD without using a retardation film. Reliability is improved by using conventional twisted nematic liquid crystal.

[0063] It is to be understood that the form of the preferred embodiments of the present invention shown and described herein are to be taken as a preferred examples of the same and that various modifications and applications may be resorted to without departing from the spirit of the present invention or the scope of the appended claims.

[0064] It will be apparent to those skilled in the art that various modifications and variations can be made in the liquid crystal display of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A liquid crystal display device comprising:

a first substrate having a first surface, a second surface, and a reference line;

a first alignment layer formed on the second **5** surface of the first substrate;

a second substrate having a first surface and a second surface;

a second alignment layer formed on the second surface of the second substrate;

a molecular liquid crystal layer between the second surface of the first substrate and the second surface of the second substrate; and

a pair of electrodes formed in parallel on the second surface of the first substrate.

2. A liquid crystal display device according to claim 1, further including:

a polarizer formed on the first surface of the first substrate and having a transmittance axis; and

an analyzer formed on the first surface of the second substrate and having a transmittance axis.

3. A liquid crystal display device in accordance with claim 1, wherein the molecules of the liquid crystal layer adjacent to the second surface of the first substrate are aligned parallel to the reference line of the first substrate.

4. A liquid crystal display device in accordance with claim 1, wherein the molecules of the liquid crystal layer adjacent

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to the second surface of the first substrate are aligned perpendicular to the reference line of the first substrate.

5. A liquid crystal display device in accordance with claim 1, wherein the distance between the electrodes i n less than the thickness of the liquid crystal layer.

6. A liquid crystal display device in accordance with claim 2, wherein the transmittance axis of the polarizer is perpendicular to the transmittance axis of the analyzer.

7. A liquid crystal display device in accordance with claim 2, wherein the transmittance axis of the polarizer is parallel with the alignment direction of the liquid crystal molecules adjacent to the second surface of the first substrate.

8. A liquid crystal display device in accordance with claim 2, wherein the first substrate has a reference line and wherein the electrodes are formed at an angle of θ_{EL} with respect to the reference line of the first substrate, and wherein $0°<\theta_{EL}<90°$.

9. A liquid crystal display device in accordance with claim 8, wherein the angle θ_{EL} includes 85°.

10. A liquid crystal display device in accordance with claim 8, wherein $90°<\theta_{EL}<180°$.

11. A liquid crystal display device in accordance with claim 10, wherein the angle θ_{EL} includes 95°.

12. A liquid crystal display device in accordance with claim 2, wherein the liquid crystal layer has a retardation value Δnd in the range of $\lambda/2<\Delta$nd$<\lambda$ (wherein, Δn is the refractive anisotrophy, d is the thickness of liquid crystal layer, and λ is a wave length, wherein the retardation value Δnd of the liquid crystal includes 0.74λ.

13. A liquid crystal device in accordance with claim 2, wherein the first alignment layer is formed from a different material than the second alignment layer, and the material for the first alignment layer has a smaller anchoring energy with respect to liquid crystal molecules than the anchoring energy with respect to liquid crystal molecules of the material for the second alignment layer.

14. A liquid crystal display device in accordance with claim 2, wherein the material for the first alignment layer includes an inorganic material.

15. A liquid crystal display device comprising:

a first substrate having a first surface, a second surface, and a reference line, the second surface of the first substrate being coated with a first alignment layer;

a second substrate having a first surface and a second surface, the second surface of the second substrate facing the second surface of the first substrate;

a molecular liquid crystal layer between the second surface of the first substrate and the second surface of the second substrate;

a pair of electrodes formed on the first substrate, the electrodes being parallel to each other and angularly disposed by the angle $\theta_{EL}\neq0°$ with respect to the reference line of the substrate;

a polarizer attached to the first surface of the first substrate; and

an analyzer attached to the first surface of the second substrate.

16. A liquid crystal display device in accordance with claim 15, wherein an alignment direction of liquid crystal molecules adjacent to the first substrate is parallel to the reference line of the first substrate.

17. A liquid crystal display device in accordance with claim 15, wherein an alignment direction of liquid crystal molecules adjacent to the first substrate is perpendicular to the reference line of the first substrate.

18. A liquid crystal device in accordance with claim 15, wherein the polarizer has a transmittance axis perpendicular to a transmittance axis of the analyzer.

19. A liquid crystal display device in accordance with claim 15, wherein the polarizer has a transmittance axis parallel to the alignment direction of the liquid crystal molecules adjacent to the second surface of the first substrate.

20. A liquid crystal display device in accordance with claim 14, wherein the electrodes are formed at an angle of θ_{EL} with respect to the reference line of the first substrate and wherein the angle θ_{EL} includes $0°<\theta_{EL}<90°$.

21. A liquid crystal device in accordance with claim 20, wherein the θ_{EL} includes 85°.

22. A liquid crystal device in accordance with claim 15, wherein θ_{EL} includes $90°<\theta_{EL}<180°$.

23. A liquid crystal device in accordance with claim 21, wherein the angle θ_{EL} includes 95°.

24. A liquid crystal device in accordance with claim 15, wherein the liquid crystal layer has a retardation value Δnd and wherein $\lambda/2<\Delta$nd$<\lambda$(Δn is the refractive anisotrophy of the liquid crystal layer, d is the thickness of liquid crystal layer, and λ is a wave length of light, and wherein the retardation value Δnd of the liquid crystal is 0.74λ.

25. A liquid crystal device in accordance with claim 15, further including a second alignment layer on the second surface of the second substrate, the first alignment layer and the second alignment layer being made of different materials, and wherein the material of the first alignment layer has a smaller anchoring energy with respect to liquid crystal molecules than the anchoring energy of the material of the second alignment layer.

26. A liquid crystal display device in accordance with claim 15, wherein the material for the first alignment layer includes an inorganic material.

27. A liquid crystal display device in accordance with claim 15, wherein the distance between the electrodes is less than the thickness of the liquid crystal layer.

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专利名称(译)	液晶显示器		
公开(公告)号	US20010005253A1	公开(公告)日	2001-06-28
申请号	US09/768241	申请日	2001-01-25
[标]申请(专利权)人(译)	KOMATSU HIROSHI		
申请(专利权)人(译)	KOMATSU HIROSHI		
当前申请(专利权)人(译)	LG DISPLAY CO., LTD.		
[标]发明人	KOMATSU HIROSHI		
发明人	KOMATSU, HIROSHI		
IPC分类号	G02F1/133 G02F1/1343		
CPC分类号	G02F1/134363		
优先权	1019960010152 1996-04-04 KR		
其他公开文献	US6317183		
外部链接	Espacenet USPTO		

摘要(译)

一种液晶显示器，包括：涂有第一取向层的第一透明基板，涂有第二取向层的第二透明基板，面对第一透明基板的第二基板，基板之间的液晶层，附着在其上的偏振器基板的外表面，形成在第一基板上的一对电极，以及向电极施加信号电压的驱动电路。通过施加电压使与第一基板相邻的液晶分子旋转，但是，与所施加的电压无关地固定与第二基板相邻的液晶分子。

FIG.1a PRIOR ART

FIG.1b PRIOR ART

FIG.1c PRIOR ART

FIG.1d PRIOR ART