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(57) **ABSTRACT**

According to one feature of the invention, a display device comprises a pixel including a first sub-pixel having a first light-emitting element and a second sub-pixel having a second light-emitting element, a first source driver connected to a first source line included in the first sub-pixel, and a second source driver connected to a second source line included in the second sub-pixel. The first sub-pixel and the second sub-pixel are provided over one surface of a light-transmitting substrate, and a first display region using the first sub-pixel over one surface of the substrate and a second display region using the second sub-pixel over the opposite surface the substrate are provided. Accordingly, it is possible to provide a display device that realizes sophistication and a high added value, which includes a display region in each of one and the opposite sides.

Related U.S. Application Data

(30) **Foreign Application Priority Data**

Jan. 14, 2004 (JP) 2004-007387

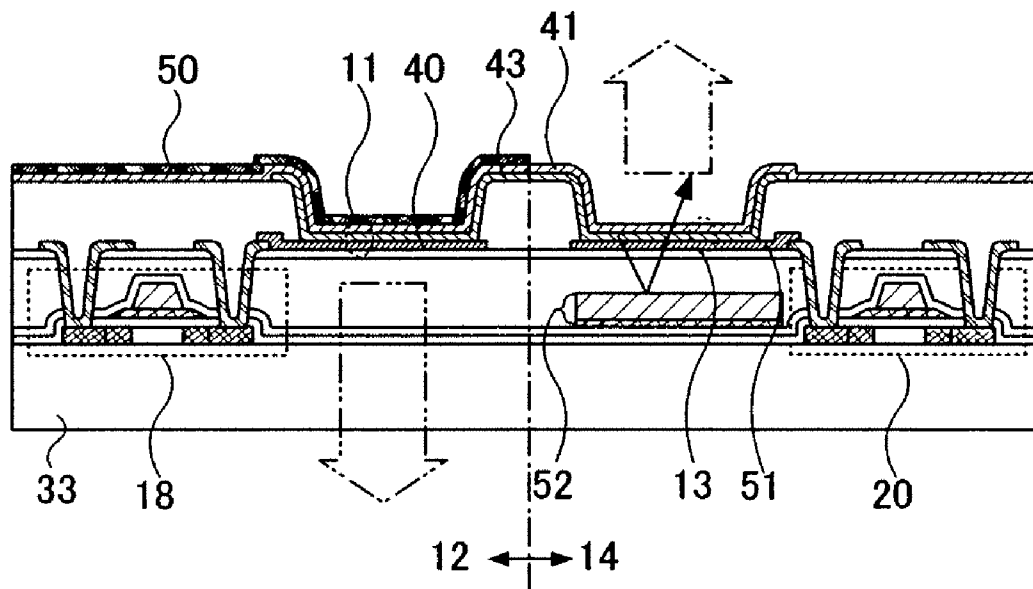


FIG. 1A

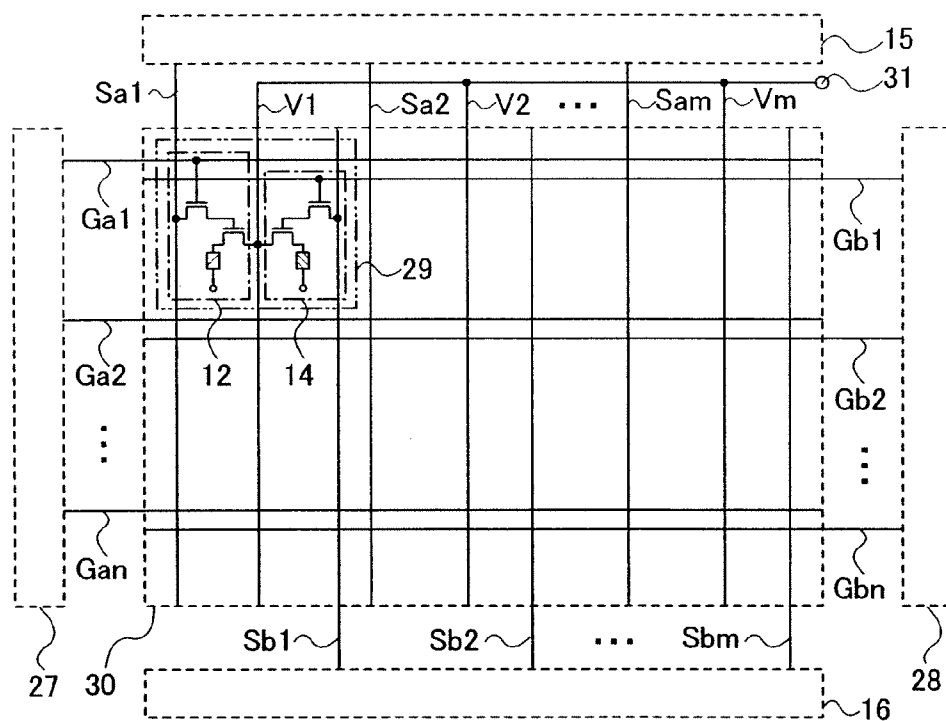
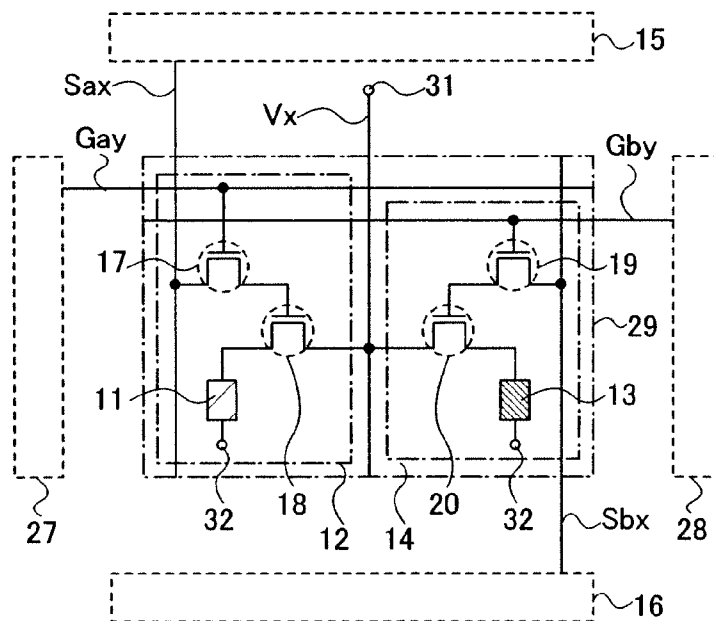


