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Maeda et al.

(54) **DISPLAY DEVICE**

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(57) **ABSTRACT**

The purpose of the present invention is to ensure uniformity among pixels when an electrode for a touch sensor also acts as an electrode for image display at the same time. This display device includes: a circuit substrate; a plurality of pixel electrodes (**12**) that are arranged in a matrix on a plane that is parallel to the circuit substrate; a liquid crystal layer that can exhibit an image display function on the basis of an image signal supplied to the plurality of pixel electrodes (**12**), a plurality of driver electrodes (**14**) arranged in the same layer with gaps therebetween, which can generate an electric field with the pixel electrodes (**12**) to alter the state of the liquid crystal layer; and a plurality of detection electrodes in the same layer that can be capacitively coupled to the plurality of driver electrodes, respectively, in which at least one of the plurality of driver electrodes (**14**) is provided with slits (**20**).

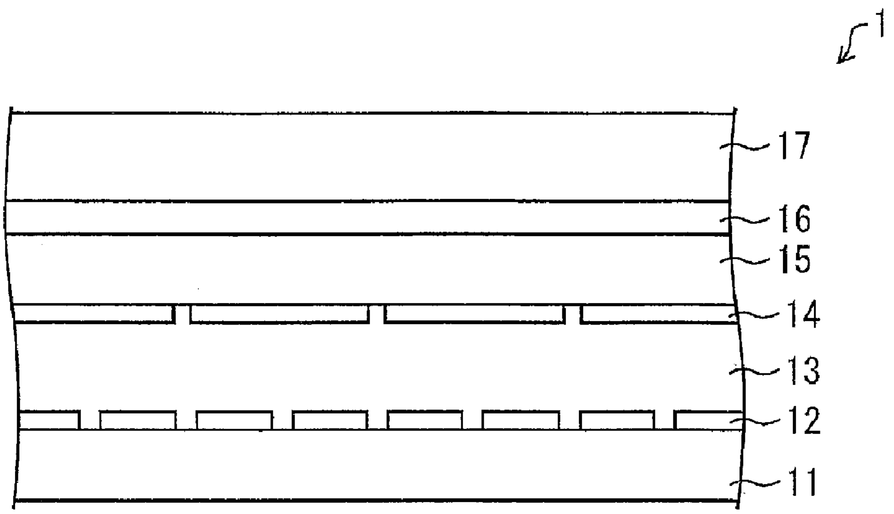
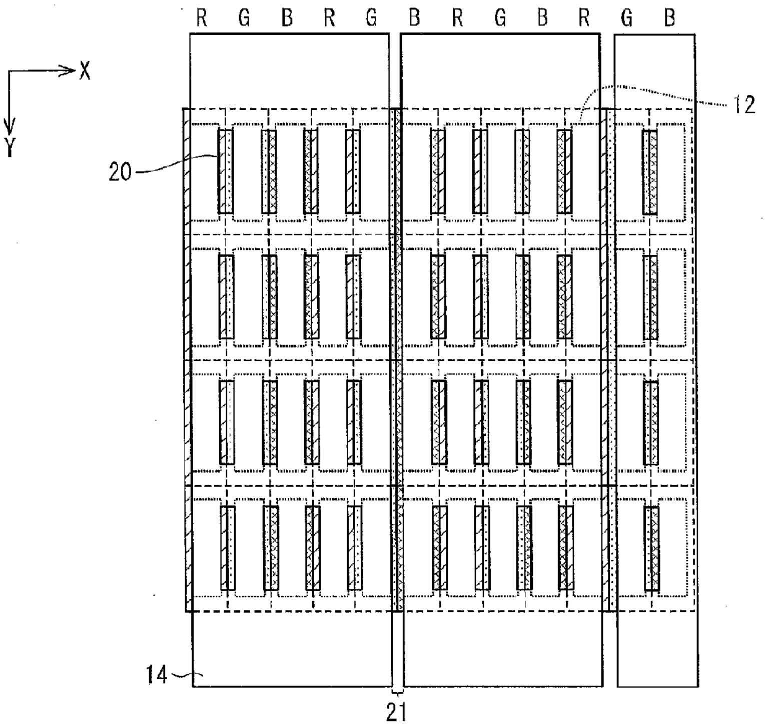


FIG. 1

(a)



(b)

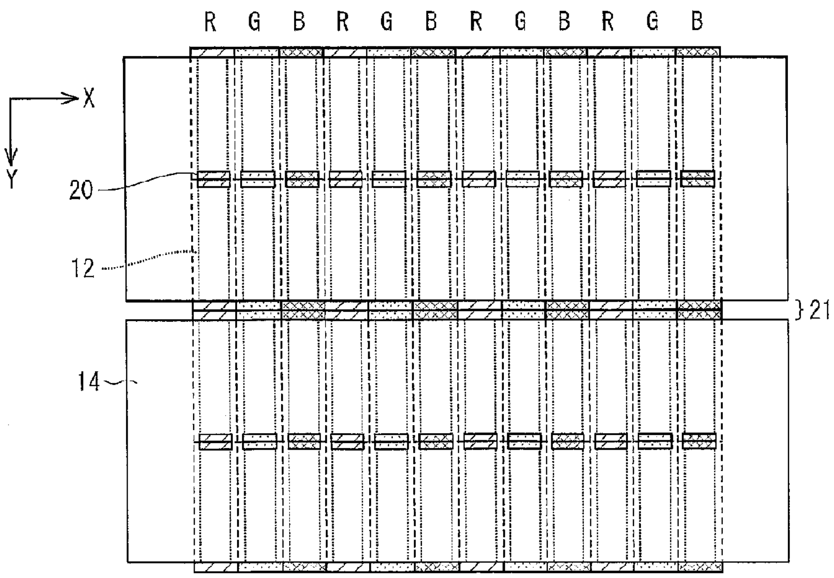


FIG. 2

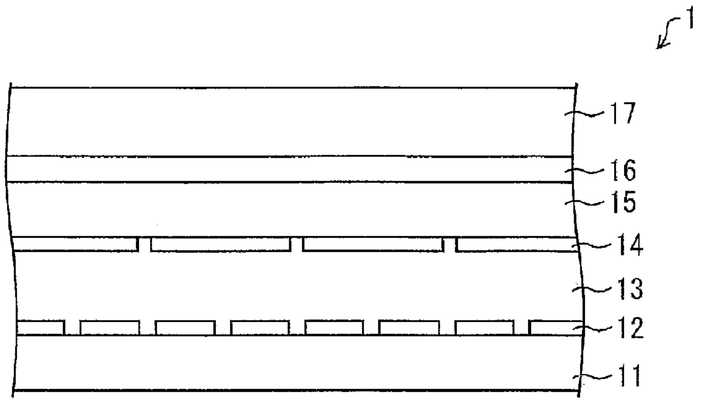


FIG. 3

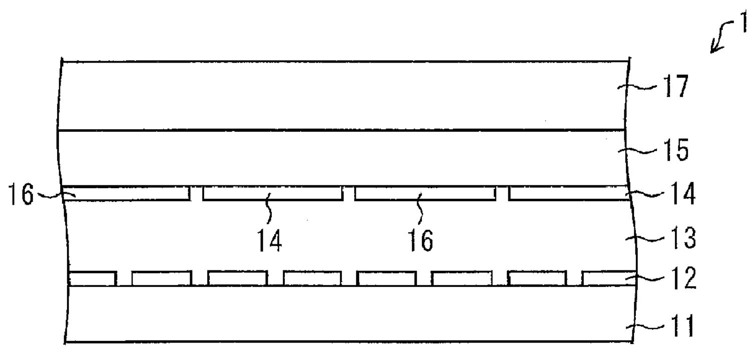
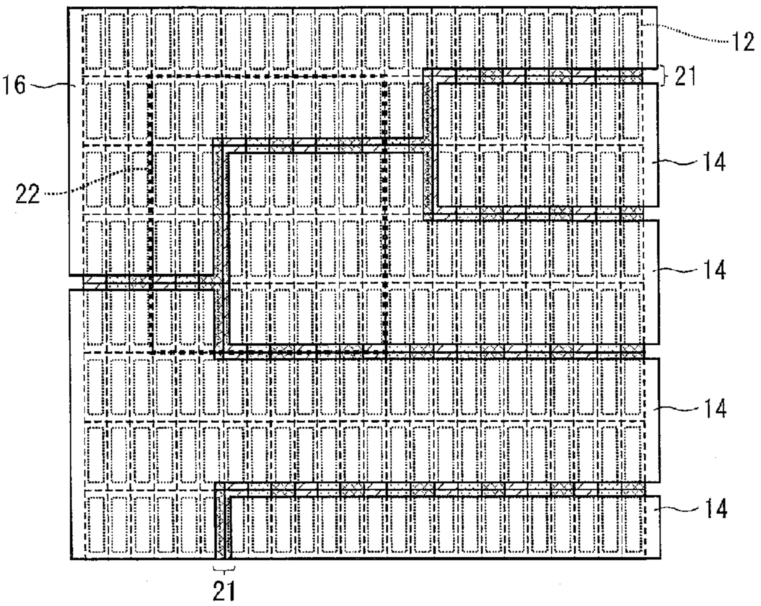


FIG. 4

(a)



(b)

