US 20030160928A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0160928 A1**

Ozawa et al. (43) **Pub. Date: Aug. 28, 2003**

(54) **LIQUID CRYSTAL DISPLAY AND ELECTRONIC DEVICE**

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(21) Appl. No.: **10/352,199**

(22) Filed: **Jan. 28, 2003**

(30) **Foreign Application Priority Data**

Jan. 29, 2002 (JP) 2002-019876
Dec. 20, 2002 (JP) 2002-369975

Publication Classification

(51) **Int. Cl.**^{7} **G02F 1/1337**
(52) **U.S. Cl.** **349/129**

(57) **ABSTRACT**

To provide a liquid crystal display capable of obtaining light and high-contrast display having a wide viewing angle in a transflective liquid crystal display. A liquid crystal display of the present invention employs a vertical alignment mode using a liquid crystal layer **50** that is vertically aligned in the initial alignment state, wherein a transparent display area T is disposed to surround the periphery of a reflective display area R in one dot, and an insulating film **21** is provided in the area that corresponds to the reflective display area R in the center of the dot, the insulating film **21** making the thickness of the liquid crystal layer **50** in the reflective display area R smaller than the thickness of the liquid crystal layer **50** in the transparent display area T.

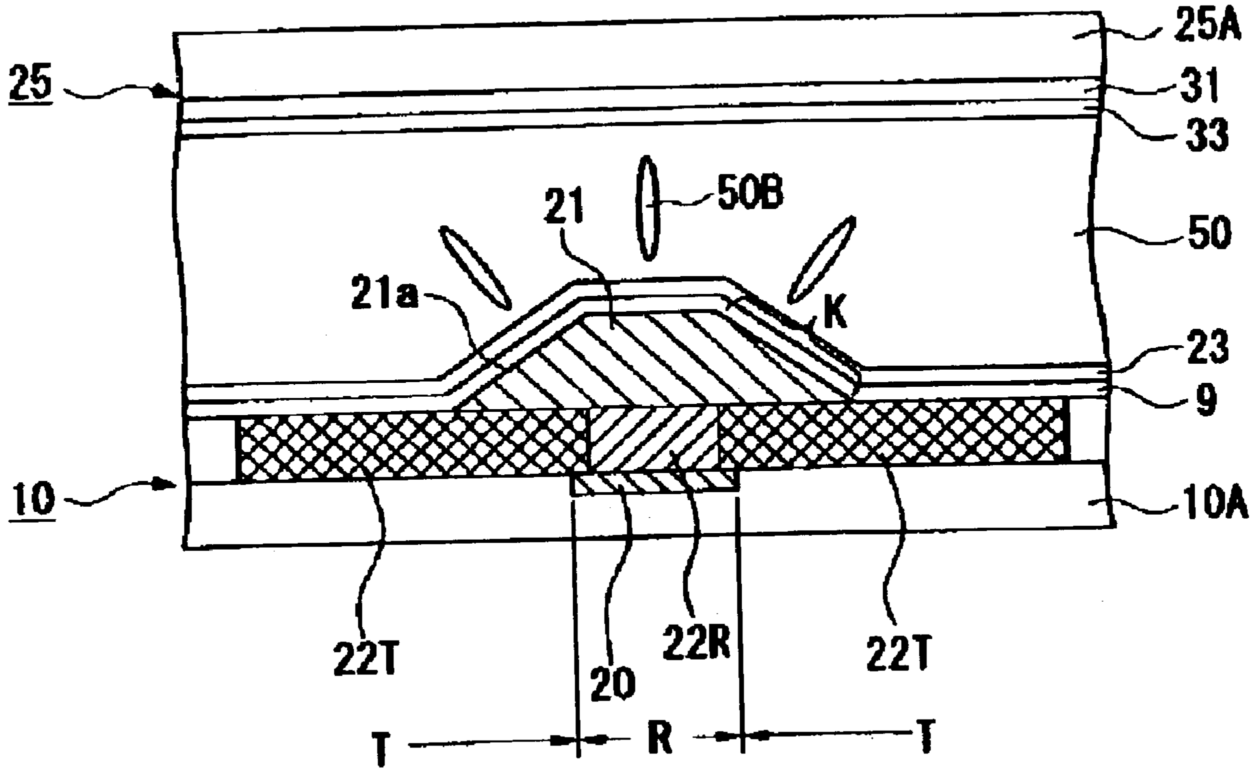


FIG. 1

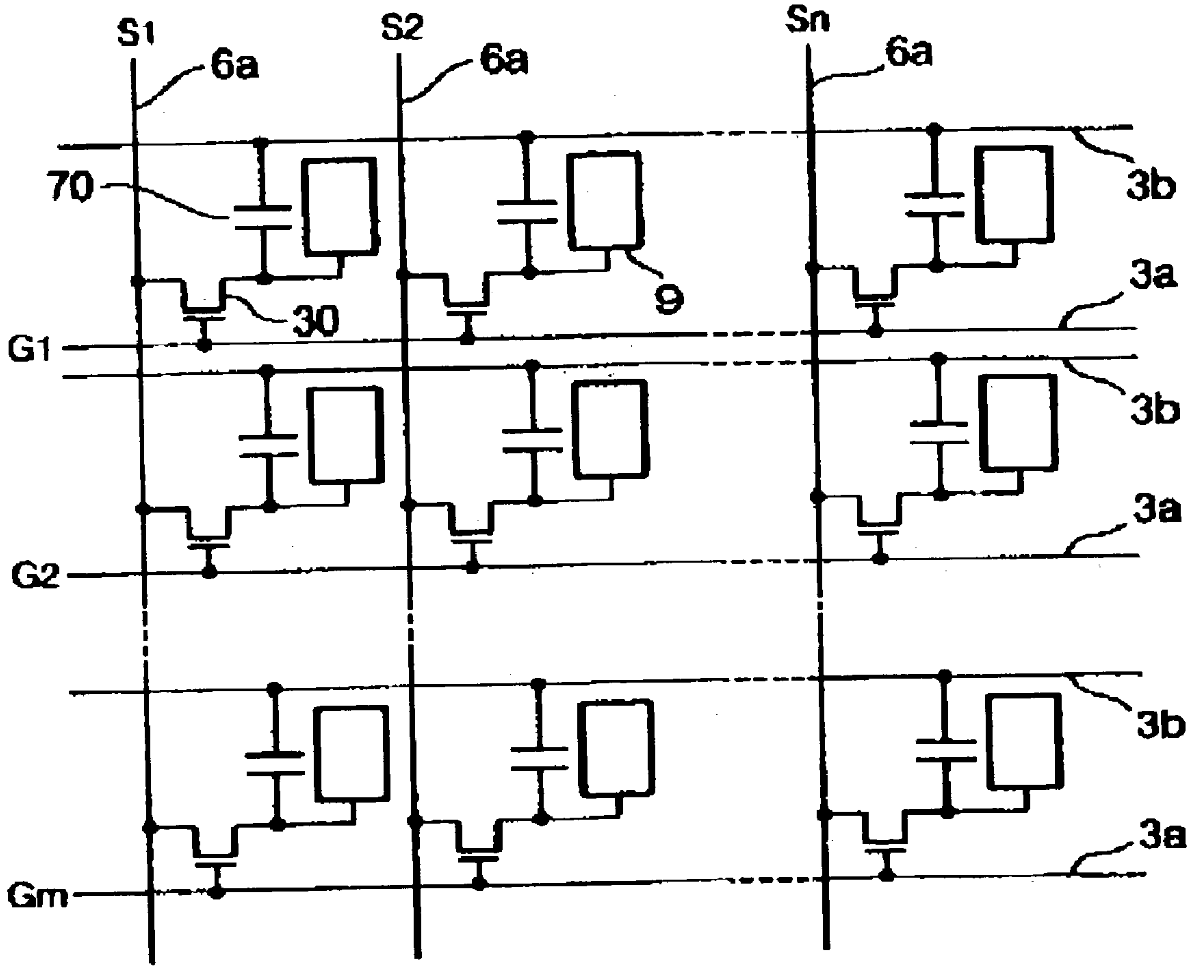


FIG. 2

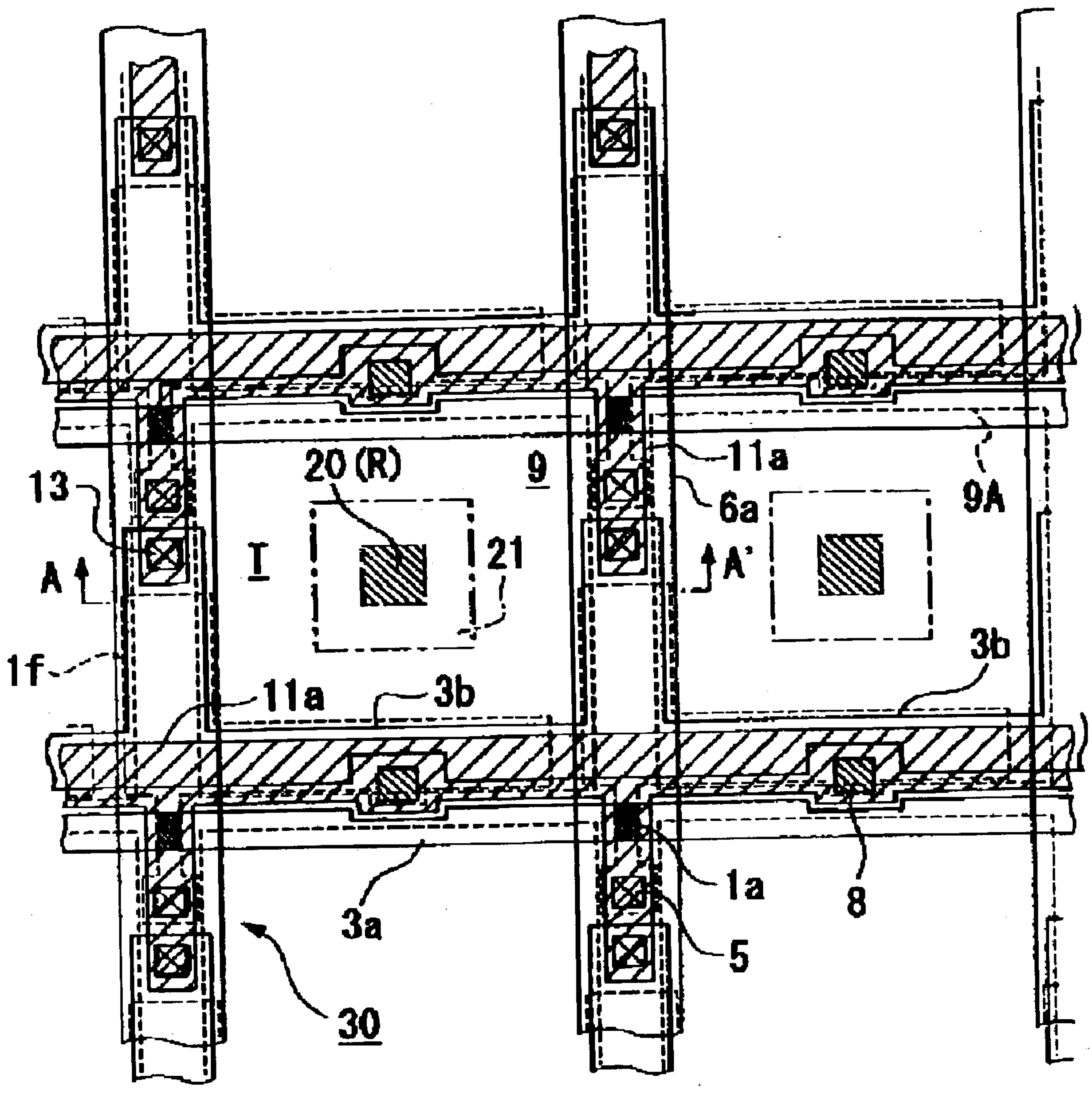


FIG. 3

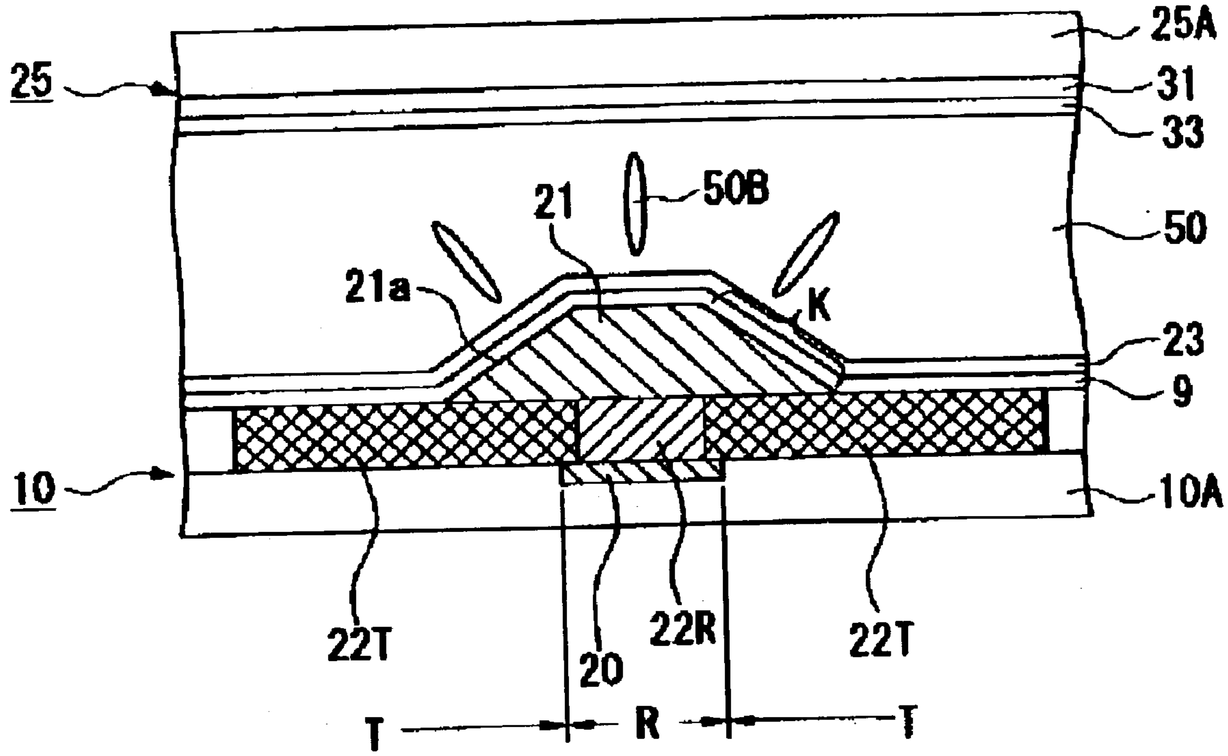


FIG. 4

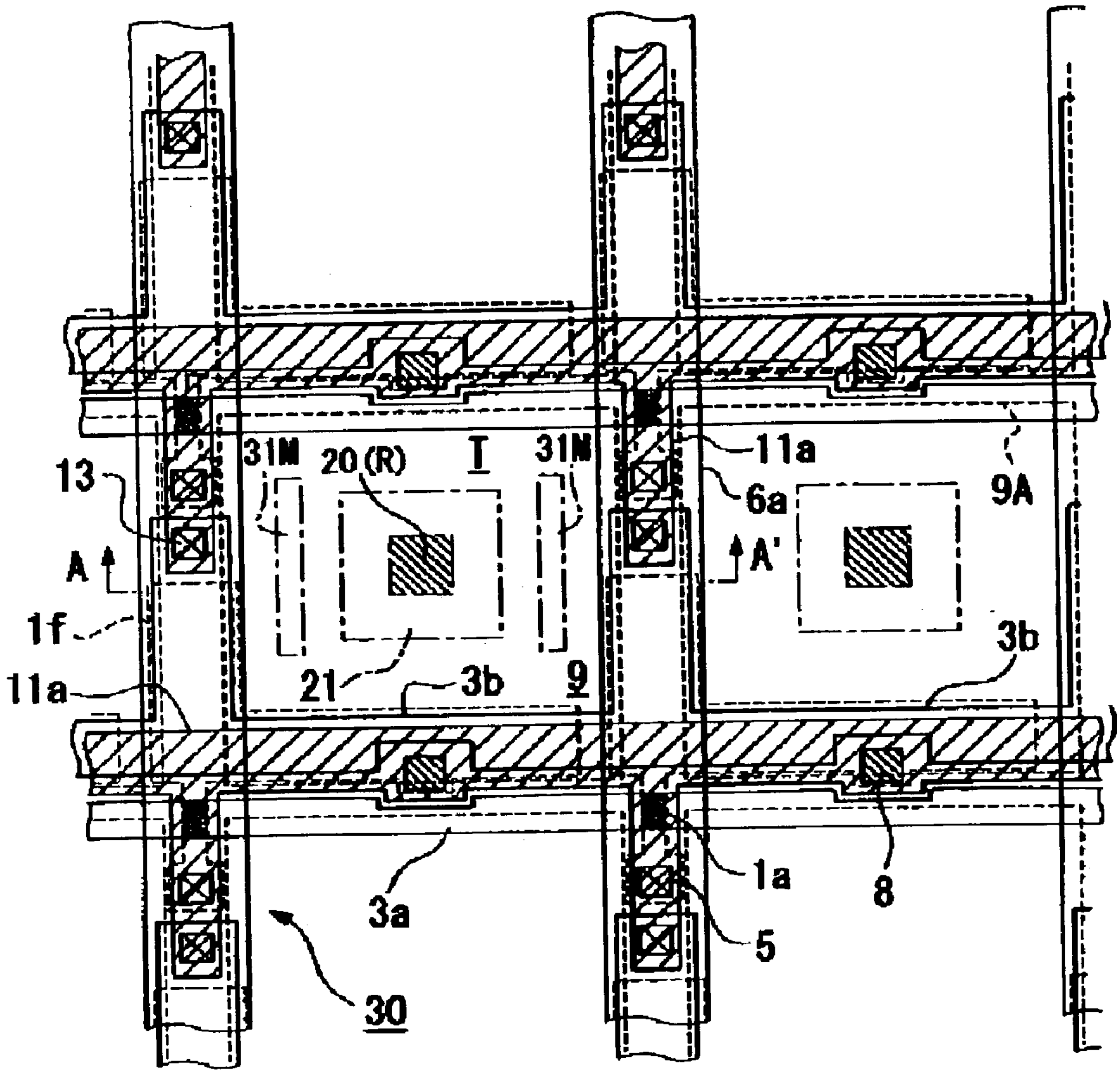
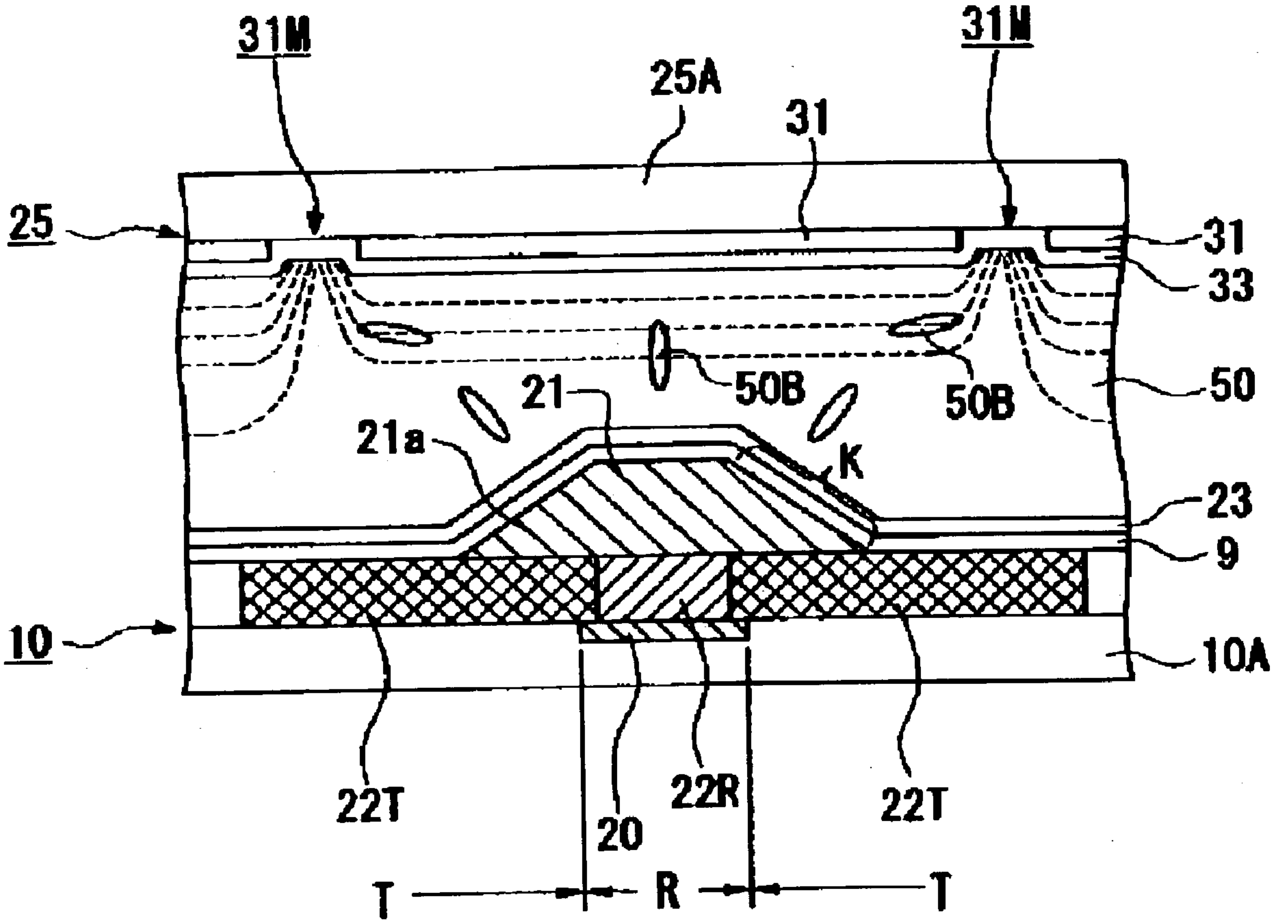