FIG. 1B



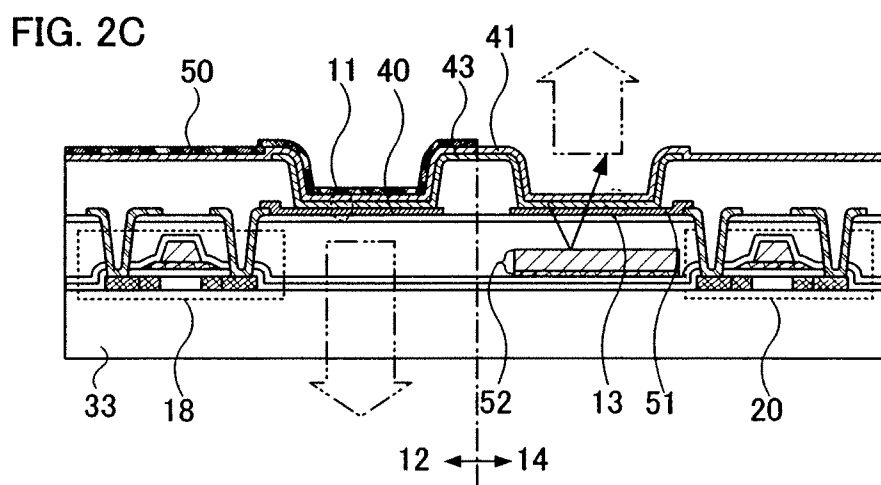
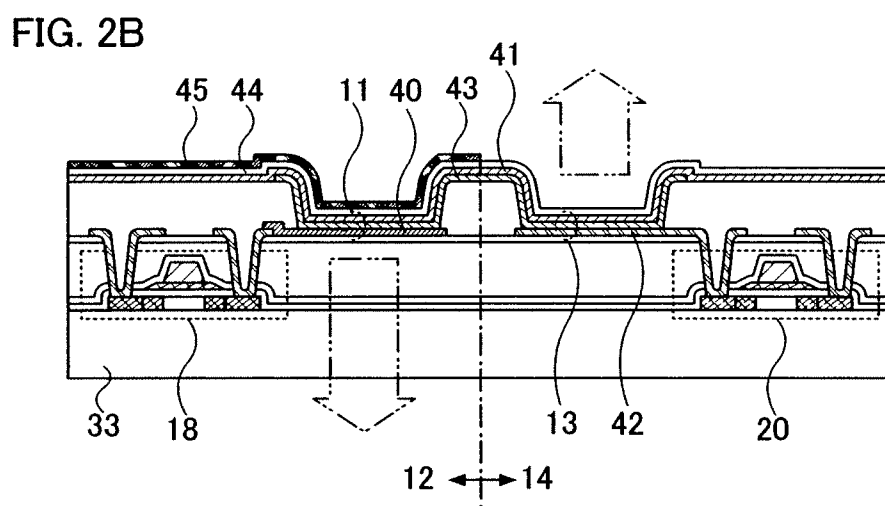
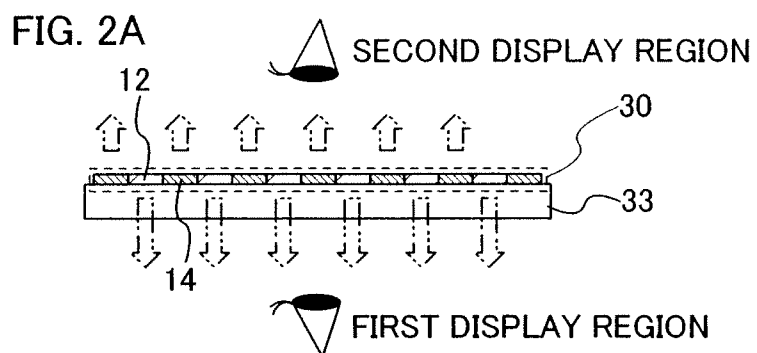