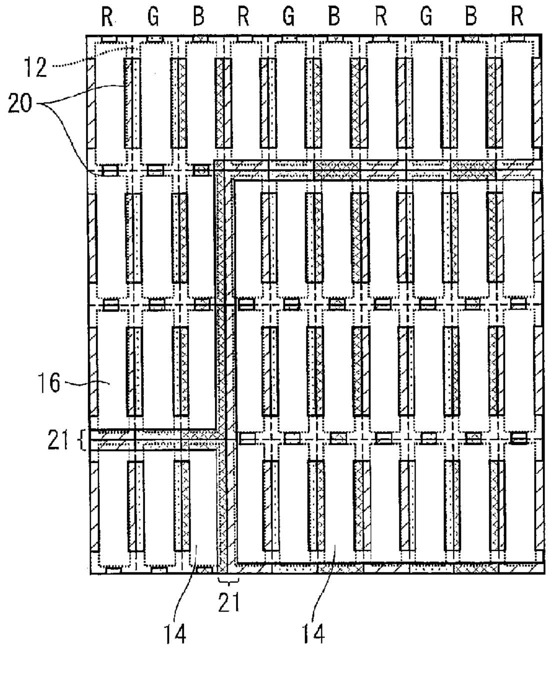
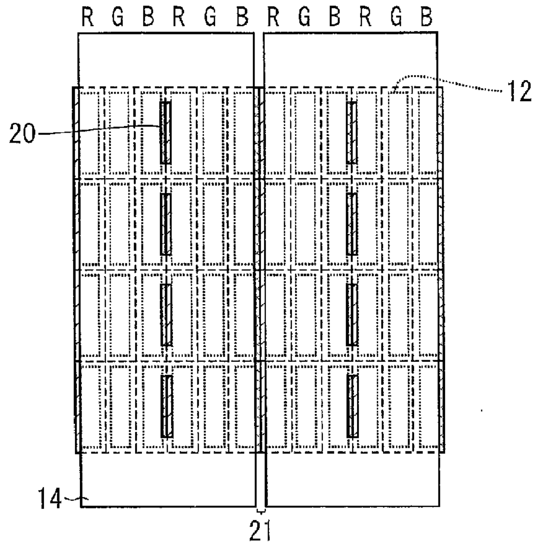
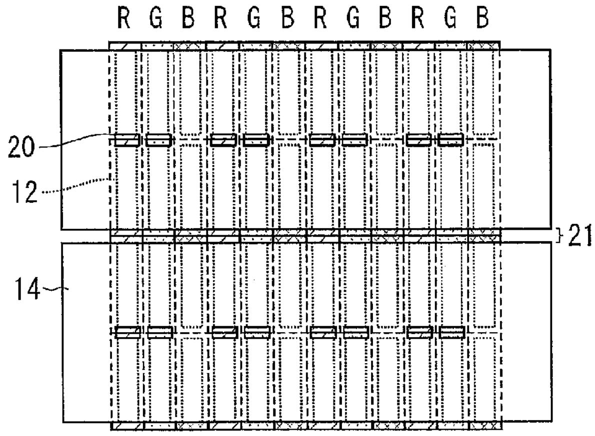


FIG. 5

(a)


R G B R G B R G B R G B
12
20
14
21

(b)


R G B R G B R G B R G B
20
12
21
14

(c)

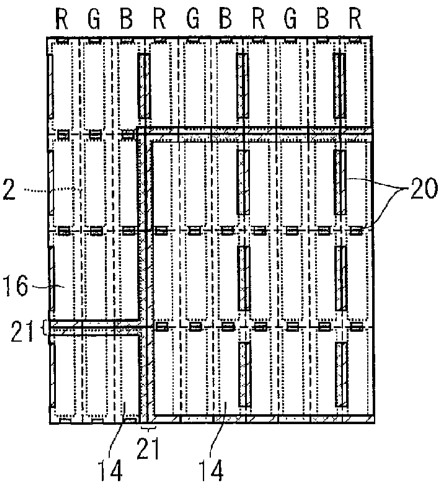

R G B R G B R G B R
12
20
16
21
14
21
14

FIG. 6

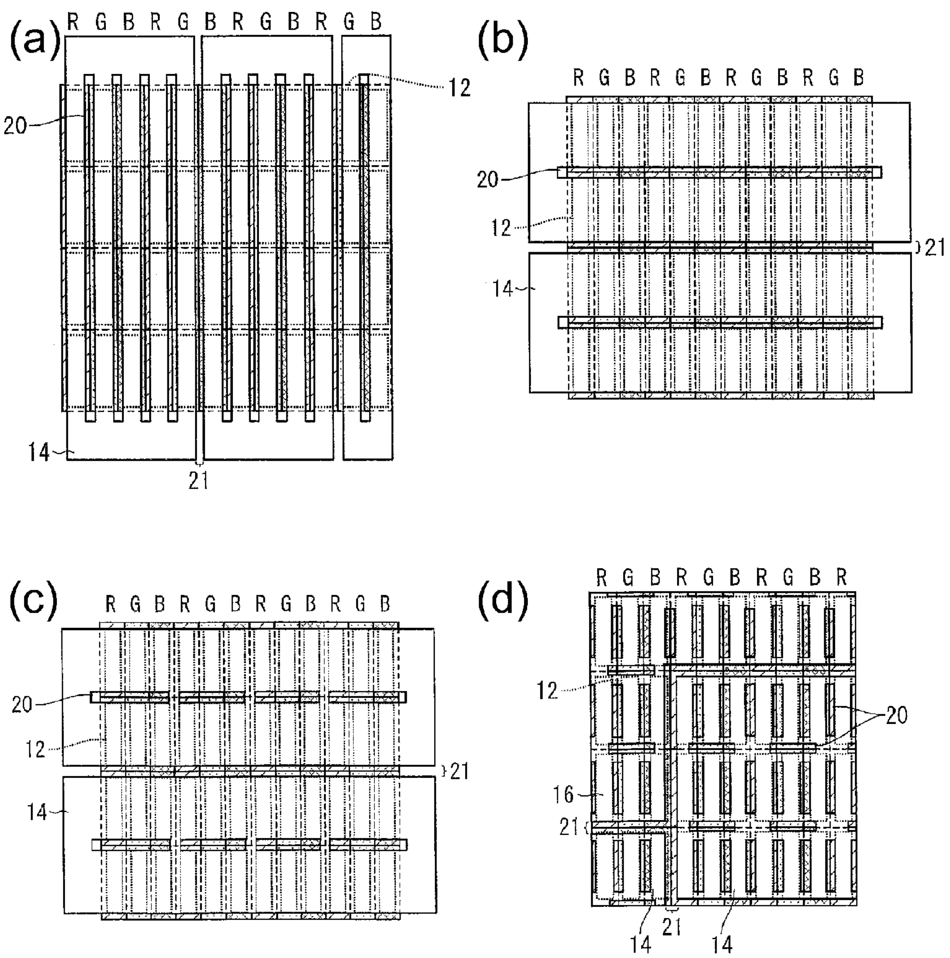

(a)
R G B R G B R G B R G B
12
20
14
21
(b)
R G B R G B R G B R G B
20
12
21
14
(c)
R G B R G B R G B R G B
20
12
21
14
(d)
R G B R G B R G B R
12
20
16
21
14
21
14