FIG. 5



31M
25A
31
31M
25
31
33
50B
50B
50
21
21a
K
23
9
10
10A
22T
20
22R
22T
T
R
T

FIG. 6

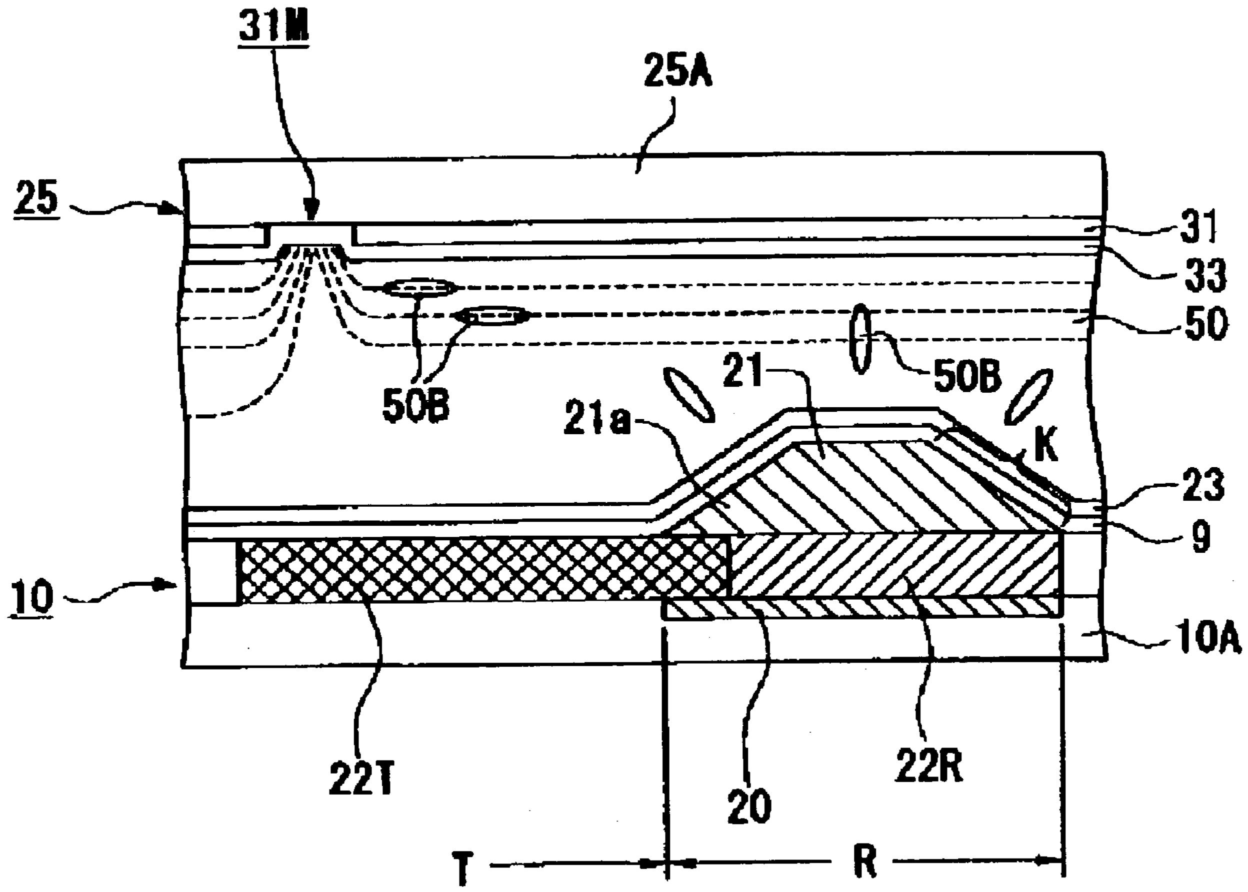


FIG. 7

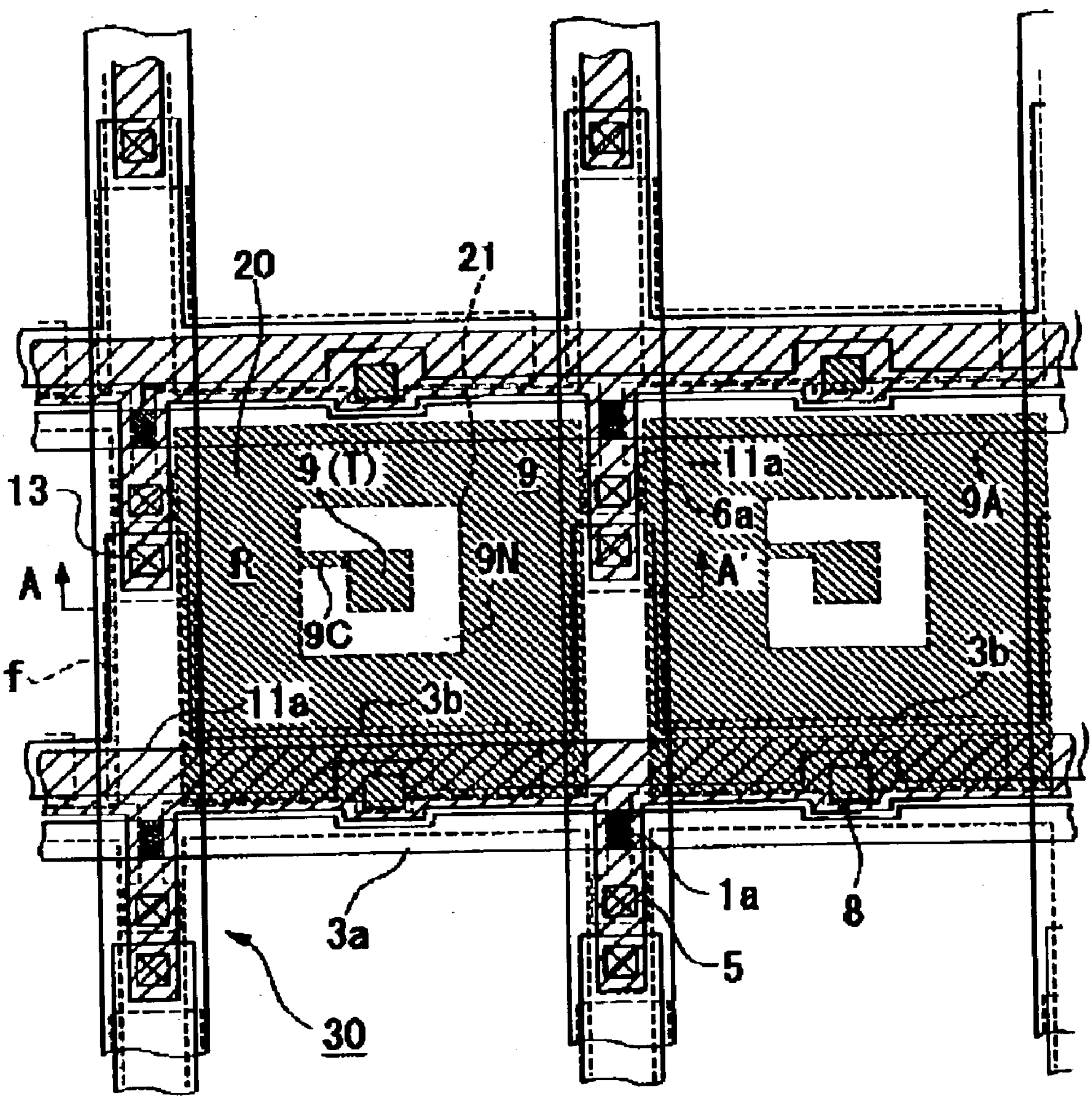


FIG. 8

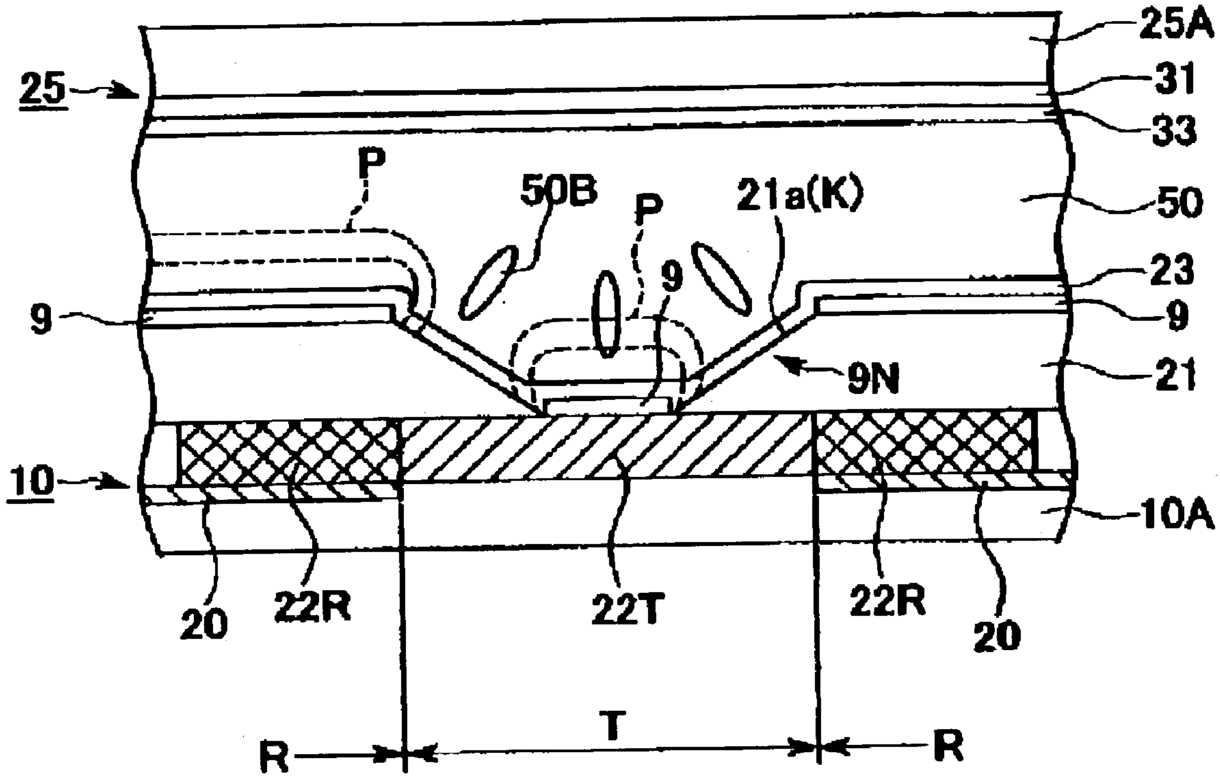

25A
25
31
33
P
50B
P
21a(K)
50
23
9
9
9
9N
21
10
10A
20
22R
22T
22R
20
R
T
R

FIG. 9

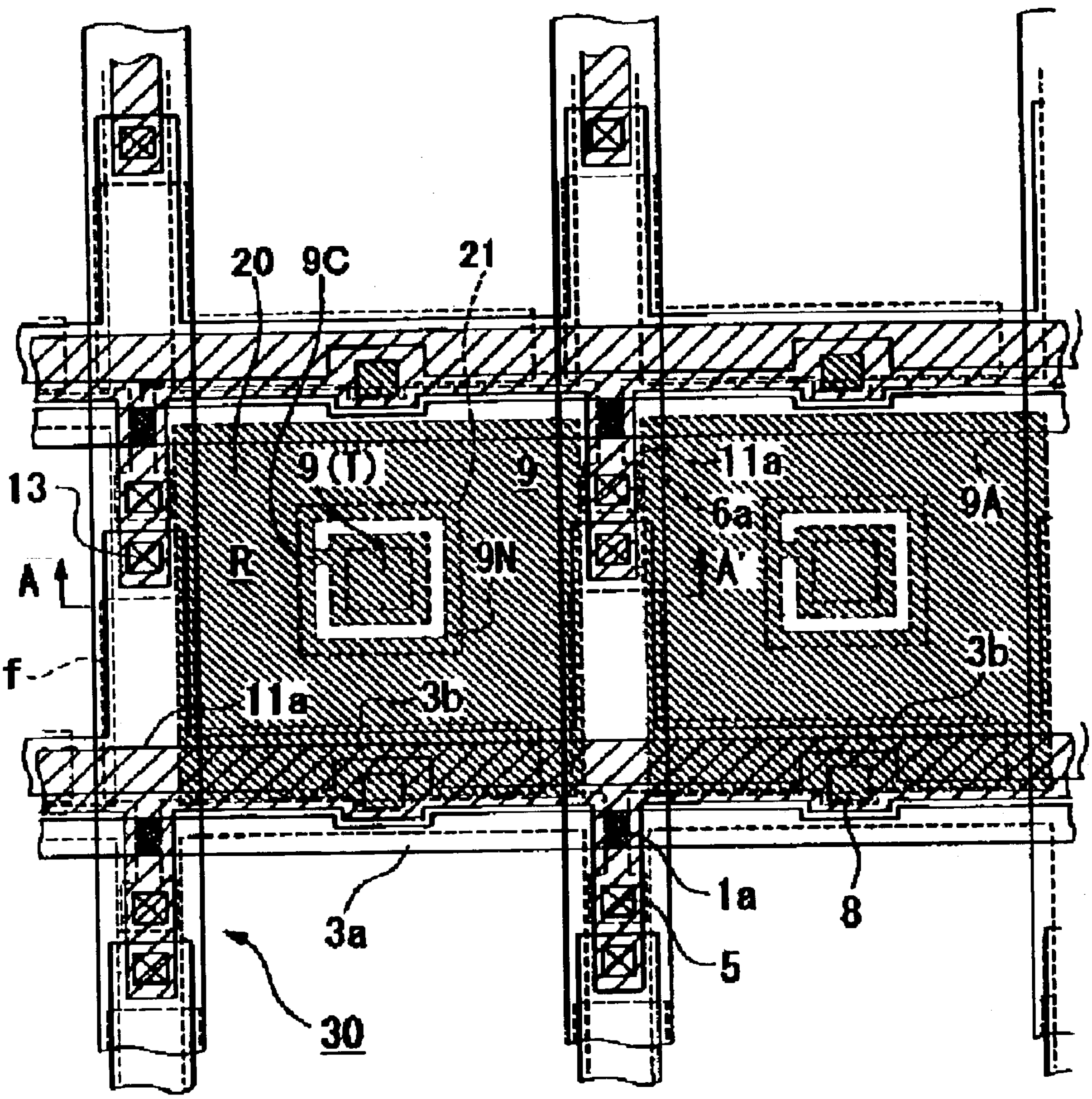
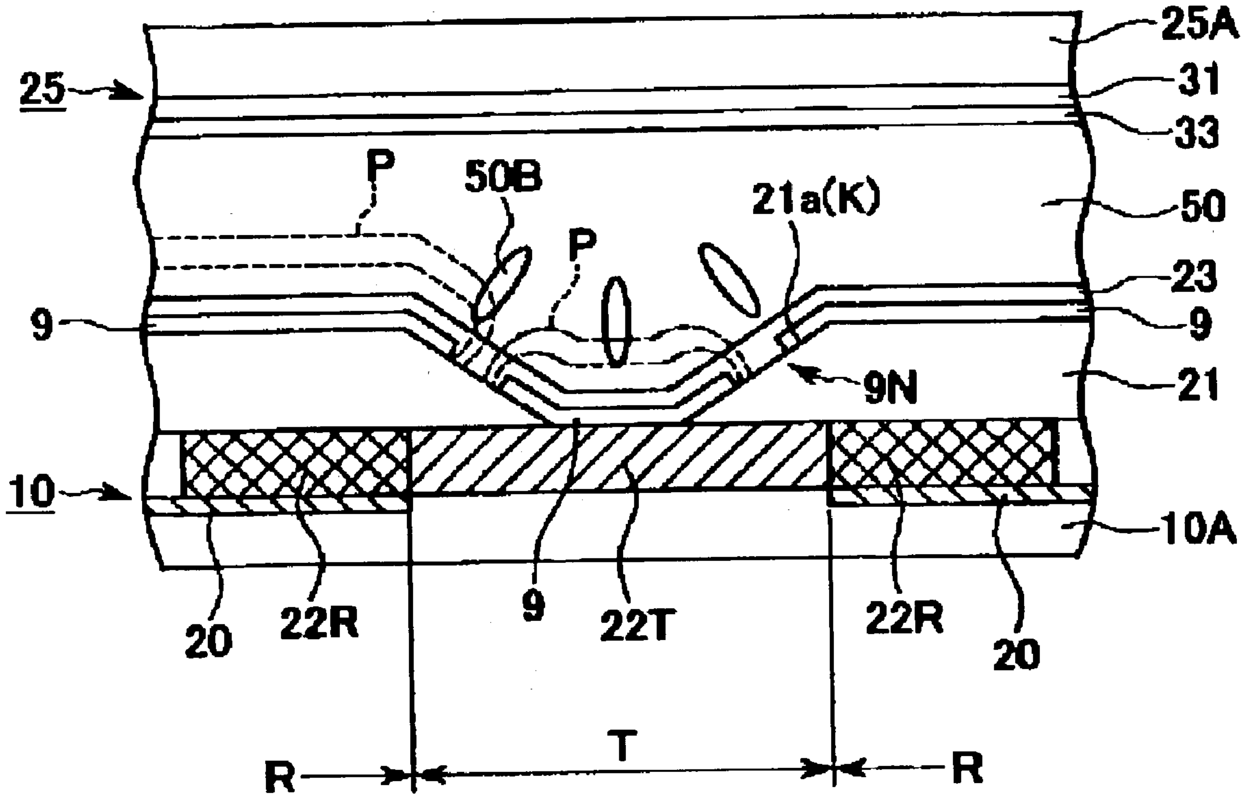