FIG. 3A

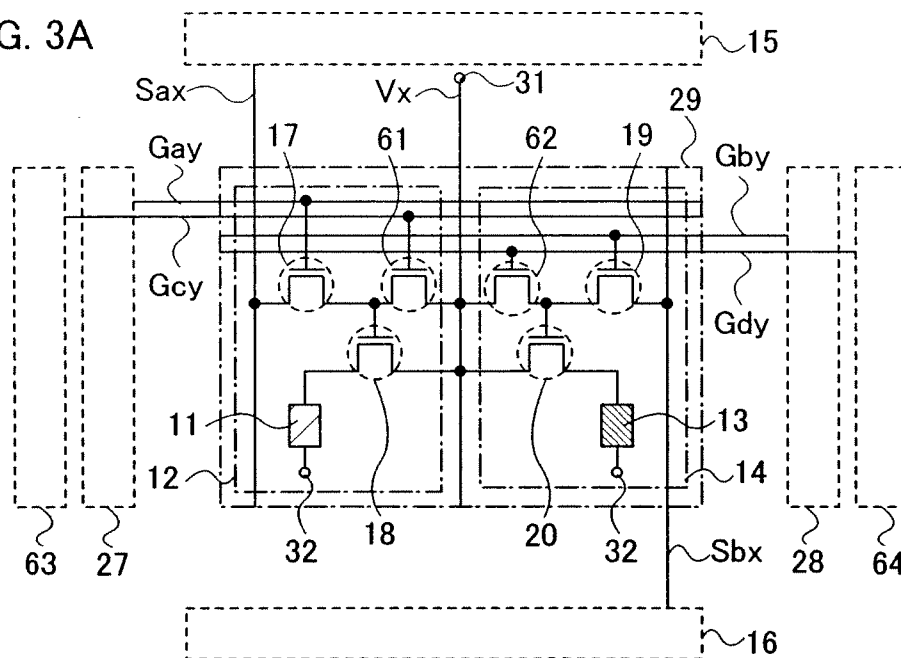


FIG. 3B

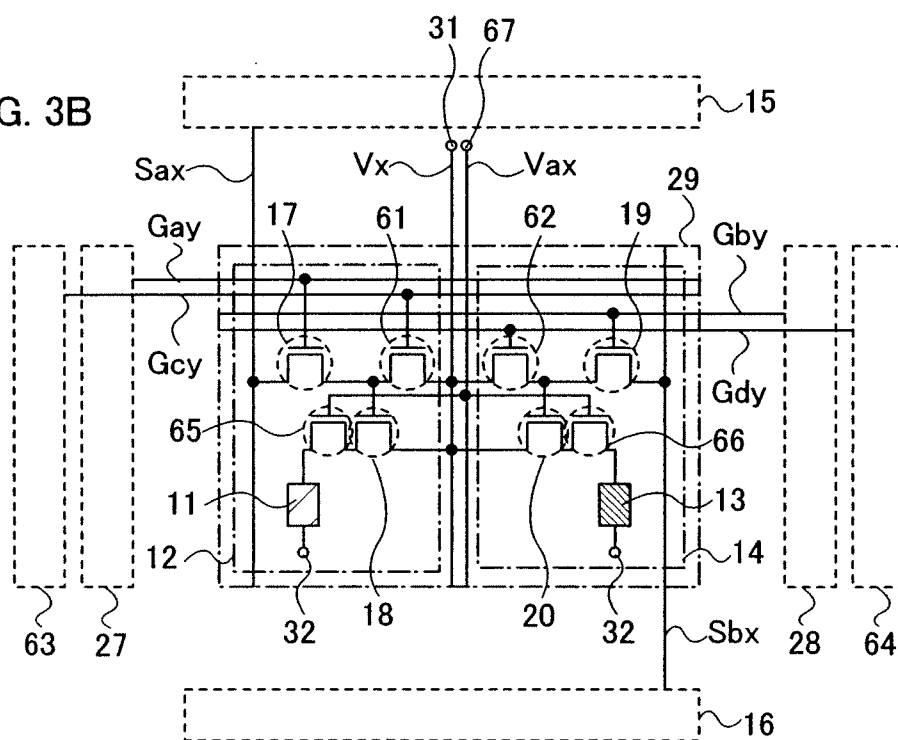


FIG. 4A

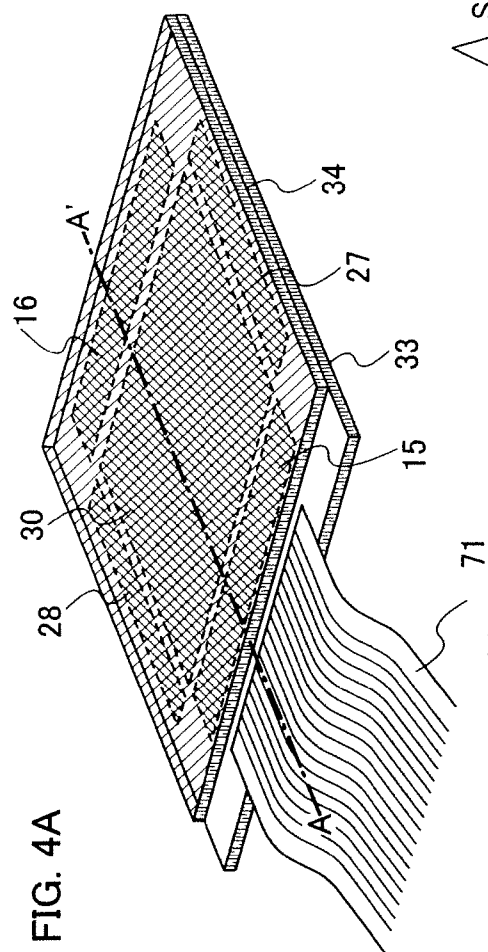


FIG. 4B

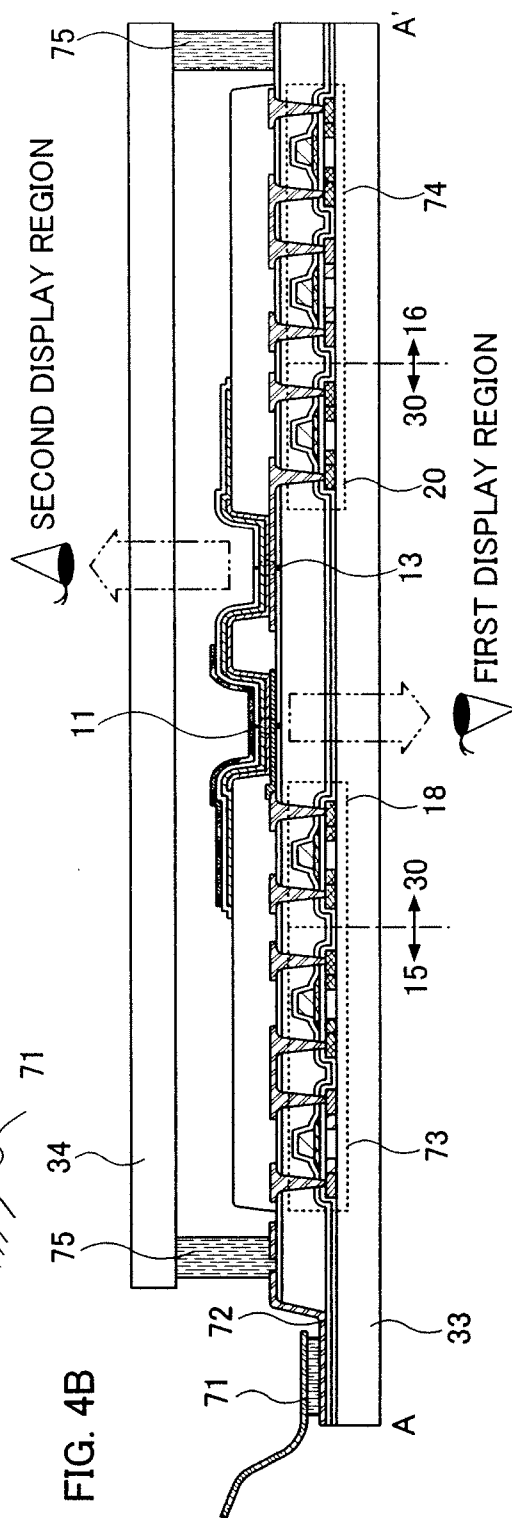