FIG. 7

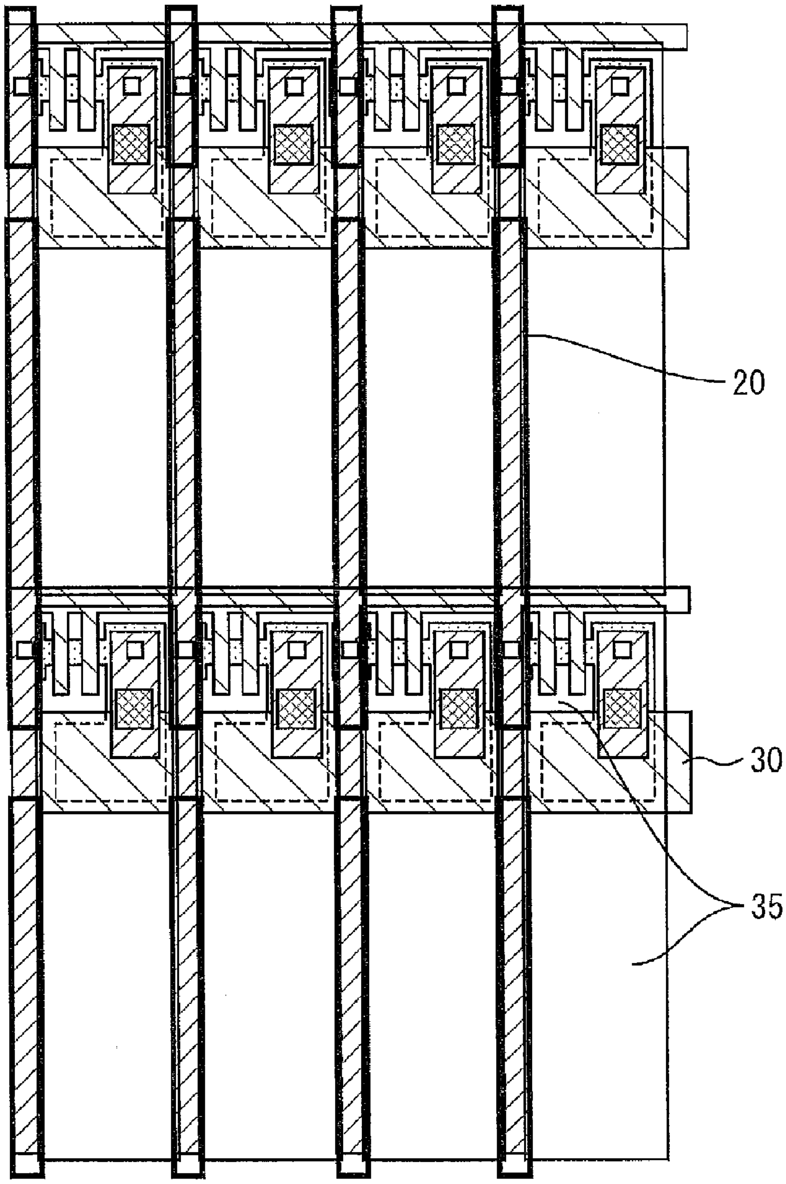


FIG. 8

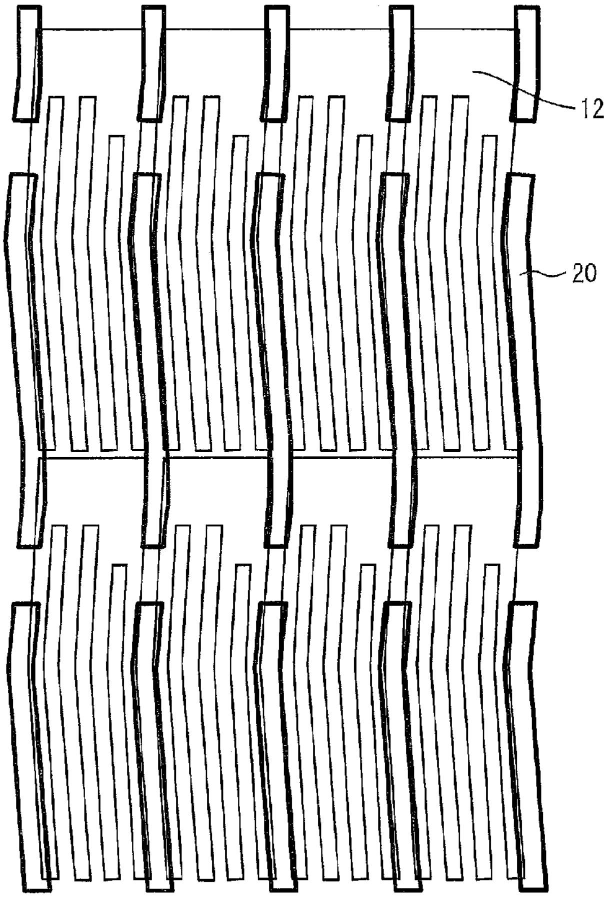


FIG. 9

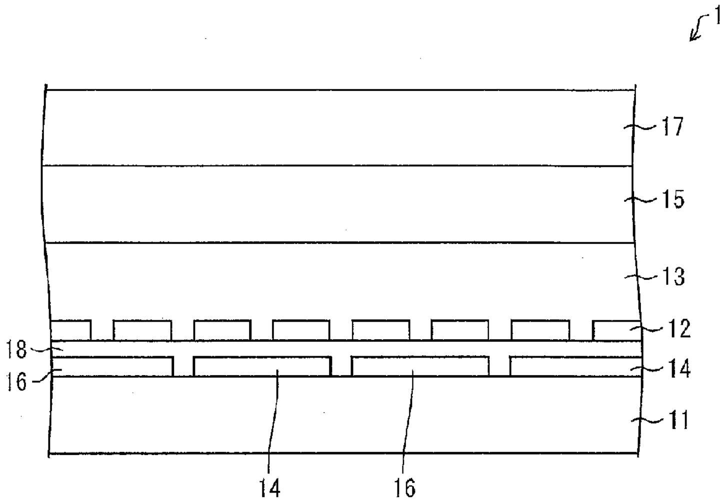
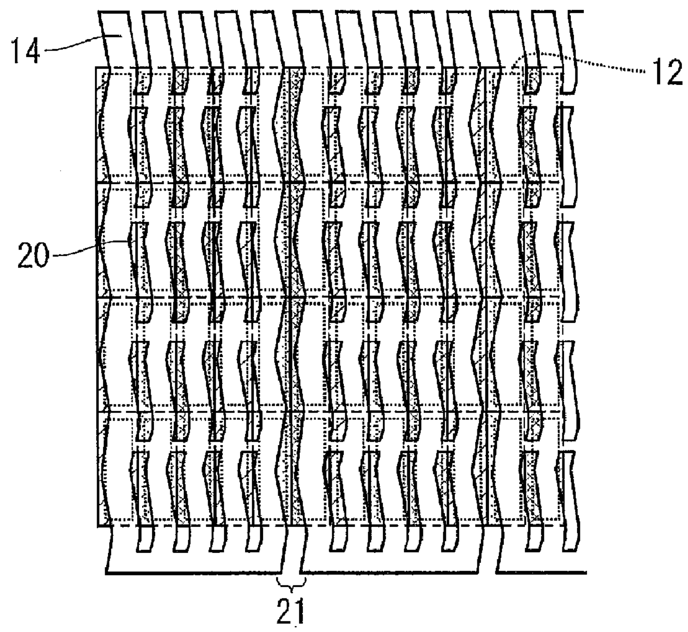


FIG. 10

(a)



(b)

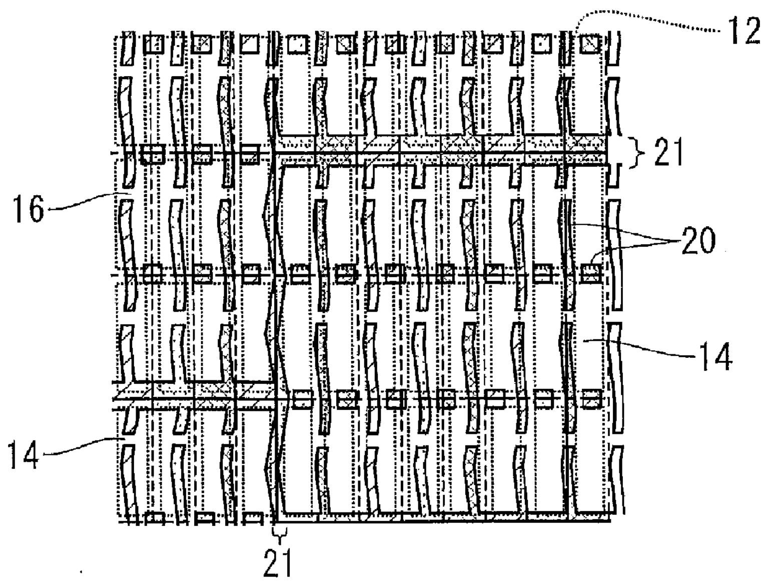


FIG. 11

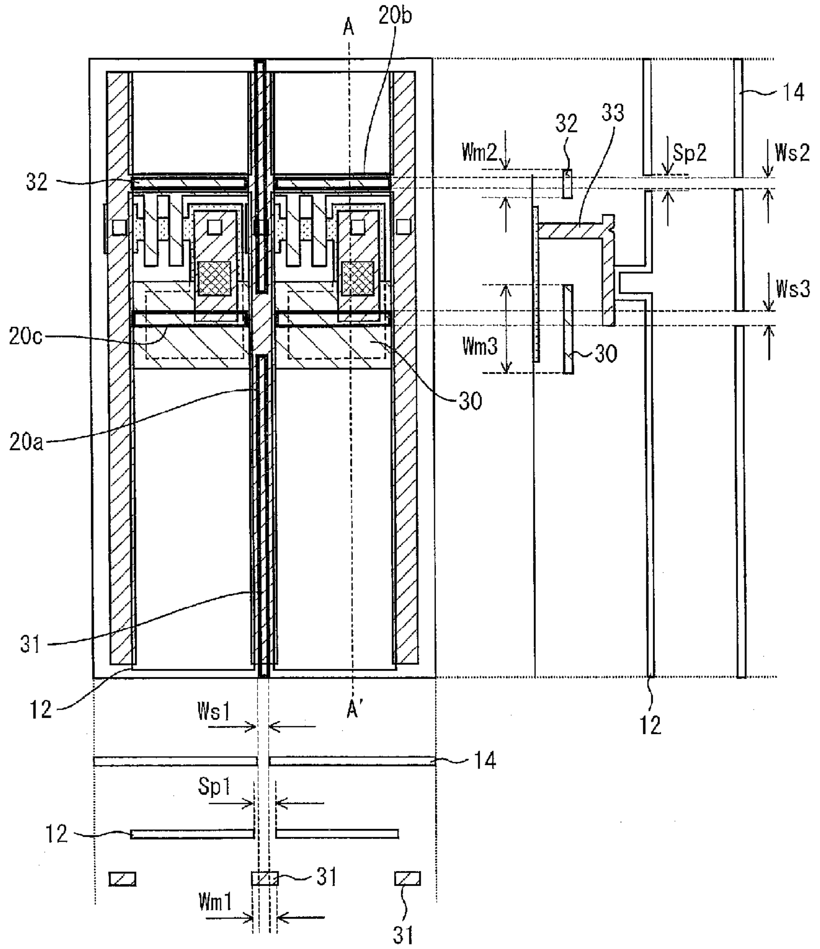
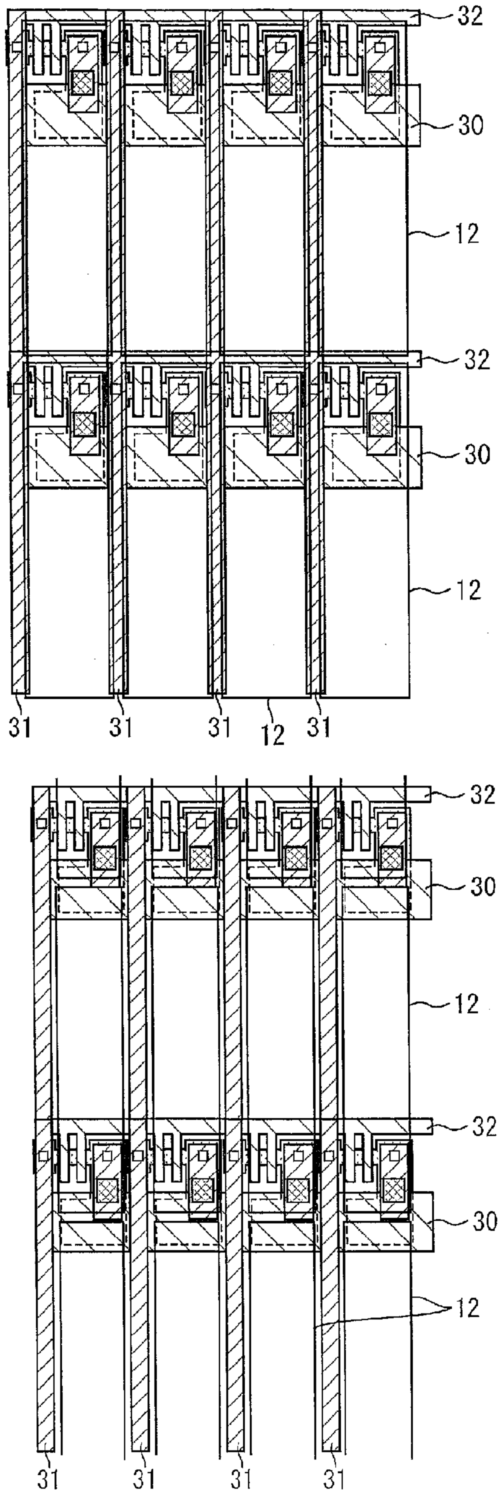

A
20b
14
32
33
Wm2
Sp2
Ws2
32
Ws3
20c
Wm3
30
30
20a
31
12
A'
12
Ws1
14
Sp1
12
31
Wm1
31

FIG. 12

(a)

(b)



DISPLAY DEVICE

TECHNICAL FIELD

[0001] The present invention relates to a display device having a capacitive-type touch sensor function.

BACKGROUND ART

[0002] A conventional touch panel that detects a position where a finger or a stylus of a user comes into contact with or approaches the touch panel is known. Also, display devices with such a touch panel that can detect a position where a finger or a stylus of a user comes into contact with or approaches a display surface of the touch panel are used in many devices.

[0003] If a touch panel is provided in a display device such as a liquid crystal panel, the display module such as a liquid crystal module as a whole becomes thick.