FIG. 10



25A
25
31
33
P
50B
21a(K)
50
P
23
9
9
9N
21
10
10A
20
22R
9
22T
22R
20
R
T
R

FIG. 11

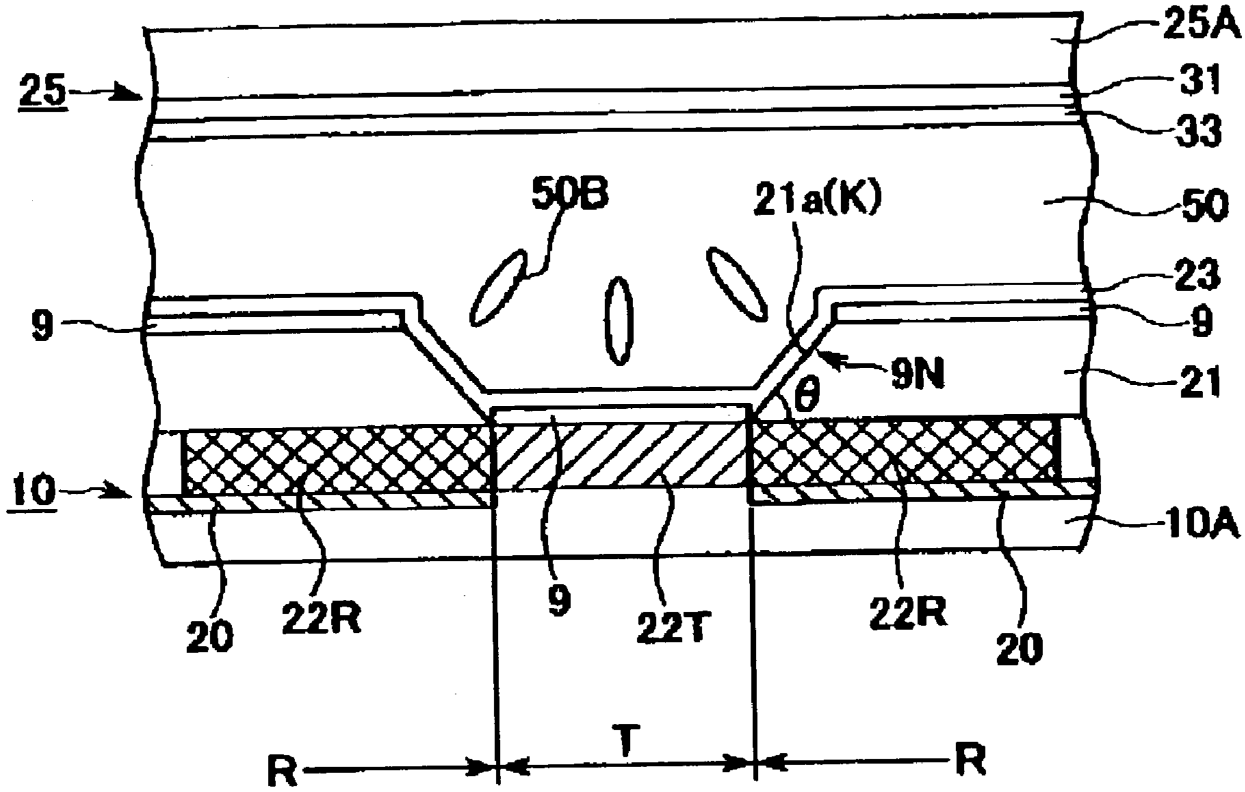


FIG. 12

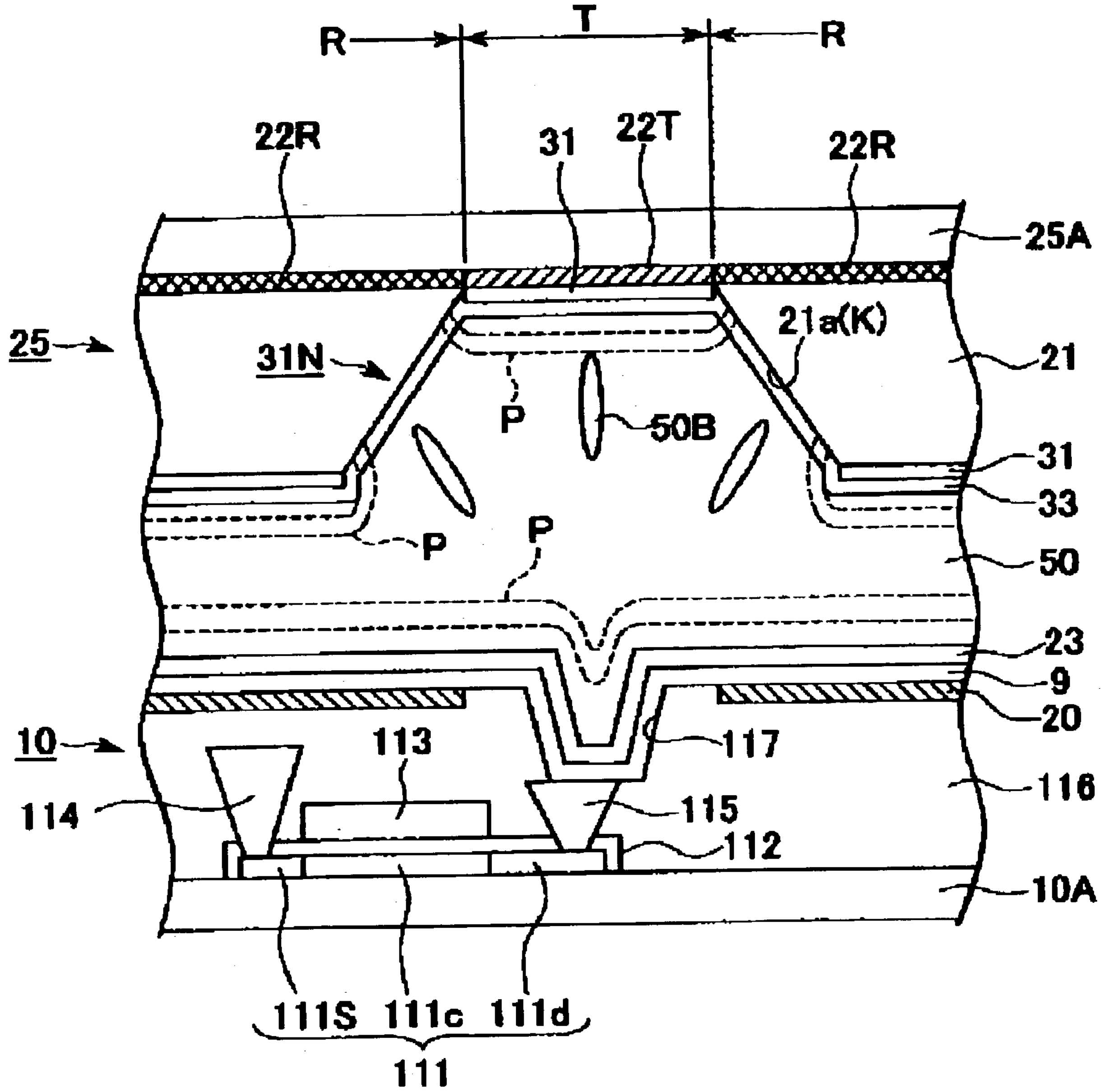

R
T
R
22R
31
22T
22R
25A
25
31N
21a(K)
21
P
50B
31
33
P
P
50
23
9
20
10
113
117
116
114
115
112
10A
111S 111c 111d
111

FIG. 13

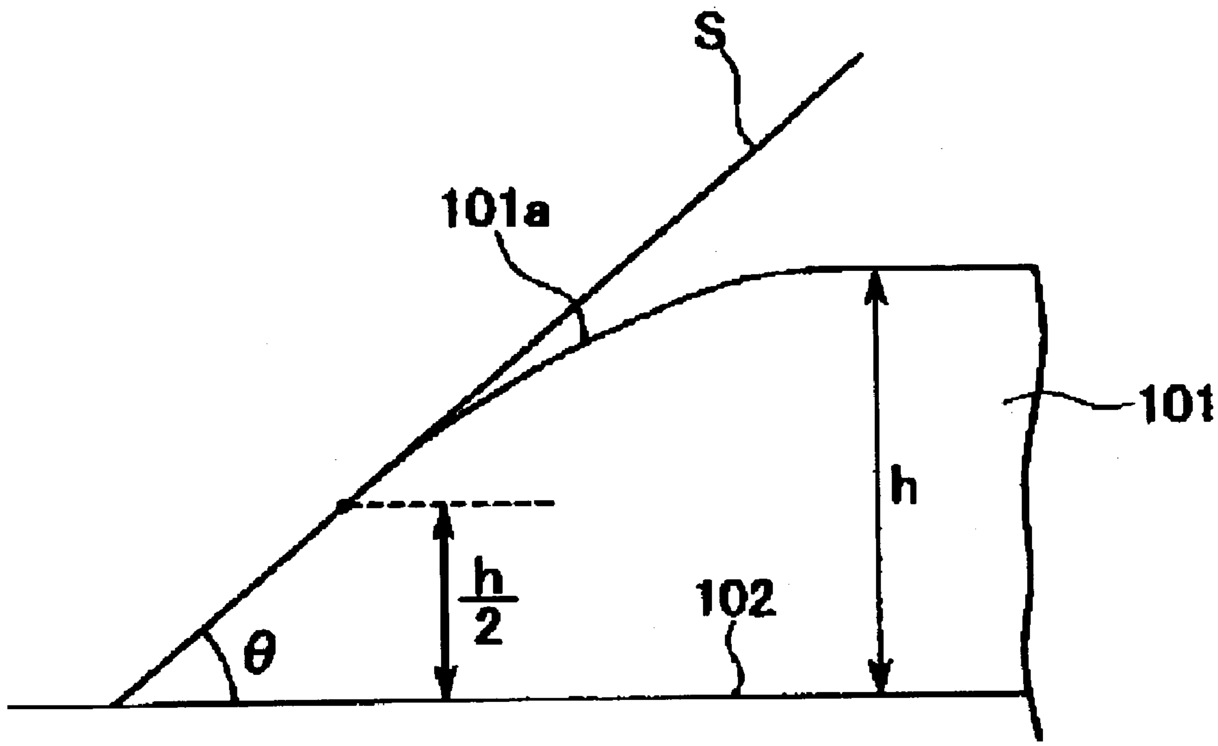


FIG. 14

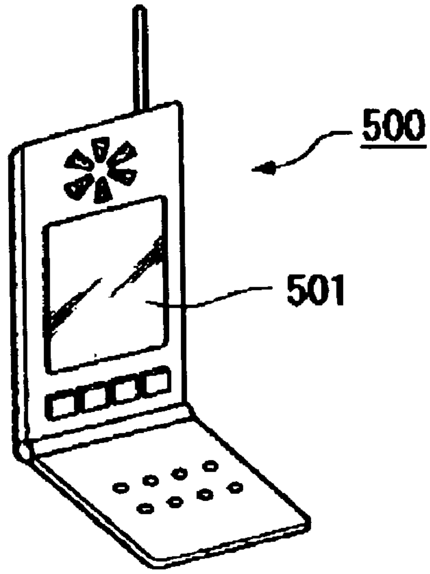


FIG. 15

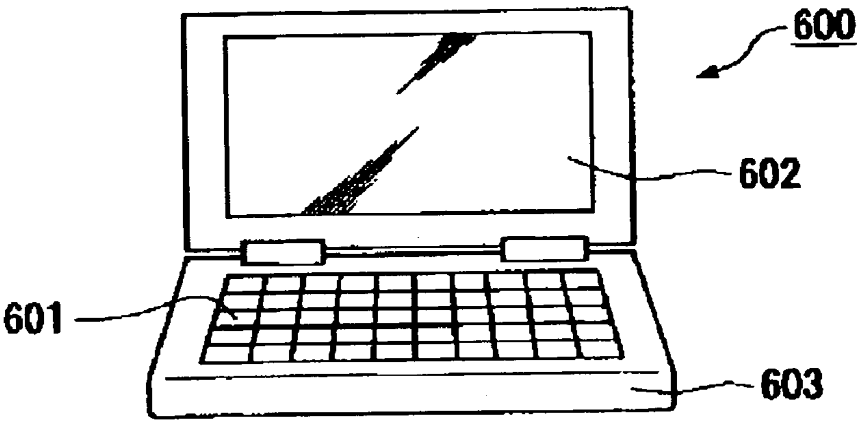
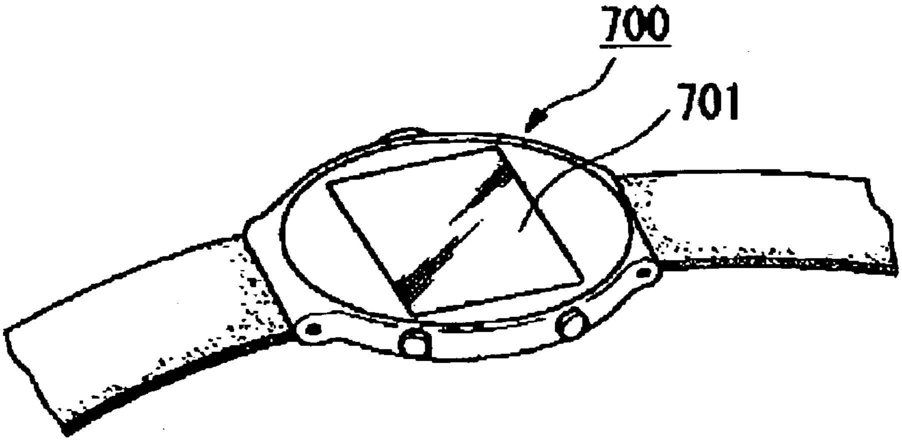


FIG. 16



LIQUID CRYSTAL DISPLAY AND ELECTRONIC DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of Invention

[0002] The present invention relates to a liquid crystal display and an electronic device, and more specifically, it relates to a technique for obtaining a high-contrast display having a wide viewing angle in a transflective liquid crystal display that performs display in both a reflective mode and a transparent mode.

[0003] 2. Description of Related Art

[0004] Since reflective liquid crystal displays have no light sources such as a backlight, they consume low power, thus having frequently been used for various portable electronic devices. However, the reflective liquid crystal displays perform display using outside light such as sunlight and illumination light, thus having a problem of low visibility in a dark place. Therefore, there have been proposed liquid crystal displays capable of making display visible using outside light in a light place, as in general reflective liquid crystal displays, and using an inside light source such as a backlight in a dark place. In other words, such liquid crystal displays employ a reflective and transparent display system, thereby allowing clear display even in low light while reducing power consumption by switching the display system between the reflective mode and the transparent mode depending on the surrounding brightness. Hereinafter, in this specification, liquid crystal displays of this type are referred to as "transflective liquid crystal displays."

[0005] For such transflective liquid crystal displays, there has been proposed a liquid crystal display having a structure in which a liquid crystal layer is sandwiched between an upper substrate and a lower substrate, wherein a reflective film having a light-transmitting window in a metallic film made of aluminum or the like is provided on the inner surface of the lower substrate, and this reflective film functions as a transflective film. In this case, in a reflective mode, outside light that has entered from the upper substrate passes through the liquid crystal layer, is then reflected by the reflective film, again passes through the liquid crystal layer, and outgoes from the upper substrate, thus contributing to display. On the other hand, in a transparent mode, light from the backlight, which has entered from the lower substrate, passes through the liquid crystal layer from the window of the reflective film, and then emerges from the upper substrate to the exterior, thereby contributing to display. Accordingly, in the reflective-film formed area, the area which has the window serves as a transparent display area and the other area serves as a reflective display area.

[0006] Liquid crystal alignment modes include a twisted nematic (hereinafter, abbreviated to a TN) mode in which liquid crystal molecules exhibit a twisted alignment substantially parallel to the substrate surface and vertical to the substrate; and a vertical alignment mode in which liquid crystal molecules exhibit vertical alignment, under no voltage applied state. Although the TN mode has been mainstream in view of reliability, liquid crystal displays in the vertical alignment mode have come to receive attention owing to their some excellent characteristics.

[0007] For example, in the vertical alignment mode, since the state in which the liquid crystal molecules are aligned vertically to the substrate surface (there is no optical retardation seen from the normal) is used as black display, the black display is superior in quality, thus providing high contrast. In vertical-alignment LCDs which are superior in front contrast, the range of viewing angle in which a fixed contrast can be obtained is wider than that of the horizontal-alignment-mode TN liquid crystal. Furthermore, employing an alignment dividing (multidomain) technique of dividing the alignment orientation of a liquid crystal in pixels provides remarkably wide viewing angle.

[0008] In the transflective liquid crystal display with the aforesaid structure, the retardation of the liquid crystal in the reflective display area is expressed by $2\times\Delta n\cdot d$ because the incident light passes through the liquid crystal layer two times and then reaches the observer, where the thickness of the liquid crystal layer is d, the refractive index anisotropy of the liquid crystal is Δn, and the retardation of the liquid crystal which is expressed as their integrated value is $\Delta n\cdot d$. On the other hand, the retardation of the liquid crystal in the transparent display area is expressed by $1\times\Delta n\cdot d$ because the light from the backlight passes through the liquid crystal layer only once.

[0009] As described above, when the alignment of the liquid crystal molecules of the liquid crystal layer is controlled even with the structure having different retardation values in the reflective display area and in the transparent display area, an electric field has been applied to the liquid crystal at the same driving voltage in both display modes. In such a case, when the liquid crystal with different display modes, in other words, the liquid crystal with different retardations between the transparent display area and the reflective display area is aligned at the same driving voltage, it poses a problem of obtaining no high-contrast display. In order to solve the problem, there has been proposed a liquid crystal display (refer to, for example, Patent Document 1) with a structure having different thicknesses of the liquid crystal layer in the transparent display area and in the reflective display area.

SUMMARY OF THE INVENTION

[0010] As described above, using the vertical alignment mode is also one method of achieving high contrast; therefore, there is a requirement for a liquid crystal display with a combination of the transflective liquid crystal display and the vertical alignment mode. However, there remain problems to be solved including a problem of decreased contrast due to the difference in retardation in the reflective and transparent display modes, problems of alignment control and alignment division in the vertical alignment mode, and so on, thus obstructing the realization.

[0011] The present invention has been made to solve the above problems; accordingly, the object of the present invention is to provide a liquid crystal display capable of obtaining light and high-contrast display having a wide viewing angle in a transflective liquid crystal display.

[0012] In order to achieve the above object, a liquid crystal display according to the present invention includes a liquid crystal layer sandwiched between a pair of substrates and separately having a transparent display area for transparent display and a reflective display area for reflective display in one dot area, and is characterized in that: the liquid crystal layer exhibits vertical alignment in the initial alignment state; and an insulating film is provided between at least one of the pair of substrates and the liquid crystal layer and in at least the reflective display area, the insulating film making the thickness of the liquid crystal layer in the reflective display area and in the transparent display area different owing to its film thickness.