[0004] As a countermeasure, a technique has been developed in which the same electrode is used for the touch panel and for image display in the display device (Patent Documents 1 to 6). For example, in Patent Document 1, driver electrodes of a plurality of touch sensors are used for scanning driving for the touch sensor, and for the so-called VCOM driving for an image display device at the same time, thus mitigating an increase in thickness of the liquid crystal module.

[0005] In Patent Document 2, a common electrode in a display region is divided into blocks, and a portion thereof is additionally used as a driver electrode for a touch sensor, and the remaining portion is additionally used as a detection electrode for the touch sensor, thus mitigating an increase in thickness of the liquid crystal module.

RELATED ART DOCUMENTS

Patent Documents

[0006] Patent Document 1: Japanese Patent Application Laid-Open Publication, "Japanese Patent Application Laid-Open Publication No. 2010-197576 (Published on Sep. 9, 2010)"

[0007] Patent Document 2: US Patent Application Publication No. 2010/0001973 (Published on Jan. 7, 2010)

[0008] Patent Document 3: Japanese Patent Application Laid-Open Publication (Japanese Translation of PCT International Application) No. 2009-540374 (Published on Nov. 19, 2009)"

[0009] Patent Document 4: Japanese Patent Application Laid-Open Publication, "Japanese Patent Application Laid-Open Publication No. 2009-199093 (Published on Sep. 3, 2009)"

[0010] Patent Document 5: Japanese Patent Application Laid-Open Publication (Japanese Translation of PCT International Application) No. 2009-540375 (Published on Nov. 19, 2009)"

[0011] Patent Document 6: Japanese Patent Application Laid-Open Publication, "Japanese Patent Application Laid-Open Publication No. 2009-211706 (Published on Sep. 17, 2009)"

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0012] However, if the common electrode for image display is divided into a plurality of parts, at the color pixel unit, there is a difference in physical and electrical properties between pixels at a separation region, which is a gap in the common electrode, and pixels not at the separation region. As a result, the physical and electrical states become non-uniform among pixels, which causes a decrease in display quality.

[0013] The present invention was made in view of the above-mentioned problem, and an object thereof is to provide a display device with improved uniformity among pixels in terms of physical and electrical properties when a plurality of common electrodes that double as touch sensor electrodes are provided.

Means for Solving the Problems

[0014] In order to solve the above-mentioned problem, a display device according to the present invention includes: a substrate; a plurality of pixel electrodes arranged in a matrix on a plane parallel to the substrate; a display function layer that exhibits image display functionality based on an image signal provided to the plurality of pixel electrodes; a plurality of first electrodes provided in a same layer as each other with gaps therebetween, the plurality of first electrodes generating an electric field with the pixel electrodes and thereby changing a state of the display function layer; and a plurality of second electrodes in a same layer as each other, respectively capacitively coupled with the plurality of first electrodes, wherein at least one of the plurality of first electrodes is provided with slits.

[0015] With this configuration, the display device according to the present invention includes a plurality of pixel electrodes arranged in a matrix, and a plurality of first electrodes that are respectively in the same layer. The plurality of first electrodes generate an electric field with the pixel electrodes, thus changing the state of the display function layer. Therefore, the first electrodes can function as a common electrode for realizing image display by causing the display function layer to exhibit image display functionality together with the pixel electrodes. The display device further includes a plurality of second electrodes that are in the same layer as each other, the second electrodes being capacitively coupled with the plurality of first electrodes, respectively. If a finger, a stylus, or the like approaches the second electrodes, the capacitance between the first electrodes and the second electrodes can change. Since a plurality of first electrodes and a plurality of second electrodes are respectively provided, the combination thereof allows a position to be specified where the capacitance between a first electrode and a second electrode has changed, or in other words, where a finger or a stylus has approached the device. Thus, the first electrodes and the second electrodes can also function as touch sensor electrodes.

[0016] Because the first electrodes, which can function as a common electrode, are provided with gaps therebetween, pixels with portions that do not overlap the first electrodes may exist. A degradation of display quality occurs due to changes in the electric field generated between each pixel electrode of such pixels and the first electrode even if the same image signal is sent to the respective pixel electrodes, when compared to pixels that are completely covered by the first electrodes.

[0017] However, in the display device of the present invention, slits are provided in at least one first electrode. By being provided with slits, the interior of the first electrode is provided with analogues to the gap between the first electrodes. Thus, in pixels with portions overlapping the slits, the relation between the first electrodes and the pixel electrodes of such pixels is similar to the relation between the first electrodes and the pixel electrodes of pixels having a portion that overlaps a gap between the first electrodes. As a result, it is possible to maintain uniformity between pixels that have a portion overlapping a gap between the first electrodes and pixels that do not have a portion overlapping a gap between the first electrodes, and thus, it is possible to improve display quality.

Effects of the Invention

[0018] As stated above, in the display device of the present invention, the first electrodes that also function as image display electrodes are provided with slits. As a result, it is possible to attain uniformity between pixels that have a portion overlapping a gap between the first electrodes and pixels that do not have a portion overlapping a gap between the first electrodes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** shows patterns of driver electrodes and slits of an embodiment of the present invention.

[0020] FIG. **2** is a cross-sectional view that shows a schematic configuration of a display device of the present embodiment.

[0021] FIG. **3** is a cross-sectional view that shows a schematic configuration of a display device of another embodiment.

[0022] FIG. **4** shows a pattern of driver electrodes and slits in the display device shown in FIG. **3**.

[0023] FIG. **5** shows another example of patterns of driver electrodes and slits of the present embodiment.

[0024] FIG. **6** shows yet another example of patterns of driver electrodes and slits of the present embodiment.

[0025] FIG. **7** shows a slit pattern of the present embodiment corresponding to a pixel structure.

[0026] FIG. **8** shows a slit pattern of another embodiment corresponding to a pixel electrode.

[0027] FIG. **9** is a cross-sectional view that shows a schematic configuration of a display device of another embodiment.

[0028] FIG. **10** shows an example of patterns of driver electrodes and slits in the display device shown in FIG. **9**.

[0029] FIG. **11** shows a slit pattern of another embodiment corresponding to a pixel structure.

[0030] FIG. **12** shows pixel structures of the embodiment shown in FIG. **11**.

DETAILED DESCRIPTION OF EMBODIMENTS

Embodiment 1

(Configuration of Display Device)

[0031] One embodiment of a display device according to the present invention will be described below.

[0032] FIG. **2** is a cross-sectional view that shows a schematic configuration of a display device of the present embodiment.

[0033] A display device **1** is provided with capacitive-type touch sensors. The capacitive-type touch sensors are provided with two types of electrodes for forming capacitance in order to detect contact or an approach by a finger, a stylus, or the like. Here, the electrode that conducts scanning driving for the touch sensor is the driver electrode (first electrode), and the other electrode is the detection electrode (second electrode). In the present embodiment, in general, a display device in which the driver electrodes are provided in the display panel and the detection electrodes are provided outside of the display panel will be described. However, the present invention is not limited to this configuration, and as will be described later, both electrodes may be provided in the display panel.

[0034] As shown in FIG. **2**, the display device **1** of the present embodiment includes a circuit substrate (substrate) **11**, a plurality of pixel electrodes **12** arranged in a matrix on a plane parallel to the circuit substrate **11**, a liquid crystal layer (display function layer) **13**, driver electrodes **14** provided facing the pixel electrodes **12**, an opposite substrate **15**, detection electrodes **16** provided on the outer side of the opposite substrate, and a protective layer **17** for protecting these elements.

[0035] Besides thin film transistors (TFT), wiring lines, electrodes, and the like necessary for driving the liquid crystal layer **13**, such as source bus lines, gate bus lines, and Cs electrodes are formed on the circuit substrate **11**. In each of the matrix of regions divided by the plurality of source bus lines and the plurality of gate bus lines, a pixel electrode **12** is formed. Each of the regions corresponds to a color pixel assigned a color (here, red (R), green (G), or blue (B)).

[0036] The liquid crystal layer **13** is a layer that can realize image display by changing the orientation of liquid crystal based on an image signal supplied to the pixel electrodes **12**.

[0037] The circuit substrate **11**, the pixel electrodes **12**, and the liquid crystal layer **13** can have conventionally known configurations of a circuit substrate, pixel electrodes, and a liquid crystal layer.

[0038] As stated above, the driver electrodes **14** are electrodes for conducting scanning driving of the touch sensors and form a capacitance with the detection electrodes **16**, and the driver electrodes **14** also detect a contact position or an approach position of a finger, a stylus, or the like based on detected changes in the capacitance. Here, the driver electrodes **14** are provided facing the pixel electrodes **12**, and also function as a common electrode that conducts Vcom driving for image display. The respective driver electrodes **14** are disposed at a distance from each other with gaps therebetween. FIG. **2** is simply a drawing for showing the driver electrodes **14** disposed at a distance from each other, and therefore, the separation pattern of the driver electrodes **14** in FIG. **2** does not necessarily correspond to that of the real device.

[0039] Of the plurality of driver electrodes **14**, at least one driver electrode **14** has slits, and it is preferable that all driver electrodes **14** have slits. If all driver electrodes **14** have slits, it is preferable that the respective driver electrodes **14** have slits of the same form (pattern, shape, size). Details on the slits in the driver electrodes **14** will be described below.

[0040] The opposite substrate **15** is provided with color filters of R, G, or B on one side thereof in positions corresponding to the color pixels of each color.

[0041] The detection electrodes **16** are electrodes that capacitively couple respectively with the plurality of driver electrodes **14**, and the respective detection electrodes **16** are formed in the same layer as each other. The number and shape of the detection electrodes **16** can be determined according to desired function and performance of the touch sensors.

(Driver Electrodes)

[0042] The driver electrodes **14** are configured as a plurality of electrodes in the same layer as each other for detecting a position of a finger, a stylus, or the like on a touch sensor. The driver electrodes **14** are each separated from each other, and a separation region (gap) **21** is formed between each driver electrode **14**. Here, the driver electrodes **14** also function as a common electrode, and thus, are provided covering substantially the entire surface of the liquid crystal layer **13**. The number and shape of the driver electrodes **14** can be determined according to desired function and performance of the touch sensors.

[0043] FIG. **1** shows patterns of the driver electrodes **14** and slits **20** provided in the driver electrodes **14**, and, for ease of description, only shows respective color pixels (including the pixel electrodes **12**) and driver electrodes **14** (including slits **20**). Because the driver electrodes **14** are transparent electrodes, normally, color pixels are seen through the driver electrodes **14** even in regions where the slits **20** are not provided, in addition to portions where the slits **20** are provided, but for ease of description, in the affixed drawings, the pixels in portions overlapping the driver electrodes **14** are shown with broken lines.

[0044] As shown in FIG. **1**(*a*), in the present embodiment, the driver electrodes **14** are belt-shaped electrodes that extend in the column direction (direction along the Y arrow in the drawing, simply referred to as the column direction below) of the matrix constituted of the color pixels. The belt-shaped plurality of driver electrodes **14** are aligned in the row direction (direction along the X arrow in the drawing, simply referred to as the row direction below) of the matrix constituted of the color pixels. The separation regions **21** in this case are formed so as to extend along the column direction. Each driver electrode **14** is formed such that the separation regions **21** overlap respective column direction sides of specific color pixels.

[0045] FIG. **1**(*b*) shows another example of an arrangement of driver electrodes. As shown in FIG. **1**(*b*), the driver electrodes **14** may be belt-shaped electrodes that extend in the row direction, aligned in the column direction. The separation regions **21** in this case are formed so as to extend along the row direction. Each driver electrode **14** is formed such that the separation regions **21** overlap respective row direction sides of color pixels.

[0046] Because the driver electrodes **14** also function as a common electrode, it is preferable that the driver electrodes **14** be provided over the pixel electrodes **12**, facing the pixel electrodes **12**, in order to prevent degradation in display quality. In other words, it is preferable that each driver electrode **14** be provided such that the separation regions **21** between the driver electrodes **14** do not overlap the pixel electrodes **12**.

[0047] (Slits)

[0048] The driver electrodes **14** are provided with at least one, and preferably a plurality of slits **20** aligned along at least one of the row direction and the column direction. As shown in FIG. **1**(*a*), in the present embodiment, the plurality of slits **20** having the same shape and extending along the column direction are aligned along the row direction and the column direction. In the case shown in FIG. **1**(*a*), the slits **20** are provided in the driver electrodes **14** over the boundaries between all of the color pixels adjacent to each other in the row direction, in all rows of pixels. Thus, slits **20** are provided in the driver electrodes **14** over boundaries between all color pixels: between R and G; between G and B; and between B and R. However, if the boundary corresponds to the separation region **21** between the driver electrodes **14**, slits **20** in the driver electrodes **14** are not present in this position, since the driver electrodes **14** are not present over this boundary.

[0049] If a plurality of belt-shaped driver electrodes are aligned to form an opposite electrode, separation regions are formed between the driver electrodes. Thus, if driver electrodes not provided with slits are used as an opposite electrode, then there is a mixture of color pixels having a side overlapping the separation region and color pixels in which all sides thereof are covered by the opposite electrode. There is a physical difference between color pixels that have a side overlapping a separation region and color pixels in which all sides thereof are covered by the opposite electrode, and thus, even if the same image signal is supplied thereto, the electrical state is not necessarily the same among the color pixels. As a result, a difference in liquid crystal orientation occurs, thus causing a degradation of display quality such as display unevenness. If, in order to mitigate this, the separation regions **21** between the driver electrodes **14** are sufficiently shielded from light, this results in a decrease in aperture ratio, causing a degradation of display quality in the liquid crystal panel.

[0050] On the other hand, in the display device **1**, as stated above, slits **20** are provided in the driver electrodes **14** over boundaries between color pixels adjacent to each other in the row direction. Because there are no electrodes in the slit **20** portion, even in color pixels that would normally be in positions having all sides completely covered by an opposite electrode, the slits **20** allow such color pixels to have a similar state to color pixels with a side (side in the column direction) overlapping a separation region **21**. As a result, the physical and electrical states of color pixels that do not have a side overlapping the separation region **21** are similar to the physical and electrical states of color pixels having a side overlapping the separation region **21**, and thus, it is possible to attain physical and electrical uniformity among the color pixels. Therefore, as a result of the driver electrodes **14** being provided with the slits **20**, it is possible to prevent the occurrence of differences in liquid crystal orientation among color pixels, thus mitigating the occurrence of display unevenness.

[0051] In the present embodiment, the slits **20** are provided in the driver electrodes **14** in positions corresponding to all of the boundaries between R and G color pixels, G and B color pixels, and B and R color pixels. As a result, this configuration is effective regardless of whether the boundary of color pixels overlapping the separation region **21** is formed by a combination of R and G, G and B, or B and R. In this case, the slits **20** are formed at the same pitch in the row direction as the pitch between the color pixels in the row direction. Also, because the slits **20** are formed similarly for all rows of pixels, the slits **20** are formed with the same pitch as the color pixels in the column direction.

[0052] As shown in FIG. **1**(*b*), in the display device **1** having a plurality of belt-shaped driver electrodes **14** extending along the row direction and aligned along the column direction, a plurality of slits **20** with the same shape and extending along the row direction are aligned in the row direction. In the case of a configuration in which the plurality of belt-shaped driver electrodes **14** extending along the row direction are aligned in the column direction, color pixels having a side along the row direction overlapping the separation region **21** and color pixels that do not have a side overlapping the separation region **21** may be included (for example, if the length of the side of the driver electrode **14** along the column direction is three times the length of a side of a color pixel along the column direction). However, in the display device **1** shown in FIG. **1**(*b*), slits **20** are provided in the driver electrodes **14** over boundaries of all color pixels adjacent to each other in the column direction, in all columns of pixels. However, if the separation region **21** between the driver electrodes **14** is over a boundary, slits **20** in the driver electrodes **14** are not present in this position, since the driver electrodes **14** are not present over this boundary.

[0053] Even in the configuration shown in FIG. **1**(*b*), pixels in which all sides would be covered by an opposite electrode if slits **20** were not provided have similar physical and electrical states to pixels with a side overlapping a separation region **21**, due to the presence of the slits **20**. Thus, uniformity in physical and electrical properties is attained between pixels having a side overlapping a separation region **21** and pixels that do not have a side overlapping a separation region **21**. Therefore, it is possible to prevent the occurrence of differences in liquid crystal orientation among pixels, thus mitigating the occurrence of display unevenness.

[0054] The patterned driver electrodes **14** and slits **20** may be formed using a known conventional patterning technique.

[0055] With a slit forming method of the present embodiment, it is possible to increase the flexibility by which patterns for separating the driver electrodes **14** are formed.

[0056] Also, in the present embodiment, the separation regions **21** are not limited to being formed between color pixels of specific colors, but when the separation regions **21** are formed between color pixels of specific colors, and if physical effects caused by the presence of the separation region **21** affect display quality, such as the viewing angle of only color pixels with a portion overlapping the separation regions **21** becoming narrow, for example, then it is preferable that the pattern of slits **20** of the present embodiment be formed.

Embodiment 2

[0057] Another embodiment of a display device according to the present invention is as described below with reference to FIGS. **3** and **4**. For ease of description, members having the same functions as those used in the previous embodiment are assigned the same reference characters with descriptions thereof being omitted.

[0058] FIG. **3** is a cross-sectional view that shows a schematic configuration of a display device of the present embodiment.

[0059] In the previous embodiment, the driver electrodes **14** were on the inner side of the circuit substrate **11** and the opposite substrate **15** and doubled as a common electrode for image display, and the detection electrodes **16** were formed on the outer side of the opposite substrate **15**. By contrast, in a display device **1** according to the present embodiment, as shown in FIG. **3**, detection electrodes **16** are on the inner side of the circuit substrate **11** and the opposite substrate **15**, and are formed in the same layer as driver electrodes **14**. In addition, both the driver electrodes **14** and the detection electrodes **16** double as a common electrode. Thus, slits **20** are also formed in the detection electrodes **16**. As in FIG. **2**, FIG. **3** is simply a drawing for showing that the driver electrodes **14** and the detection electrodes **16** are disposed at a distance from each other in the same layer, and thus, the separation pattern of the driver electrodes **14** and the detection electrodes **16** in FIG. **3** does not necessarily correspond to that of the real device.

[0060] FIG. **4** shows one example of a pattern of the driver electrodes **14**, the detection electrodes **16**, and the slits **20** of the present embodiment. FIG. **4**(*a*) shows a portion of the patterned driver electrodes **14** and detection electrodes **16**, and for ease of description, the slits **20** in each electrode are omitted. As shown in FIG. **4**(*a*), the driver electrodes **14** and the detection electrodes **16** both form appropriate island shapes, and a combination thereof functions as a common electrode that covers substantially the entire surface of the liquid crystal layer **13**. The display device disclosed in Patent Document 2 is known as an example of a display device having such driver electrodes and detection electrodes. Therefore, the entire description in Patent Document 2 can be incorporated by reference in the present specification.

[0061] FIG. **4**(*b*) is a drawing that magnifies the dotted line frame **22** portion in FIG. **4**(*a*), shown without omitting the slits **20**. In the display device **1** in which the common electrode is separated into islands, separation regions **21** that are gaps between the driver electrodes **14** or between a driver electrode **14** and a detection electrode **16** can either be formed along the row direction or formed along the column direction.

[0062] In the display device **1** according to the present embodiment, slits **20** having the shape and pattern shown in FIG. **1**(*a*) of Embodiment **1** (slits extending along the column direction of the pixels), and slits **20** having the pattern and shape shown in FIG. **1**(*b*) (slits extending along the row direction of the pixels) are both formed in each driver electrode **14** and each detection electrode **16**.

[0063] In the case of island-shaped electrodes, there may be not only color pixels that have one side overlapping a separation region **21**, but also color pixels that have two perpendicular sides overlapping a separation region **21**. In the display device **1** of the present embodiment, slits **20** are provided in the driver electrodes **14** or the detection electrodes **16** in positions corresponding to the boundaries between adjacent color pixels in the row direction and the column direction. Thus, even in the case of a display device in which a plurality of island-shaped driver electrodes **14** and detection electrodes **16** are in the same layer and function as a common electrode, it is possible to attain uniform physical and electrical states among pixels having a side overlapping the separation region **21** and pixels that do not have a side overlapping the separation region **21**.

Embodiment 3

[0064] Another embodiment of a display device according to the present invention is as described below with reference to FIG. **5**. For ease of description, members having the same functions as those used in the previous embodiments are assigned the same reference characters with descriptions thereof being omitted.

[0065] In Embodiment 1 described above, the slits **20** were provided in positions in the driver electrodes **14** corresponding to all boundaries between adjacent color pixels, in at least one of the row direction and the column direction. In other words, the slits **20** were provided with the same pitch as the pitch between the color pixels in that direction.