[0013] The liquid crystal display of the present invention is a combination of a transflective liquid crystal display and a liquid crystal in a vertical alignment mode. There has been proposed a transflective liquid crystal display with a structure in which in order to solve the problem of reduction in contrast due to the difference of retardation between the reflective and the transparent display modes, the thickness of the liquid crystal layer is varied in the reflective display area and in the transparent display area by forming an insulating film with a fixed thickness in the reflective display area on the lower substrate so as to project toward the liquid crystal layer. The applicant has applied many inventions of this type of liquid crystal display. With such a structure, the thickness of the liquid crystal layer in the reflective display area can be made smaller than that of the liquid crystal layer in the transparent display area owing to the presence of the insulating film; therefore, the retardation in the reflective display area and the retardation in the transparent display area can sufficiently be close to or substantially equal to each other, thereby allowing an increase in contrast.

[0014] The inventors have found that the alignment orientation of the liquid crystal in a vertical alignment mode during the application of an electric field can be controlled by combining a liquid crystal layer in a vertical alignment mode to the liquid crystal display having the above insulating film. More specifically, a negative liquid crystal is generally used when the vertical alignment mode is employed; however, the direction in which the liquid crystal molecules fall cannot be controlled without any considerations (unless a pre-tilt is given) because the liquid crystal molecules are brought down from a state of standing vertically to the substrate surface in the initial alignment state, thus generating disturbance of alignment (disclination) to cause imperfect display such as light dropout, resulting in a decrease in display quality. Therefore, when the vertical alignment mode is employed, an important factor is to control the alignment orientation of the liquid crystal molecules in applying an electric field. In the liquid crystal display having the aforesaid insulating film, the insulating film projects toward the liquid crystal layer, which serves as a projection; thus, a pre-tilt that corresponds to the shape of the projection can be given with the liquid crystal molecules vertically aligned in the initial state. Due to this action, the alignment orientation when an electric field is applied to the liquid crystal molecules can be controlled; consequently, high-contrast display can be achieved without imperfect display such as light drop.

[0015] With the structure of the present invention, the transflective liquid crystal display in a vertical alignment mode has an insulating film; accordingly, the problem of reduction in contrast due to the difference of retardation between the reflective and the transparent display modes can be solved, which was a fundamental problem of the transflective liquid crystal display, and imperfect display because of the fact that the alignment orientation of the liquid crystal molecules in the vertical alignment mode cannot be controlled can be reduced. Consequently, both the advantage of the vertical alignment mode and the advantage of the transflective type can fully be taken to realize a liquid crystal display of high display quality.

[0016] The arrangement of the transparent display area and the reflective display area in one dot area can be set arbitrarily; however, it is preferable to arrange the transparent display area so as to surround the periphery of the reflective display area and to arrange the insulating film in the area that corresponds to the reflective display area in the center of the dot.

[0017] From such a viewpoint, another liquid crystal display of the present invention includes a liquid crystal layer sandwiched between a pair of substrates and separately having a transparent display area for transparent display and a reflective display area for reflective display in one dot area, and is characterized in that: an insulating film is provided between at least one of the pair of substrates and the liquid crystal layer and in at least the reflective display area, the insulating film making the thickness of the liquid crystal layer in the reflective display area and in the transparent display area different owing to its film thickness; and the thickness of the liquid crystal layer in the center of the dot area is set smaller than in the periphery in the one dot area.

[0018] With such a structure, if a rectangular reflective display area is provided in the center of one dot area and a rectangular insulating film is disposed therein, around which a transparent display area is formed, the alignment orientations of the liquid crystal molecules are specified to four orientations that are perpendicular to each side of the rectangle with the insulating film in the center of the dot as the center. As a result, four areas each having a different alignment orientation are formed in one dot area to realize an alignment dividing structure, thus achieving a wide viewing angle.

[0019] Alternatively, contrarily to the aforesaid structure, it is also possible to have a structure in which an insulating film is provided between at least one of the pair of substrates and the liquid crystal layer and in at least the reflective display area, the insulating film making the thickness of the liquid crystal layer in the reflective display area and in the transparent display area different owing to its film thickness; and the thickness of the liquid crystal layer in the periphery of the one dot area is set smaller than in the center. More specifically, the reflective display area is provided so as to surround the periphery of the transparent display area in the one dot; and the insulating film is disposed in the area corresponding to the reflective display area in the periphery of the dot.

[0020] With such a structure, if a rectangular reflective display area is provided in the center of one dot area, a rectangular-frame-shaped insulating film is disposed on the outside thereof, and a reflective display area is formed in the periphery thereof, the alignment orientations of the liquid crystal molecules are specified to four orientations that are perpendicular to each side of the rectangular frame from the insulating film in the periphery of the dot area toward the center. As a result, four areas each having a different alignment orientation are formed in one dot area, as in the aforesaid structure, to realize an alignment dividing structure, thus achieving a wide viewing angle.

[0021] Preferably, the insulating film includes an inclined area in the vicinity of the boundary between the reflective display area and the transparent display area, the inclined area having an inclined plane so that its thickness continuously varies.

[0022] The end of the insulating film, which corresponds to the boundary between the reflective display area and the transparent display area, may have a step-like difference in thickness; however, in such a case, the thickness of the liquid crystal layer sharply changes because of the aforesaid step in the vicinity of the boundary between the reflective display area and the transparent display area, thus causing alignment disturbance of the liquid crystal to exert a bad influence upon display. On the other hand, when the insulating film has an inclined plane so as to continuously vary the thickness thereof, the alignment of the liquid crystal also varies continuously depending on the position of the inclined plane of the insulating film, thus causing no large disturbance of alignment to prevent imperfect display. When the insulating film is rectangular, as described above, the inclined plane is also inclined in four directions perpendicularly crossing each other; therefore, the presence of the inclined plane allows smooth formation of the alignment dividing structure.