[0066] By contrast, in a display device **1** of the present embodiment, slits **20** are formed only between color pixels of specific colors.

[0067] FIGS. **5**(*a*) to **5**(*c*) show examples of patterns of the driver electrodes **14** or the detection electrodes **16**, and the slits **20** in the present embodiment. For ease of description, only the color pixels (including the pixel electrodes **12**) and the driver electrodes **14** (driver electrodes **14** and detection electrodes **16** in FIG. **5**(*c*)) (including slits **20**) are shown. As shown in FIG. **5**(*a*), in the present embodiment, each driver electrode **14** is a belt-shaped electrode that extends along the column direction, and by aligning these driver electrodes **14** in the row direction, the driver electrodes **14** function as a common electrode that covers substantially the entire liquid crystal layer **13**. In this case, the separation regions **21** extend along the column direction. Each driver electrode **14** is provided such that the separation regions **21** are formed over boundaries between blue pixels (B) (first color pixels) and red pixels (R) (second color pixels) adjacent to each other in the row direction.

[0068] The slits **20** in the driver electrodes **14** are formed in the portion of the driver electrodes **14** overlapping the boundaries between the blue pixels (B) and the red pixels (R) that are adjacent to each other in the row direction. In other words, when the separation regions **21** between the driver electrodes **14** are formed over the boundaries of color pixels of specific colors, slits **20** are formed in positions of the driver electrodes **14** corresponding to boundaries between color pixels with the same combination of specific colors for pixels that do not overlap a separation region **21**. Here, the color pixels of specific colors are the blue pixel (B) and the red pixel (R), but the color combination is not limited thereto.

[0069] If slits **20** are not formed in the driver electrodes **14**, sets of blue pixels and red pixels that have a side not covered by a driver electrode **14** due to overlapping a separation region **21**, and sets of blue pixels and red pixels in which all sides thereof are covered by the driver electrodes **14** due to not overlapping the separation region **21** can both exist. In this case, it is possible for non-uniformity in physical and electrical states to occur among blue pixels and among red pixels, thus resulting in a degradation of display quality.

[0070] As a countermeasure, in the display device **1**, for all blue pixels and red pixels, a side of a blue pixel (side adjacent to a red pixel) and a side of a red pixel (side adjacent to a blue pixel) either overlap a separation region **21** or have a slit **20** formed thereabove. As a result, uniformity in the physical and electrical states among blue pixels and among red pixels is attained, thus preventing a degradation of display quality.

[0071] Also, unlike the display device **1** of the embodiments described above in which slits **20** are generally formed over all color pixels, the display device **1** of the present embodiment has slits **20** provided in the driver electrodes **14** in positions corresponding only to color pixels of specific colors. Thus, it is possible to keep the number of slits **20** formed in the driver electrodes **14** small, thus mitigating an increase in impedance in the electrodes.

[0072] FIG. **5**(*b*) shows another example of the present embodiment. The driver electrodes **14** shown in FIG. **5**(*b*) are belt-shaped electrodes that extend along the row direction, and are aligned along the column direction. The separation regions **21** in this case are formed so as to extend along the row direction. Also, each of the driver electrodes **14** is formed such that the separation regions **21** therebetween overlap a side of the color pixels in the row direction.

[0073] In Embodiment 1 described above, slits **20** were formed over boundaries between color pixels of the respective same colors adjacent to each other in the column direction, for color pixels of all colors. By contrast, in the display device **1** shown in FIG. **5**(*b*), slits **20** are formed over boundaries between color pixels adjacent to each other in the column direction only for red pixels (R) and green pixels (G), and slits **20** are not formed over boundaries between blue pixels (B) adjacent to each other in the column direction. In general, it is known that blue pixels have a low visibility. Thus, the effect on display quality from a presence or lack of a slit **20** is less for the vicinity of blue pixels compared to other color pixels. Thus, if the number of slits **20** formed in the driver electrodes **14** is to be reduced in order to mitigate an increase in impedance in the electrodes, it is possible to mitigate a worsening of visibility while mitigating an increase in impedance by not forming slits **20** in the vicinity of the blue pixels, which have a low visibility.

[0074] FIG. **5**(*c*) shows yet another example of the present embodiment. The display device **1** of FIG. **5**(*c*) has the same configuration as the display device **1** of Embodiment **2** with the exception of the configuration of the slits **20**.

[0075] In the display device **1** of FIG. **5**(*c*), driver electrodes **14** and detection electrodes **16** are formed in island shapes in the same layer, and both have two types of slits **20** formed therein. One type of slit **20** is similar to that of the display device **1** shown in FIG. **5**(*a*) in being formed only over the boundaries of color pixels of specific colors (between blue pixels (B) and red pixels (R) in this case), and extending along the column direction. There are separation regions **21** that extend in the row direction and separation regions **21** that extend in the column direction, but the separation regions **21** that extend in the column direction are positioned over the boundaries between color pixels of specific colors (between the blue pixel (B) and the red pixel (R)). The other type of slits **20** are similar to that of the display device **1** of FIG. **1**(*b*) in being formed over the boundaries between all pixels adjacent to each other in the column direction, and extending along the row direction.

[0076] In the configuration shown in FIG. **5**(*c*), for all blue pixels and red pixels, a separation region **21** or a slit **20** is formed over a side of the blue pixel (side adjacent to the red pixel) and a side of the red pixel (side adjacent to the blue pixel). As a result, uniformity in the physical and electrical states among blue pixels and among red pixels is attained, thus preventing a degradation of display quality. Also, it is possible to keep the number of slits **20** formed in the driver electrodes **14** and detection electrodes **16** small, thus mitigating an increase in impedance in the electrodes.

Embodiment 4

[0077] Another embodiment of a display device according to the present invention is as described below with reference to FIG. **6**. For ease of description, members having the same functions as those used in the previous embodiments are assigned the same reference characters with descriptions thereof being omitted.

[0078] In Embodiments 1 to 3 described above, the length of the slits **20** extending in the column direction was shorter than the side of the region constituting the color pixel (pixel area) parallel to the column direction. Similarly, the length of the slits **20** extending in the row direction was shorter than the side of the region constituting the color pixel parallel to the row direction.

[0079] By contrast, in a display device **1** of the present embodiment, the length of the slits **20** extending in the column direction is longer than the side parallel to the column direction of the region constituting the color pixel, and the length of the slits **20** extending in the row direction is longer than the side parallel to the row direction of the region constituting the color pixel.

[0080] FIGS. **6**(*a*) to **6**(*d*) show examples of patterns of the driver electrodes **14** or the detection electrodes **16**, and the slits **20** in the present embodiment. For ease of description, only the color pixels (including the pixel electrodes **12**) and the driver electrodes **14** (driver electrodes **14** and detection electrodes **16** in FIG. **6**(*d*)) (including slits **20**) are shown.

[0081] In the display device **1** shown in FIG. **6**(*a*), belt-shaped driver electrodes **14** extending in the column direction are aligned in the row direction, thus functioning as a common electrode that covers substantially the entire liquid crystal layer **13**. In this case, the slits **20** extend in the column direction, and the length thereof spans over a plurality of color pixels in the column direction. As in Embodiment **1**, the slits **20** are formed at all boundaries between color pixels adjacent to each other in the row direction. However, the position of the slits **20** is not limited thereto, and may alternatively be formed only between color pixels of specific colors as shown in FIG. **5**(*a*).

[0082] As shown in FIG. **6**(*a*), if one slit **20** is formed spanning over a plurality of color pixels, it is possible to have the physical and electrical states in the vicinity of the slits **20** to be closer to the states in the vicinity of the separation regions **21**, compared to a case in which slits **20** are formed for each color pixel as in the embodiments described above. Thus, it is possible to more reliably maintain uniform physical and electrical states between color pixels having a portion overlapping a separation region **21** and color pixels that do not have a portion overlapping a separation region **21**, thus further improving display quality.

[0083] In the display device **1** shown in FIGS. **6**(*b*) and **6**(*c*), belt-shaped driver electrodes **14** extending in the row direction are aligned in the column direction, thus functioning as a common electrode that covers substantially the entire liquid crystal layer **13**. In this case, the slits **20** extend in the row direction, and the length thereof spans over a plurality of color pixels in the row direction. The slits **20** need only to span over a plurality of pixels, and the length thereof is not limited to spanning over all pixels in the row direction as shown in FIG. **6**(*b*), and as shown in FIG. **6**(*c*), the slits **20** may be separated between color pixels of specific colors (in this case, between blue pixels (B) and red pixels (R)).

[0084] As in the case shown in FIG. **6**(*b*), if the slits **20** span over all pixels in the row direction, then as in the case shown in FIG. **6**(*a*), it is possible to have the physical and electrical states in the vicinity of the slits **20** closer to the states in the vicinity of the separation regions **21**. Thus, it is possible to more reliably maintain uniform physical and electrical states between color pixels having a portion overlapping a separation region **21** and color pixels that do not have a portion overlapping a separation region **21**, thus further improving display quality.

[0085] In the vicinity of color pixels with high visibility colors, the effect of the presence or lack of the slits **20** on display quality is relatively high compared to color pixels of colors that do not have high visibility. It is generally known that green pixels (G) have a high visibility. Thus, it is preferable that slits **20** be provided in regions of the driver electrode **14** corresponding to the green pixels (G). As in the case shown in FIG. **6**(*c*), although the slits **20** span over a plurality of pixels, if the slits **20** are separated between color pixels of specific colors, it is preferable that separations of the slits **20** not be provided at the green pixels (G), which have a high visibility, and that separations of the slits **20** be provided at other color pixels (R and B).

[0086] FIG. **6**(*d*) shows yet another example of the present embodiment. The display device **1** of FIG. **6**(*d*) has the same configuration as the display device **1** of Embodiment 2 with the exception of the configuration of the slits **20**. In the display device **1** of FIG. **6**(*d*), driver electrodes **14** and detection electrodes **16** are formed in island shapes in the same layer, and both have two types of slits **20** formed therein. One type of slits **20** extending in the column direction have the same pattern and form as the slits **20** extending in the column direction in the driver electrodes **14** and the detection electrodes **16** in the display device **1** of Embodiment 2. On the other hand, as in the case shown in FIG. **6**(*c*), the other type of slits **20** extending in the row direction span over the red pixel (R), the green pixel (G), and the blue pixel (B), and are separated between R and B. Therefore, the present embodiment can be suitably applied even to a display device in which the driver electrodes **14** and the detection electrodes **16** are in the same layer and respectively function as a common electrode.

Embodiment 5

[0087] In Embodiments 1 to 4 described above, the form of the slits was described from a wide perspective such as a display region. Below, the form of the slits will be described from a narrow perspective such as a pixel unit.

[0088] FIG. **7** shows a pixel structure from above. For ease of description, only the slits **20** are shown of the driver electrodes **14**, and the driver electrodes **14** themselves are omitted.

[0089] As stated above, in a display device **1** in which a common electrode is constituted of a plurality of driver electrodes **14**, there are separation regions **21** between the driver electrodes **14**. There are no electrodes in the separation region **21**, and thus, color pixels having a portion that overlaps a separation region **21** may have a different electric field state compared to color pixels that do not have a portion overlapping a separation region **21**. Therefore, when forming the slits **20**, it is preferable that slits **20** be formed in portions of the color pixels where the electric field state would change as a result of forming the slits **20**, having an effect on display.

[0090] As shown in FIG. **7**, each color pixel has a display contributing part **35** that directly contributes to display. Specifically, the display contributing part **35** is an opening located in a region where the pixel electrode **12** is formed. A Cs electrode **30** does not transmit light, and is therefore not included in the display contributing part **35**, for example.

[0091] The slits **20** are formed in a position of such a display contributing part **35** that has an effect on the electric field. In FIG. **7**, the slits **20** extend in the column direction along the display contributing parts **35**. On the other hand, the Cs electrodes **30** are not parts that directly contribute to display, and thus, the slits **20** are separated thereat. By forming slits **20** in positions that have an effect on the display contributing parts **35** while not providing slits **20** in positions that do not have a direct effect on display, it is possible to maintain display quality with a uniform electric field state among the color pixels while mitigating an increase in impedance. Besides the Cs electrodes **30**, the gate bus lines are also not part of the display contributing parts **35**, and thus, the slits **20** may be separated over the gate bus lines.

Embodiment 6

[0092] Another embodiment of a display device according to the present invention is as described below with reference to FIGS. **8** to **10**. For ease of description, members having the same functions as those used in the previous embodiments are assigned the same reference characters with descriptions thereof being omitted.

[0093] In Embodiments 1 to 5 described above, the pixel electrodes **12** are rectangular, and the slits **20** have a rectangular shape with a side parallel to one side of the rectangular pixel electrode **12**.

[0094] By contrast, in the display device **1** of the present embodiment, pixel electrodes **12** are comb-shaped electrodes with a zigzag shape, and a portion of each slit **20** has a shape following the zigzag portion of the pixel electrodes **12**.

[0095] FIG. **8** shows an example of patterns of the pixel electrodes **12** and driver electrodes **14** of the present embodiment. In FIG. **8**, for ease of description, only the pixel electrodes **12** and the slits **20** in the driver electrodes **14** are shown.

[0096] The display device **1** of the present embodiment is an IPS (in-plane switching) mode (or AFFS (advanced fringe field switching) mode) liquid crystal display device. Thus, unlike the display device **1** of the embodiments described above, as shown in FIG. **8**, the pixel electrodes **12** are comb-shaped electrodes.

[0097] FIG. **9** is a cross-sectional view that shows a schematic configuration of the display device **1** of the present embodiment. In the display device **1** of the present embodiment, the driver electrodes **14** and the detection electrodes **16** function as a common electrode. As shown in FIG. **9**, the driver electrodes **14** and the detection electrodes **16** that function as a common electrode are formed between the pixel electrodes **12** and the circuit substrate **11**, the driver electrodes **14** and the detection electrodes **16** being separated from the pixel electrodes **12** by an insulating film **18**. By generating a transverse electric field between the comb-shaped pixel electrodes **12**, and the driver electrodes **14** or the detection electrodes **16** located in a layer below each comb shape, the orientation of liquid crystal in the liquid crystal layer **13** is changed.

[0098] FIG. **10**(*a*) shows an example of a pattern of the pixel electrodes **12**, the driver electrodes **14**, and the slits **20** of the present embodiment, and FIG. **10**(*b*) shows an example of a pattern of the pixel electrodes **12**, the driver electrodes **14**, the detection electrodes **16**, and the slits **20** of a different example of the present embodiment. The comb-shaped pixel electrode **12** provided for each color pixel in the present embodiment has a structure in which the entirety thereof has a bent shape in a zigzag form. Separation regions **21** between the driver electrodes **14** or between a driver electrode **14** and a detection electrode **16** are formed along the pixel electrode **12**, and portions of the sides of the driver electrode **14** and the detection electrode **16** follow the bent shape of the pixel electrodes **12**. In other words, the shape is follows the shape of the side of the pixel electrode **12**. In this case, the separation region **21** between the driver electrodes **14** or between a driver electrode **14** and a detection electrode **16** has a shape that follows the pixel electrode **12**, and thus, it is possible to keep the effect of the separation regions **21** on the sides of the pixel electrodes **12** uniform and minimal for each color pixel.

[0099] Similarly, the slits **20** are also provided following the pixel electrodes **12**, and the portion of the side has a shape that follows the bend in the pixel electrode **12**. In other words, the shape follows the shape of the side of the pixel electrode **12**.

[0100] As stated above, the slits **20** have a shape that follows the pixel electrodes **12** and that also corresponds to the separation regions **21**, and the effect of slits **20** in the side of the pixel electrodes **12** on image display is almost the same as the effect of the separation regions **21** on image display, and as a result, it is possible to maintain uniform display quality over substantially the entire surface. In the present embodiment, an example of zigzag comb-shaped electrodes and slits with a shape that corresponds thereto was described, but as long as the slits have a shape that follows the side of the pixel electrodes, any shape can be used.

Embodiment 7

[0101] Another embodiment of a display device according to the present invention is as described below with reference to FIGS. **11** and **12**. For ease of description, members having the same functions as those used in the previous embodiments are assigned the same reference characters with descriptions thereof being omitted.

[0102] In a conventional pixel structure, regions that do not transmit light due to being provided with wiring lines such as gate bus lines and source bus lines or Cs electrodes and the like, and regions that do not have a pixel electrode do not directly contribute to image display. In a display device of the present embodiment, by providing slits in such regions that do not directly contribute to image display, it is possible to minimize degradation of display quality.

[0103] FIG. **11** shows a pattern of slits **20** of the driver electrode **14** in each pixel in a display device of the present embodiment. The lower part of the drawing is a cross-section along the row direction of the configuration in the upper left portion of the drawing, and the right side of the drawing shows a cross-section along the dashed line A-A' in the configuration shown in the upper left portion of the drawing. As shown in FIG. **11**, in a display device **1** of the present embodiment, the slits **20** are provided in a plurality of locations. A first slit **20***a* is formed in a position that overlaps a source bus line **31** that extends along the column direction. A second slit **20***b* is formed in a position that overlaps a gate bus line **32** that extends along the row direction. A third slit **20***c* is formed extending along the row direction in a region that overlaps a Cs electrode **30**. The source bus line **31** and the gate bus line **32** are provided in positions that overlap the areas between adjacent pixel electrodes **12**. Thus, regions that do not have a pixel electrode **12** are regions on either the source bus line **31** or the gate bus line **32**.

[0104] A width Ws1 of the slit **20***a* (length along the row direction) and a width Wm1 of the source bus line **31** satisfy $Ws1 \leqq Wm1$. Similarly, the width Ws1 of the slit **20***a* and a width Sp1 of a gap extending in the column direction between the pixel electrodes **12** satisfy $Ws1 \leqq Sp1$.

[0105] Similarly, a width Ws2 of the slit **20***b* (length along the column direction) and a width Wm2 of the gate bus line **32** satisfy $Ws2 \leqq Wm2$. Similarly, the width Ws2 of the slit **20***b* and a width Sp2 of a gap extending in the row direction between the pixel electrodes **12** satisfy $Ws2 \leqq Sp2$.

[0106] The slit **20***a* and the slit **20***b* are over the source bus line **31** and the gate bus line **32**, which respectively do not directly contribute to display, and both have a width less than or equal to the respective wiring lines. Also, both the slit **20***a* and the slit **20***b* are in regions that do not have a pixel electrode **12** and do not directly contribute to display (above the gaps between the pixel electrodes **12**), and both have a width less than or equal to each gap. Therefore, both the slit **20***a* and the slit **20***b* are not in regions that directly contribute to display, and as a result, it is possible to minimize degradation of display quality due to the slits.

[0107] A width Ws3 of the slit **20***c* (length along the column direction) and a width Wm3 of the Cs electrode **30** (length along the column direction) satisfy Ws3≦Wm3. In other words, the slit **20***c* is over the Cs electrode **30**, which does not directly contribute to display, and the width of the slit is less than or equal to the width of the Cs electrode **30**. Thus, the slits **20***c* are not in regions that directly contribute to display, and as a result, it is possible to minimize degradation of display quality due to the slits.

[0108] The slit **20***a* and the slit **20***b* in the present embodiment both fulfill two conditions on the width (Ws≦Sp, Ws≦Wm), but if at least one of the width Wm of the wiring lines and the width Sp between the pixel electrodes is sufficiently larger than the other, then there may be cases in which only one of the two conditions needs to be fulfilled.

[0109] FIG. **12** omits the driver electrodes **14** and the slits **20** and shows only configurations of each color pixel. FIG. **12**(*a*) corresponds to the configuration shown in FIG. **11**, and each pixel electrode **12** is formed such that pixel electrodes **12** adjacent to each other in the column direction have a gap over the gate bus line **32**. However, the position of the pixel electrodes **12** is not limited thereto. For example, as shown in FIG. **12**(*b*), each pixel electrode **12** may be formed such that the gap between pixel electrodes **12** adjacent to each other in the column direction is over the Cs electrode **30**.

[0110] As shown in FIG. **12**(*b*), if the gap between the pixel electrodes **12** in the column direction is positioned above the Cs electrode **30**, then generally, the Cs electrode **30** is sufficiently wide with respect to the gap between the pixel electrodes **12**. Thus, when providing a slit **20** over the Cs electrode **30**, it is possible to have a configuration in which the gap between the pixel electrodes **12** in the column direction (Sp2 in FIG. **11**) is less than or equal to the width of the slit **20** (Ws2 in FIG. **11**), which is less than or equal to the width of the Cs electrode **30** (Wm3 in FIG. **11**).