[0023] It is also possible to provide an electrode for driving the liquid crystal layer to the substrate having the insulating film and to provide a no electrode formed area where the electrode is absent in at least part of the inclined plane of the insulating film.

[0024] With the structure of the present invention, as described above, merely providing an insulating film that is a projection projecting toward the liquid crystal layer allows control of alignment orientation. However, when no electrode formed area is provided to at least part of the inclined plane of the insulating film, an electric field (potential lines) generating between the electrodes on both the substrates is distorted in the vicinity of the no electrode formed area. The action of the distorted electric field allows smooth control of the alignment orientation of the liquid crystal molecules.

[0025] Assuming that the center of one dot is a rectangular reflective display area, the periphery is a transparent display area and a rectangular-frame-shaped no electrode formed area is provided in the inclined area of the insulating film, which corresponds to the boundary between the reflective display area and the transparent display area, the electrode of the reflective display area and the electrode of the transparent display area are completely separated; therefore, it becomes difficult to apply the same driving voltage to both of them at the same time. Accordingly, it is preferable to provide a structure in which the electrode in the reflective display area and the electrode in the transparent display area, which are provided on both sides of the no electrode formed area, are electrically connected through a connecting section formed of the same layer as the electrodes. Alternatively, it is also preferable to provide a structure in which the electrode in the reflective display area and the electrode in the transparent display area are electrically connected through a connecting section formed of a different layer from the electrodes. With such a structure, the same driving voltage can easily be applied simultaneously to the electrode in the reflective display area and the electrode in the transparent display area.

[0026] When one of the substrates is an element substrate having a pixel electrode and a switching element and the other substrate is an opposed substrate having a common electrode and the insulating film, it is preferable to dispose a contact hole for electrically connecting the pixel electrode and the switching element on the one substrate in the position not overlapping the inclined area.

[0027] Since the contact hole that electrically connects the pixel electrode and the switching element is formed on the upper layer of one substrate, the pixel electrode is generally recessed at the portion of the contact hole. Therefore, with the aforesaid structure, the electric field that has been distorted in the vicinity of the no electrode formed area is further distorted because of the recess of the pixel electrode, thereby facilitating control of the alignment of the liquid crystal molecules.

[0028] Furthermore, when an electrode for driving the liquid crystal layer and an insulating film are provided on one of the pair of substrates, and an electrode for driving the liquid crystal layer is provided on the other substrate, it is preferable that the electrode on the other substrate include a window on the outside of the inclined area of the insulating film.

[0029] With the structure of the present invention, as described above, merely providing the insulating film that is a projection projecting toward the liquid crystal layer allows control of alignment orientation. However, when the electrode on the other substrate, which is opposed to the insulating film, has a window on the outside of the inclined area of the insulating film, an electric field generating between the electrodes on both the substrates tilts because there are no electrodes at the window. The action of the tilted electric field allows smoother control of the alignment orientation of the liquid crystal molecules.

[0030] When the insulating film has an inclined plane, it is preferable that the inclination angle of the inclined plane of the insulating film relative to the substrate surface be in the range of 5 to 50°. The inclined plane may be either planar or curved. Here, "the inclination angle of the inclined plane" means an angle θ formed by the tangential line S of an inclined plane **101***a* in the position where the layer thickness in the inclined area is h/2 and a substrate surface **102** (planar plane), where the thickness of the flat part of the insulating film **101** is h, as shown in **FIG. 13**.

[0031] When the inclination angle is less than 5°, it forms a gentle inclined plane; therefore, the inclined area increases in size to have too large area where the retardation becomes fragmentary, thus increasing optical loss. On the other hand, when the inclination angle exceeds 50°, it forms a steeply inclined plane; therefore, the liquid crystal molecules are aligned vertically to the inclined plane when non-selected voltage is applied, thereby generating disclination between the liquid crystal molecules on the inclined plane and those on the planar plane. Consequently, black floating (a leak of light) occurs to decrease in contrast. Therefore, it is desirable that the inclination angle be in the range of 5° to 50°.

[0032] The outline of the insulating film in one dot area is not particularly limited; however, when it is an equilateral polygon or a circle, the liquid crystal molecules are uniformly divided in each direction in one dot area. As a result, a viewing angle at which high contrast is obtained can be isotropically widened.

[0033] Furthermore, providing a circularly-polarized-light radiating means for radiating circularly polarized light to the one substrate or the other substrate allows preferable reflective display and transparent display.

[0034] An electronic device of the present invention is characterized by comprising the liquid crystal display according to the present invention.

[0035] With such a structure, electronic devices can be provided which have a light and high-contrast liquid crystal display having a wide viewing angle irrespective of use environment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] **FIG. 1** is an equivalent circuit diagram of a plurality of dots arranged in the form of matrix which constitute an image display area of a liquid crystal display according to a first embodiment of the present invention;

[0037] **FIG. 2** is a plan view showing the structure of an adjacent plurality of dots on a TFT array substrate which constitutes the liquid crystal display of the same;

[0038] **FIG. 3** is a sectional view taken along line A-A' of **FIG. 2**, showing the structure of the liquid crystal display of the same;

[0039] **FIG. 4** is a plan view showing the structure of an adjacent plurality of dots on a TFT array substrate, which constitutes a liquid crystal display according to a second embodiment of the present invention;

[0040] **FIG. 5** is a sectional view taken along line A-A' of **FIG. 4**, showing the structure of the liquid crystal display of the same;

[0041] **FIG. 6** is a sectional view showing the structure of a liquid crystal display according to a third embodiment of the present invention;

[0042] **FIG. 7** is a plan view showing the structure of an adjacent plurality of dots on a TFT array substrate, which constitutes a liquid crystal display according to a fourth embodiment of the present invention;

[0043] **FIG. 8** is a sectional view taken along line A-A' of **FIG. 7**, showing the structure of the liquid crystal display of the same;

[0044] **FIG. 9** is a plan view showing the structure of an adjacent plurality of dots on a TFT array substrate, which constitutes a liquid crystal display according to a fifth embodiment of the present invention;

[0045] **FIG. 10** is a sectional view taken along line A-A' of **FIG. 9**, showing the structure of the liquid crystal display of the same;

[0046] **FIG. 11** is a sectional view showing the structure of a liquid crystal display according to a sixth embodiment of the present invention;

[0047] **FIG. 12** is a sectional view showing the structure of a liquid crystal display according to a seventh embodiment of the present invention;

[0048] **FIG. 13** is a diagram for explaining the inclination angle of an insulating film of the present invention;

[0049] **FIG. 14** is a perspective view showing an example of an electronic device of the present invention;

[0050] **FIG. 15** is a perspective view showing another example of an electronic device of the present invention; and

[0051] **FIG. 16** is a perspective view showing still another example of an electronic device of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0052] Referring to FIGS. **1** to **3**, a first embodiment of the present invention will be described hereinafter.

[0053] A liquid crystal display of this embodiment is an example of an active-matrix liquid crystal display that uses a thin film transistor (hereinafter, abbreviated to a TFT) as a switching element.

[0054] **FIG. 1** is an equivalent circuit diagram of a plurality of dots arranged in the form of matrix which constitute an image display area of the liquid crystal display according to this embodiment. **FIG. 2** is a plan view showing the structure of the adjacent plurality of dots on a TFT array substrate. **FIG. 3** is a sectional view taken along line A-A' of **FIG. 2**, showing the structure of the liquid crystal display. In the following drawings, the layers and members are scaled variously in order to make them discernible on the drawings.

[0055] In the liquid crystal display of this embodiment, each of the plurality of dots constituting an image display area and arranged in the form of matrix includes a pixel electrode **9** and a TFT **30** serving as a switching element for controlling the pixel electrode **9**, and a data line **6***a,* to which an image signal is supplied, is electrically connected to the source of the TFT **30** as shown in **FIG. 1**. Image signals S**1**, S**2**, . . . , Sn, which are written to the data line **6***a,* are line-sequentially supplied in this order or, alternatively, supplied to the adjacent plurality of data lines **6***a* by group. A scanning line **3***a* is electrically connected to the gate of the TFT **30**, and scanning signals G**1**, G**2**, . . . , Gm are line-sequentially applied to the plurality of scanning lines **3***a* at a fixed timing and in pulse. The pixel electrode **9** is electrically connected to the drain of each TFT **30**, and write the image signals S**1**, S**2**, . . . , Sn supplied over the data lines **6***a* at a fixed timing by turning on the TFT **30** serving as a switching element only for a fixed period of time.

[0056] The image signals S**1**, S**2**, . . . , Sn, which were written to the liquid crystal through the pixel electrodes **9**, are held between the pixel electrodes **9** and a common electrode, which will be described later, for a fixed period of time. The liquid crystal modulates light by varying the orientation and order of the molecular association depending on the applied voltage level, thereby allowing gray scale to be assigned. Here, a storage capacitor **70** is added in parallel with a liquid crystal capacitor formed between each pixel electrode **9** and the common electrode in order to prevent leakage of the held image signals. Reference numeral **3***b* denotes a capacitor line.

[0057] Next, referring to **FIG. 2**, the planar structure of the TFT array substrate that constitutes the liquid crystal device of this embodiment will be described.

[0058] As shown in **FIG. 2**, the plurality of rectangular pixel electrodes **9** (the outline is shown by the dotted line **9**A) is arranged in the form of matrix on the TFT array substrate, and the data lines **6***a,* the scanning lines **3***a,* and the capacitor lines **3***b* are provided along the vertical and horizontal boundaries of the pixel electrodes **9**. In this embodiment, the inside of the area having each pixel electrode **9** and the data line **6***a*, the scanning line **3***a*, and the capacitor line **3***b* disposed to surround each pixel electrode **9** forms one dot area, having a structure capable of displaying for each dot area disposed in matrix form.

[**0059**] The data line **6***a* is electrically connected to a later-described source area of a semiconductor layer la constituting the TFT **30** and formed of, for example, a polysilicon film, through a contact hole **5**; and each pixel electrode **9** is electrically connected to a later-described drain area of the semiconductor layer **1***a* through a contact hole **8**. The scanning line **3***a* is arranged so as to face a channel area (left-upward obliquely shaded area in the drawing) of the semiconductor layer **1***a*, the scanning line **3***a* functioning as a gate electrode at a portion facing the channel area.

[**0060**] The capacitor line **3***b* includes a main line section (a first area along the scanning line **3***a* in plan view) extending substantially linearly along the scanning line **3***a*, and a projecting section (a second area extending along the data line **6***a* in plan view) projecting from a portion intersecting the data line **6***a* toward the preceding stage (upward in the drawing) along the data line **6***a*. In **FIG. 2**, the area shown by a right-upward obliqely shaded area includes a plurality of first light shielding films **11***a*.

[**0061**] More specifically, the first light shielding films **11***a* are each arranged in the position to cover the TFTs **30** including the channel area of the semiconductor layer **1***a*, seen from the TFT array substrate side, and include a main line section extending linearly along the scanning line **3***a* and facing the main line section of the capacitor line **3***b*, and a projecting section projecting from a portion intersecting the data line **6***a* toward the adjacent post stage (downward in the drawing) along the data line **6***a*. The end of the downward projecting section in each stage (pixel row) of the first light shielding films **11***a* overlaps the end of the upward projecting section of the post-stage capacitor line **3***b* under the data line **6***a*. The overlapped portions each include a contact hole **13** that electrically connects the first light shielding film **1** la and the capacitor line **3***b* to each other. In other words, in this embodiment, the first light shielding films **11** a are electrically connected to the preceding- or post-stage capacitor line **3***b* through the contact holes **13**.

[**0062**] As shown in **FIG. 2, a** rectangular reflective film **20** is formed in the center of one dot area, an area including the reflective film **20** serving as a reflective display area R and the peripheral area including no reflective film **20** serving as a transparent display area T. Also, a rectangular insulating film **21** is formed so as to include the area including the reflective film **20** therein in plan view.

[**0063**] Referring to **FIG. 3**, the sectional structure of the liquid crystal display of this embodiment will be described hereinafter. **FIG. 3** is a sectional view taken along line A-A' of **FIG. 2**; however, the present invention is characterized in the structure of the insulating film in the center of the dot and the sectional structures of the TFT and other wirings are the same as those of the conventional one, so that the drawing and the description of the TFT and wirings will be omitted.

[**0064**] As shown in **FIG. 3, a** liquid crystal layer **50** formed of a liquid crystal that is vertically aligned in the initial alignment state is sandwiched between a TFT array substrate **10** and an opposed substrate **25** opposed thereto. The TFT array substrate **10** includes the reflective film **20** formed of a high-reflective metallic film such as aluminum and silver on the surface of a substrate main body **10**A made of a translucent material such as quartz and glass. As described above, the area including the reflective film **20** serves as the reflective display area R and the area including no reflective film **20** serves as the transparent display area T.

[**0065**] A dye layer **22**R constituting a color filter for reflective display is formed on the reflective film **20** located in the reflective display area R; and a dye layer **22**T constituting a color filter for transparent display is formed on the substrate located in the transparent display area T. Generally, in the transflective liquid crystal display, light passes through a color filter two times in the reflective display, while in the transparent display, it does only once; thus posing a problem of different display chroma between the reflective display and the transparent display. Accordingly, the applicant has proposed a technique of improving the balance of display color between the reflective display and the transparent display by changing the color purity of the dye layer of the color filter between in the reflective display area and in the transparent display area. The aforesaid dye layers of the reflective-display color filter and the transparent-display color filter employ the technique.

[**0066**] The respective dye layers **22**R and **22**T of the reflective-display color filter and the transparent-display color filter have an insulating film **21** in the position corresponding to the reflective display area R. The insulating film **21** is made of an organic film such as an acrylic resin having a film thickness of about 2 to 3 μm, having an inclined area K including an inclined plane **21***a* so as to vary the thickness of the insulating film **21** continuously in the vicinity of the boundary between the reflective display area R and the transparent display area T. Since the thickness of a liquid crystal layer **50** at the portion including no insulating film **21** is about 4 to 6 μm, the thickness of the liquid crystal layer **50** in the reflective display area R is about one-half of the thickness of the liquid crystal layer **50** in the transparent display area T. In other words, the insulating film **21** works as a liquid-crystal-layer-thickness control layer for making the thickness of the liquid crystal layer **50** different between in the reflective display area R and the transparent display area T owing to its film thickness. The angle θ formed by the surface of the dye layers **22**R and **22**T of the color filters and the inclined plane **21***a* of the insulating film **21** is about 5° to 50°. In this embodiment, the edge of the planar plane at the upper part of the insulating film **21** and the edge of the reflective film **20** (reflective display area) coincide substantially with each other, the inclined area K being included in the transparent display area T.

[**0067**] The surface of the TFT array substrate **10** that includes the surface of the insulating film **21** has the pixel electrodes **9** made of a transparent conductive film such as indium tin oxide (hereinafter, abbreviated to ITO) and an alignment film **23** made of polyimide or the like.

[**0068**] On the other hand, the opposed substrate **25** has a common electrode **31** made of a transparent conductive film such as an ITO and an alignment film **33** made of polyimide or the like on a substrate main body **25**A made of a translucent material such as glass and quartz. The respective alignment films **23** and **33** of the TFT array substrate **10** and the opposed substrate **25** are both subjected to vertical alignment treatment.

[**0069**] The TFT array substrate **10** has a circularly polarizing plate on the outer surface thereof and the opposed substrate **25** also has a circularly polarizing plate on the outer surface, which are not shown..

[**0070**] According to the liquid crystal display of this embodiment, since the reflective display area R includes the insulating film **21**, the thickness of the liquid crystal layer **50** in the reflective display area R can be as small as about one-half of the thickness of the liquid crystal layer **50** in the transparent display area T. Therefore, the retardation in the reflective display area R and the retardation in the transparent display area T can be made substantially equal, thereby improving the contrast. Furthermore, since the insulating film **21** projects toward the liquid crystal layer **50**, which serves as a projection, a pre-tilt that corresponds to the shape of the projection can be given with the liquid crystal molecules **50**B vertically aligned in the initial state. Due to this action, when an electric field is applied to the liquid crystal molecules **50**B, the alignment orientation of the liquid crystal molecules **50**B can be controlled; consequently, high-contrast display can be achieved without imperfect display such as light drop.

[**0071**] That is, with the structure of this embodiment, the transflective liquid crystal display in a vertical alignment mode has the insulating film **21**; accordingly, the problem of reduction in contrast due to the difference of retardation between the reflective and the transparent display modes can be solved, and imperfect display because of the fact that the alignment orientation of the liquid crystal molecules in the vertical alignment mode cannot be controlled can be reduced. Consequently, both the advantage of the vertical alignment mode and the advantage of the transflective type can be fully taken to realize a liquid crystal display of high display quality.

[**0072**] In this embodiment, the rectangular reflective display area R is provided in the center of one dot area and the rectangular insulating film **21** is disposed at a portion corresponding to the reflective display area R in the center of the dot area. Therefore, the alignment orientations of the liquid crystal molecules are specified to four orientations that are perpendicular to each side of the rectangle with the insulating film **21** in the center of the dot as the center. As a result, four areas (domains) each having a different alignment orientation are formed in one dot area to realize an alignment dividing structure, thus achieving a wide viewing angle.

[**0073**] The insulating film **21** includes the inclined area K in the vicinity of the boundary between the reflective display area R and the transparent display area T, and the alignment of the liquid crystal molecules **50**B varies continuously depending on the position of the inclined plane **21***a* of the insulating film **21**. Accordingly, no large alignment turbulence occurs, thus preventing imperfect display. The inclined plane **21***a* of the insulating film **21** is also inclined in four directions perpendicularly intersecting each other; thus, the presence of the inclined plane **21***a* allows smooth formation of the alignment dividing structure.

[**0074**] Referring to **FIGS. 4 and 5**, a second embodiment of the present invention will be described hereinafter.

[**0075**] The principle structure of a liquid crystal display of this embodiment is much the same as that of the first embodiment, but is different in only that the common electrode has a window for alignment control. Therefore, in **FIGS. 4 and 5**, components that are common to those of **FIGS. 2 and 3** are given the same reference numerals and a detailed description thereof will be omitted.

[**0076**] In this embodiment, as shown in **FIGS. 4 and 5**, the structure of the TFT array substrate **10** is not different from that of the first embodiment; however, a common electrode **31** on the opposed substrate **25** has a window **31**M. Two windows **31**M are provided for one dot, being formed in a long rectangle shape along the data line **6***a* in plan view. The windows **31**M are located on the outside of the inclined area K of the insulating film **21**.

[**0077**] As described in the first embodiment, with the structure of the present invention, merely providing the insulating film that is a projection toward the liquid crystal layer allows control of alignment orientation. However, as in this embodiment, when the windows **31**M are provided in the common electrode **31** on the opposed substrate **25** that faces the insulating film **21** and on the outside of the inclined area K of the insulating film **21**, an electric field generating between the electrodes on both the substrates tilts because the windows **31**M include no electrodes. The action of the inclined electric field allows smoother control of the alignment orientation of the liquid crystal molecules **50**B. The broken lines shown in the liquid crystal layer **50** of **FIG. 5** are potential lines. The liquid crystal molecules **50**B are aligned along the potential lines, thus being aligned smoothly without generating disclination due to the insulating film **21**.

[**0078**] The shape of the window is not limited to that shown in **FIG. 4**, but may be formed in a rectangular ring shape in accordance with the four-directional domains. However, in that case, the inside and the outside of the window must be electrically connected as one electrode; therefore, preferably, it is not a perfectly continuous rectangular ring but the inside and the outside of the window are connected at an arbitrary portion.

[**0079**] Referring to **FIG. 6, a** third embodiment of the present invention will be described.

[**0080**] The principle structure of a liquid crystal display of this embodiment is much the same as that of the first and second embodiments, but a mere difference is the position of the insulating film. Therefore, in **FIG. 6**, components that are common to **FIGS. 3 and 5** are given the same reference numerals and a detailed description thereof will be omitted.

[**0081**] In the first and second embodiments, the insulating film **21** is provided in the center of one dot; on the other hand, in this embodiment, the insulating film **21** is disposed near one end of one dot, as shown in **FIG. 6**. Corresponding to that, only one window **31**M is provided for one dot, being arranged on the outside of the inclined area K of the insulating film **21**.

[**0082**] In this embodiment, since the insulating film **21** is not located in the center of the dot, the alignment of the liquid crystal molecules **50**B is not controlled so as to form four domains substantially uniformly in one dot, as in the first and second embodiments. However, it produces the similar advantages to those of the first and second embodiments in that the problem of reduction in contrast due to the difference of retardation between the reflective and the transparent display modes can be solved, and imperfect display because of the fact that the alignment orientation of the liquid crystal molecules in the vertical alignment mode cannot be controlled can be reduced; thus, a liquid crystal display of high display quality can be realized. Although also this embodiment has the window **31**M as in the second embodiment, the broken lines shown in the liquid crystal layer **50** of **FIG. 6** are potential lines, and the liquid crystal molecules **50**B are aligned along the potential lines, thus being aligned smoothly without generating disclination due to the insulating film **21**.

[0083] Referring to **FIGS. 7 and 8**, a fourth embodiment of the present invention will be described.

[0084] **FIG. 7** is a plan view showing the structure of an adjacent plurality of dots on a TFT array substrate. **FIG. 8** is a sectional view taken along line A-A' of **FIG. 7**, showing the structure of the liquid crystal display of the same.

[0085] The principle structure of a liquid crystal display of this embodiment is substantially the same as that of the first to third embodiments, but the positional relationship between the reflective display area R and the transparent display area T is inversed and the shape of the pixel electrode is different. In **FIGS. 7 and 8**, components that are common to **FIGS. 2 and 3** are given the same reference numerals and a detailed description thereof will be omitted.

[0086] The TFT array substrate of this embodiment has the reflective film **20** shaped like a rectangular frame in the periphery of one dot area, as shown in **FIG. 7**. An area including the reflective film **20** serves as the reflective display area R, and an area including no reflective film **20**, which is inside the reflective display area R, serves as the transparent display area T. In other words, in the first to third embodiments, the inside of one dot area is the reflective display area R and the outside is the transparent display area T; on the other hand, in this embodiment, they are inversed. Also, the insulating film **21** shaped like a rectangular frame is formed so as to include the area of the reflective film **20** therein in plan view.

[0087] For the sectional structure, the reflective film **20** formed of a high-reflective metallic film such as aluminum and silver is formed on the TFT array substrate **10**, as shown in **FIG. 8**. As described above, the area of the reflective film **20** serves as the reflective display area R and the area having no reflective film **20** serves as the transparent display area T. The dye layer **22**R constituting a reflective-display color filter is provided on the reflective film **20** which is located in the reflective display area R; and the dye layer **22**T constituting a transparent-display color filter is provided on the substrate located in the transparent display area T. On the respective dye layers **22**R and **22**T of the reflective-display color filter and the transparent-display color filter, the insulating film **21** is formed in the position corresponding to the reflective display area R. The insulating film **21** has the inclined area K including the inclined plane **21***a* so as to vary its thickness continuously in the vicinity of the boundary between the reflective display area R and the transparent display area T. In this embodiment, the edge of the planar plane at the upper part of the insulating film **21** and the edge of the reflective film **20** (reflective display area) coincide substantially with each other, the inclined area K being included in the transparent display area T.

[0088] On the surface of the TFT array substrate **10** including the surface of the insulating film **21**, the pixel electrodes **9** formed of a transparent conductive film such as an ITO are provided. However, in the first to third embodiments, the pixel electrodes **9** are formed over the entire one dot area; on the other hand, in this embodiment, the pixel electrodes **9** are formed on the planar plane of the insulating film **21**, but are not formed on the inclined plane **21***a*, which becomes a no electrode formed area **9**N.

[0089] This construction is shown as a plan view in **FIG. 7**, wherein the area including the pixel electrodes **9** is indicated by a right-downward obliquely shaded area. More specifically, the insulating film **21** includes a recessed area shaped like an inverse quadrangular pyramid in the center of the dot area, on the inclined plane **21***a* of which has no pixel electrodes **9**, thus forming the no electrode formed area **9**N shaped like a substantially rectangular frame. However, when the no electrode formed area **9**N is shaped like a rectangular frame, the electrodes on the outside (reflective display area R) and the electrodes on the inside (transparent display area T) are completely separated. Therefore, the pixel electrodes **9** in the reflective display area R and the pixel electrodes **9** in the transparent display area T are electrically connected through a connecting section **9**C formed of an ITO which has the same layer as the electrodes. With such a structure, the same driving voltage can simultaneously be applied to the pixel electrodes **9** in both the reflective display area R and the transparent display area T. The connecting section **9**C may be formed of a different layer from the pixel electrodes **9** and may be connected to the pixel electrodes **9** through a contact hole. Also, as shown in **FIG. 8**, the alignment film **23** made of polyimide or the like is formed on the entire substrate so as to cover the pixel electrodes **9** and the inclined plane **21***a* of the insulating film **21**.

[0090] On the other hand, the opposed substrate **25** has the common electrode **31** made of a transparent conductive film such as an ITO and the alignment film **33** made of polyimide or the like on the substrate main body **25**A made of a translucent material such as glass and quartz. The respective alignment films **23** and **33** of the TFT array substrate **10** and the opposed substrate **25** are both subjected to vertical alignment treatment.