[0111] In the configuration shown in FIG. **12**(*b*), minimization of the load on the source bus line **31** is prioritized, and (the width of the source bus line (Wm1 in FIG. **11**))≦(the gap between the pixel electrodes **12** in the row direction (Sp1 in FIG. **11**)) is satisfied. In such a case, (the width of the source bus line (Wm1 in FIG. **11**))≦(the width of the slit **20** (Ws1 in FIG. **11**))≦(the gap between the pixel electrodes **12** in the row direction (Sp1 in FIG. **11**)) is satisfied. Such a configuration is also included in the scope of the present invention.

[0112] In addition to the present embodiment, if slits **20** extending in the column direction and slits **20** extending in the row direction are both formed, the width of the slits **20** extending in the column direction does not need to be the same as the width of the slits **20** extending in the row direction.

[0113] The present invention is not limited to the above-mentioned embodiments, and various modifications can be made without departing from the scope of the claims. That is, embodiments obtained by combining techniques modified without departing from the scope of the claims are also included in the technical scope of the present invention.

[0114] In the display device according to the present invention, it is preferable that each of the slits be provided over a boundary between pixel areas that are adjacent to each other in a row direction or a column direction.

[0115] If a common electrode is separated into a plurality of parts, then the common electrode is formed such that separation regions, which are gaps between the parts of the common electrode, are positioned over boundaries of adjacent pixels, in order to maintain display quality. Therefore, by providing the slits over the boundary between pixel areas adjacent to each other in the row direction or the column direction, it is possible to have a state similar to pixels having an overlapping portion with a separation region. As a result, it is possible to improve uniformity among pixels that have an overlapping portion with the separation region and pixels that do not have an overlapping portion with a separation region.

[0116] Also, in the display device according to the present invention, it is preferable that the slits be provided with a same pitch as a pitch between the pixel areas adjacent to each other in the row direction or the column direction.

[0117] With this configuration, a slit is formed over each pixel in a group of pixels in a row or a group of pixels in a column, and the position of the slits correspond to the same parts of the respective pixels. As a result, it is possible to further improve the uniformity among pixels.

[0118] Also, in the display device according to the present invention, it is preferable that a gap between adjacent first electrodes be positioned over a boundary between a pixel area corresponding to a first color pixel, and a pixel area adjacent to the aforementioned pixel area and corresponding to a second color pixel that differs from the first color pixel, and that each of the above-mentioned slits be provided over a boundary between the pixel area corresponding to the first color pixel, and the pixel area adjacent to the aforementioned pixel area and corresponding to the second color pixel, in a region covered by one of the first electrodes.

[0119] With this configuration, a slit is provided corresponding to color pixels of the same colors as the color pixels where a gap between the first electrodes is located. As a result, it is possible to mitigate the occurrence of non-uniformity in physical and electrical states among same color pixels. Also, slits only need to be provided between specific color pixels, and it is not necessary to provide slits for color pixels of the same color as color pixels where a gap is not provided, and therefore, it is possible to minimize the number of slits while mitigating an increase in impedance in the electrodes.

[0120] Also, in the display device according to the present invention, it is preferable that a length of each of the slits be shorter than a length of one side of each of the pixel areas where the boundary is formed.

[0121] With this configuration, it is possible to provide a slit for each pixel, thus increasing the flexibility of patterning while decreasing the total area of the slits, which mitigates an increase in impedance in the electrodes.

[0122] Also, in the display device according to the present invention, it is preferable that a length of each of the slits be longer than a length of one side of each of the pixel areas where the boundary is formed.

[0123] With this configuration, slits are made more analogous to the gap between the first electrodes, thus improving the uniformity among the color pixels.

[0124] Also, in the display device according to the present invention, it is preferable that the plurality of second electrodes be formed in a same layer as the plurality of first electrodes, that the second electrodes double as an electrode that generates an electric field with the pixel electrodes, thus changing a state of the display function layer, and that at least one of the plurality of second electrodes have slits provided with a same shape as the slits provided in each of the first electrodes.

[0125] With this configuration, the plurality of second electrodes are in the layer where the plurality of first electrodes are formed, and the second electrodes and the first electrodes can function as a common electrode for image display. Similarly, slits for mitigating the non-uniformity among color pixels are provided in the second electrodes. With this configuration, uniformity can be attained and the display quality can be maintained.

[0126] Also, in the display device according to the present invention, it is preferable that each of the slits be adjacent to a display contributing part of a pixel area that directly contributes to display.

[0127] An area that directly contributes to display is where a pixel electrode is formed, and contributes to the display of images by transmitting light. With this configuration, slits are adjacent to the display contributing part, which allows the provision of the slits to affect the display contributing part. Thus, it is possible to have an analogous effect to that of the gap between the first electrodes, thus more effectively eliminating non-uniformity among color pixels.

[0128] Also, in the display device according to the present invention, it is preferable that a shape of a side of each of the slits follow a portion of a shape of a side of each of the pixel electrodes.

[0129] With this configuration, slits are formed along the side of the pixel electrodes, and thus, it is possible to improve the uniformity among color pixels without affecting display quality at the pixel level.

[0130] Also, in the display device according to the present invention, it is preferable that the substrate include a wiring line that extends along a row direction or a column direction of the matrix, that each of the slits be provided overlapping the wiring line, and that a width of each of the slits be less than or equal to a width of the wiring line.

[0131] In general, regions with wiring lines do not transmit light, thus not directly contributing to display. Thus, with this configuration, slits are provided in regions not directly contributing to display, and thus, it is possible to further improve the uniformity among color pixels without affecting the display quality at the pixel level.

[0132] Also, in the display device according to the present invention, it is preferable that a width of each of the slits be less than or equal to a width of a gap between the pixel electrodes respectively in the adjacent pixel areas.

[0133] In regions that do not have pixel electrodes, it is not possible to have the display function layer exhibit image display functionality. Therefore, regions that do not have pixel electrodes do not directly contribute to display. Thus, with this configuration, slits are provided in regions not directly contributing to display, and thus, it is possible to further improve the uniformity among color pixels without affecting the display quality at the pixel level.

[0134] Also, in the display device according to the present invention, it is preferable that the plurality of first electrodes be provided opposite to the plurality of pixel electrodes, and that the display function layer be provided between a layer with the plurality of pixel electrodes and a layer with the plurality of first electrodes.

INDUSTRIAL APPLICABILITY

[0135] The present invention can be used in a display device that has a display panel with a touch panel.

DESCRIPTION OF REFERENCE CHARACTERS

[0136] **1** display device
[0137] **11** circuit substrate (substrate)
[0138] **12** pixel electrode
[0139] **13** liquid crystal layer (display function layer)
[0140] **14** driver electrode (first electrode)
[0141] **15** opposite substrate
[0142] **16** detection electrode (second electrode)
[0143] **17** protective layer
[0144] **18** insulating film
[0145] **20** slit
[0146] **21** separation region
[0147] **30** Cs electrode (wiring line)
[0148] **31** source bus line (wiring line)
[0149] **32** gate bus line (wiring line)

1. A display device, comprising:
a substrate;
a plurality of pixel electrodes arranged in a matrix on a plane parallel to the substrate;
a display function layer that exhibits image display functionality based on an image signal provided to the plurality of pixel electrodes;
a plurality of first electrodes provided in a same layer as each other with gaps therebetween, the plurality of first electrodes generating an electric field with the pixel electrodes and thereby changing a state of the display function layer; and
a plurality of second electrodes in a same layer as each other, respectively capacitively coupled with the plurality of first electrodes,
wherein at least one of the plurality of first electrodes is provided with slits.

2. The display device according to claim **1**, wherein each of the slits is provided over a boundary between pixel areas that are adjacent to each other in a row direction or a column direction.

3. The display device according to claim **2**, wherein the slits are provided with a same pitch as a pitch between the pixel areas adjacent to each other in the row direction or the column direction.

4. The display device according to claim **2**,
wherein a gap between adjacent first electrodes is positioned over a boundary between a pixel area corresponding to a first color pixel, and a pixel area adjacent to said pixel area and corresponding to a second color pixel that differs from the first color pixel, and
wherein each of the slits is provided over a boundary between the pixel area corresponding to the first color pixel, and the pixel area adjacent to said pixel area and corresponding to the second color pixel, in a region covered by one of the first electrodes.

5. The display device according to claim **2**, wherein a length of each of the slits is shorter than a length of one side of each of the pixel areas where the boundary is formed.

6. The display device according to claim **2**, wherein a length of each of the slits is longer than a length of one side of each of the pixel areas where the boundary is formed.

7. The display device according to claim **1**, wherein the plurality of second electrodes are formed in a same layer as the plurality of first electrodes, the second electrodes double as an electrode that generates an electric field with the pixel electrodes, thus changing a state of the display function layer, and at least one of the plurality of second electrodes has slits provided with a same shape as the slits provided in each of the first electrodes.

8. The display device according to claim **1**, wherein each of the slits is adjacent to a display contributing part of a pixel area that directly contributes to display.

9. The display device according to claim **1**, wherein a shape of a side of each of the slits follows a portion of a shape of a side of each of the pixel electrodes.

10. The display device according to claim **1**,

wherein the substrate includes a wiring line that extends along a row direction or a column direction of the matrix,

wherein each of the slits is provided overlapping the wiring line, and

wherein a width of each of the slits is less than or equal to a width of the wiring line.

11. The display device according to claim **2**, wherein a width of each of the slits is less than or equal to a width of a gap between the pixel electrodes respectively in the adjacent pixel areas.

12. The display device according to claim **1**,

wherein the plurality of first electrodes are provided opposite to the plurality of pixel electrodes, and

wherein the display function layer is provided between a layer with the plurality of pixel electrodes and a layer with the plurality of first electrodes.

* * * * *

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摘要(译)

本发明的目的是当用于触摸传感器的电极同时还用作用于图像显示的电极时，确保像素之间的均匀性。该显示装置包括：电路基板;多个像素电极（12），在与电路基板平行的平面上排列成矩阵状;液晶层，其可以基于提供给多个像素电极（12）的图像信号显示图像显示功能，多个驱动电极（14）布置在同一层中，其具有间隙，这可以产生具有像素电极（12）的电场改变液晶层的状态;可以分别电容耦合到多个驱动电极的同一层中的多个检测电极，其中多个驱动电极（14）中的至少一个设置有狭缝（20）。