[0091] This embodiment can also produce the similar advantages to the first to third embodiments. More specifically, as described in the above embodiments, with the structure of the present invention, merely providing the insulating film **21** serving as a projection that projects toward the liquid crystal layer allows control of alignment orientation. However, in this embodiment, there are no pixel electrodes **9** on the inclined plane **21***a* of the insulating film **21**; therefore, an electric field generating between the electrodes on both the substrates is distorted in the vicinity of the inclined area K. The distortion of the electric field allows much smoother control of the alignment orientation of the liquid crystal molecules **50**B. The broken lines p shown in the liquid crystal layer **50** of **FIG. 8** are potential lines. The liquid crystal molecules **50**B are aligned along the potential lines p, thus being aligned smoothly without generating disclination due to the insulating film **21**.

[0092] Referring to **FIGS. 9 and 10**, a fifth embodiment of the present invention will be described.

[0093] The principle structure of a liquid crystal display of this embodiment is much the same as that of the fourth embodiment, but a mere difference is the size of the no electrode formed area. Therefore, in **FIGS. 9 and 10**, components that are common to **FIGS. 7 and 8** are given the same reference numerals and a detailed description thereof will be omitted.

[0094] In the fourth embodiment, the entire inclined plane **21***a* of the insulating film **21** is no electrode formed area **9**N; on the other hand, in this embodiment, only part of the inclined plane **21***a* of the insulating film **21** is the no electrode formed area **9**N shaped like a slit as shown in **FIGS. 9 and 10**. In both the fourth and fifth embodiments, in order to form the no electrode formed area **9**N, it is enough to merely make the mask pattern into this shape in patterning the pixel electrodes **9**. Therefore, they are not particularly different in production process from the case without the no electrode formed area **9**N.

[0095] Also this embodiment includes the no electrode formed area **9**N having no pixel electrodes **9** on the inclined plane **21***a* of the insulating film **21**, thus offering the advantages similar to those of the fourth embodiment, that is, the electric field generating between the electrodes on both the substrates is distorted in this area, which allows much smoother control of alignment orientation of the liquid crystal molecules **50**B. The shape, the position and so on of the no electrode formed area **9**N in the fourth and fifth embodiments are not particularly limited to the above example, but may be modified as appropriate.

[0096] Referring to **FIG. 11, a** sixth embodiment of the present invention will be described.

[0097] The principle structure of a liquid crystal display of this embodiment is much the same as that of the fourth embodiment, but the inclination angle of the inclined plane of the insulating film is merely specified. Therefore, in **FIG. 11**, components that are common to **FIG. 8** are given the same reference numerals and a detailed description thereof will be omitted.

[0098] When the area of the transparent display area T is relatively large in one dot area (for example, the proportion of the area of the transparent display area T is 50% or more), the reflective film **20** is extended downward from the inclined area K of the insulating film **21**, and the inclined area K of the insulating film **21** is used as the reflective display area R, as shown in **FIG. 11**. The fourth embodiment (**FIG. 8**) has no reflective film **20** under the inclined area K of the insulating film **21**, and the inclined area K of the insulating film **21** is the transparent display area T. The inclination angle θ of the inclined plane **21***a* of the insulating film **21** is specified to about 50°.

[0099] The inclined area K, whether in the transparent display area T or the reflective display area R, is a cause of decreasing the display quality because the retardation is a fractional value. In this embodiment, since this area is included in the reflective display area R, the transparent display does not decrease in quality while the reflective display is slightly inferior in quality. Accordingly, this has a structure somewhat suitable for a transflective liquid crystal display that attaches importance to transparent display.

[0100] Referring to **FIG. 12, a** seventh embodiment of the present invention will be described.

[0101] **FIG. 12** is a sectional view showing the structure of a liquid crystal display of this embodiment. In **FIG. 12**, components that are common to the sectional views of the above embodiments of **FIG. 8** and so on are given the same reference numerals and a detailed description thereof will be omitted.

[0102] In the liquid crystal display of this embodiment, the liquid crystal layer **50** made of a liquid crystal, which is aligned vertically in the initial state, is sandwiched between the TFT array substrate **10** and the opposed substrate **25** opposed thereto, as shown in **FIG. 12**. The opposed substrate **25** has the dye layer **22**R constituting a reflective-display color filter and the dye layer **22**T constituting a transparent-display color filter thereon. The respective dye layers **22**R and **22**T of the reflective-display color filter and the transparent-display color filter have the insulating film **21** in the position corresponding to the reflective display area R. The common electrode **31** is formed on the insulating film **21** and the dye layer **22**T of the transparent-display color filter. Also in this embodiment, the insulating film **21** includes the inclined plane **21***a;* however, the inclined plane **21***a* has no common electrode **31** thereon, serving as a no electrode formed area **31**N.

[0103] The TFT array substrate **10** has a TFT **110** thereon. The TFT **110** has a semiconductor layer **111** including a source area **111***s,* a drain area **111***d,* and a channel area **111***c,* a gate insulating film **112**, and a gate electrode **113**. The source area **111***s* has a source line **114** (data line) connected thereto; and the drain area **111***d* has a drain electrode **115** connected thereto. To the drain electrode **115**, the pixel electrodes **9** are connected via a contact hole **117** of an interlayer insulating film **116**. In this embodiment, the contact hole **117** does not overlap the inclined area K of the insulating film **21** of the opposed substrate **25** in plan view, but is arranged in the position below the dye layer **22**T (planar plane) of the transparent-display color filter.

[0104] In this embodiment, the alignment of the liquid crystal molecules **50**B can be controlled by the shape effect of the insulating film **21** formed on the opposed substrate **25,** and further controlled by providing the no electrode formed area **31**N having no common electrode **31** on the inclined plane **21***a* of the insulating film **21**. In addition, the contact hole **117** is disposed on the TFT array substrate **10** in the area which corresponds to a planar plane and does not overlap the inclined area K of the insulating film **21** in plan view. Therefore, an electric field generating in the liquid crystal layer **50** is distorted in the vicinity of the contact hole **117**. The distortion of the electric field allows much smoother control of the alignment orientation of the liquid crystal molecules **50**B. The broken lines p shown in the liquid crystal layer **50** of **FIG. 12** are potential lines. The liquid crystal molecules **50**B are aligned along the potential lines p, thus being aligned smoothly without generating disclination.

Electronic Device

[0105] Subsequently, a specific example of an electronic device having the liquid crystal display according to the above embodiments of the present invention will be described.

[0106] **FIG. 14** is a perspective view showing an example of a cellular phone. In **FIG. 14**, reference numeral **500** denotes a cellular phone body; and reference numeral **501** indicates a display section using the above-described liquid crystal display.

[0107] **FIG. 15** is a perspective view showing an example of a portable information processing unit such as a word processor and a personal computer. In **FIG. 15**, reference numeral **600** denotes an information processing unit, numeral **601** denotes an input section such as a keyboard, numeral **603** indicates an information processing unit body, and numeral **602** indicates a display section using the above-described liquid crystal display.

[0108] **FIG. 16** is a perspective view showing an example of a wristwatch type electronic device. In **FIG. 16**, reference numeral **700** denotes a watch body, and numeral **701** indicates a display section using the above-described liquid crystal display.

[0109] The electronic devices shown in FIGS. **14** to **16** each have a display section that uses the liquid crystal display of the above embodiments. Accordingly, electronic devices can be realized which have a light and high- contrast liquid crystal display having a wide viewing angle irrespective of use environment.

[0110] The technical scope of the present invention is not limited to the above embodiments, but various modifications are possible without departing from the scope of the invention. For example, while in the above embodiments, the present invention is applied to an active-matrix liquid crystal display using a TFT as a switching element, it is also possible to apply the present invention to an active-matrix liquid crystal display, a passive-matrix liquid crystal display and so on that use a thin-film-diode (TFD) switching element. Specific description about the materials, sizes, shapes of various components and so on may be changed as appropriate.

Advantages

[0111] As specifically described above, according to the present invention, in the transflective liquid crystal display, the problem of reduction in contrast due to the difference of retardation between the reflective and the transparent display modes can be solved, and imperfect display because of the fact that the alignment orientation of the liquid crystal molecules in the vertical alignment mode cannot be controlled can be reduced. Consequently, a liquid crystal display of high display quality can be realized. Also, an alignment dividing structure can be realized depending on the arrangement of the insulating film to achieve a wide viewing angle.

What is claimed is:

1. A liquid crystal display including a liquid crystal layer sandwiched between a pair of substrates and separately having a transparent display area for transparent display and a reflective display area for reflective display in one dot area, characterized in that:

the liquid crystal layer exhibits vertical alignment in the initial alignment state; and an insulating film is provided between at least one of the pair of substrates and the liquid crystal layer and in at least the reflective display area, the insulating film making the thickness of the liquid crystal layer in the reflective display area and in the transparent display area different owing to its film thickness.

2. A liquid crystal display including a liquid crystal layer sandwiched between a pair of substrates and separately having a transparent display area for transparent display and a reflective display area for reflective display in one dot area, characterized in that:

an insulating film is provided between at least one of the pair of substrates and the liquid crystal layer and in at least the reflective display area, the insulating film making the thickness of the liquid crystal layer in the reflective display area and in the transparent display area different owing to its film thickness; and the thickness of the liquid crystal layer in the center of the dot area is set smaller than the thickness of the liquid crystal layer in the periphery of the one dot area.

3. A liquid crystal display according to claim 1, characterized in that the transparent display area is disposed to surround the periphery of the reflective display area in the one dot; and the insulating film is disposed in the area corresponding to the reflective display area in the center of the dot.

4. A liquid crystal display including a liquid crystal layer sandwiched between a pair of substrates and separately having a transparent display area for transparent display and a reflective display area for reflective display in one dot area, characterized in that:

an insulating film is provided between at least one of the pair of substrates and the liquid crystal layer and in at least the reflective display area, the insulating film making the thickness of the liquid crystal layer in the reflective display area and in the transparent display area different owing to its film thickness; and the thickness of the liquid crystal layer in the periphery of the dot area is set smaller than in the center in the one dot area.

5. A liquid crystal display according to claim 1, characterized in that the reflective display area is disposed to surround the periphery of the transparent display area in the one dot; and the insulating film is disposed in the area corresponding to the reflective display area in the periphery of the dot.

6. A liquid crystal display according to claim 1, characterized in that the insulating film includes an inclined area in the vicinity of the boundary between the reflective display area and the transparent display area, the inclined area having an inclined plane so that its thickness continuously varies.

7. A liquid crystal display according to claim 6, characterized in that an electrode for driving the liquid crystal layer is provided to the substrate having the insulating film; and a no electrode formed area where the electrode is absent is provided in at least part of the inclined plane of the insulating film.

8. A liquid crystal display according to claim 7, characterized in that the electrode in the reflective display area and the electrode in the transparent display area, which are provided on both sides of the no electrode formed area, are electrically connected through a connecting section formed of the same layer as the electrodes.

9. A liquid crystal display according to claim 7, characterized in that the electrode in the reflective display area and the electrode in the transparent display area, which are provided on both sides of the no electrode formed area, are electrically connected through a connecting section formed of a different layer from the electrodes.

10. A liquid crystal display according to claim 7, characterized in that: one of the substrates is an element substrate having a pixel electrode and a switching element; and the other substrate is an opposed substrate having a common electrode and the insulating film, wherein a contact hole for electrically connecting the pixel electrode and the switching element on the one substrate is disposed in the position not overlapping the inclined area.

11. A liquid crystal display according to claim 7, characterized in that an electrode for driving the liquid crystal layer and the insulating film are provided on one of the pair of substrates; and an electrode for driving the liquid crystal layer is provided on the other substrate, wherein the electrode on the other substrate includes a window on the outside of the inclined area of the insulating film.

12. A liquid crystal display according to claim 6, characterized in that the inclination angle of the inclined plane of the insulating film relative to the substrate surface is in the range of 5 to 50°.

13. A liquid crystal display according to claim 2, characterized in that the outline of the insulating film in the one dot area is an equilateral polygon or a circle.

14. A liquid crystal display according to claim 1, characterized in that there is provided circularly-polarized-light radiating means for radiating circularly polarized light into the one substrate and the other substrate.

15. An electronic device characterized by comprising the liquid crystal display according to claim 1.

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专利名称(译)	液晶显示器和电子设备		
公开(公告)号	US20030160928A1	公开(公告)日	2003-08-28
申请号	US10/352199	申请日	2003-01-28
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IPC分类号	G02F1/1333 G02F1/1335 G02F1/139 G02F1/1337		
CPC分类号	G02F1/133345 G02F1/133371 G02F2203/09 G02F1/1393 G02F2001/133776 G02F1/133555		
优先权	2002019876 2002-01-29 JP 2002369975 2002-12-20 JP		
其他公开文献	US7271866		
外部链接	Espacenet USPTO		

摘要(译)

提供一种能够在透反液晶显示器中获得具有宽视角的光和高对比度显示器的液晶显示器。本发明的液晶显示器采用垂直取向模式，使用在初始取向状态下垂直取向的液晶层50，其中透明显示区域T设置成围绕一个点中的反射显示区域R的周边并且，在与点的中心的反射显示区域R对应的区域中设置绝缘膜21，使反射显示区域R中的液晶层50的厚度小于绝缘膜21的厚度。透明显示区域T中的液晶层50。