FIG. 5A

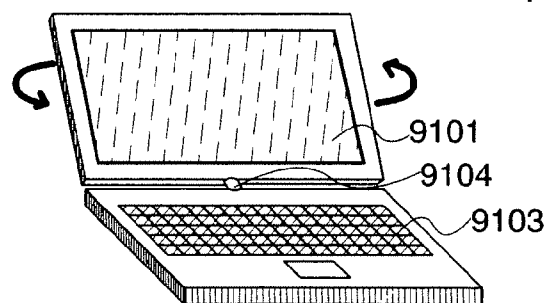


FIG. 5B

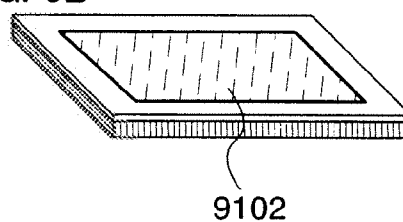


FIG. 5C

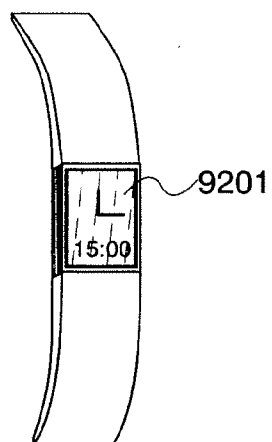
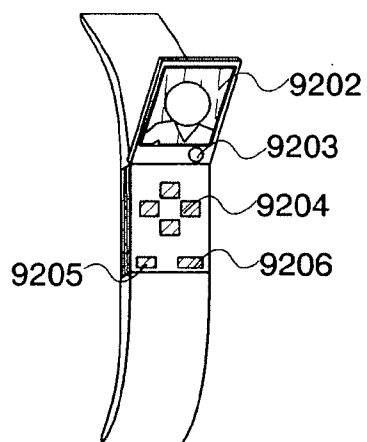


FIG. 5D



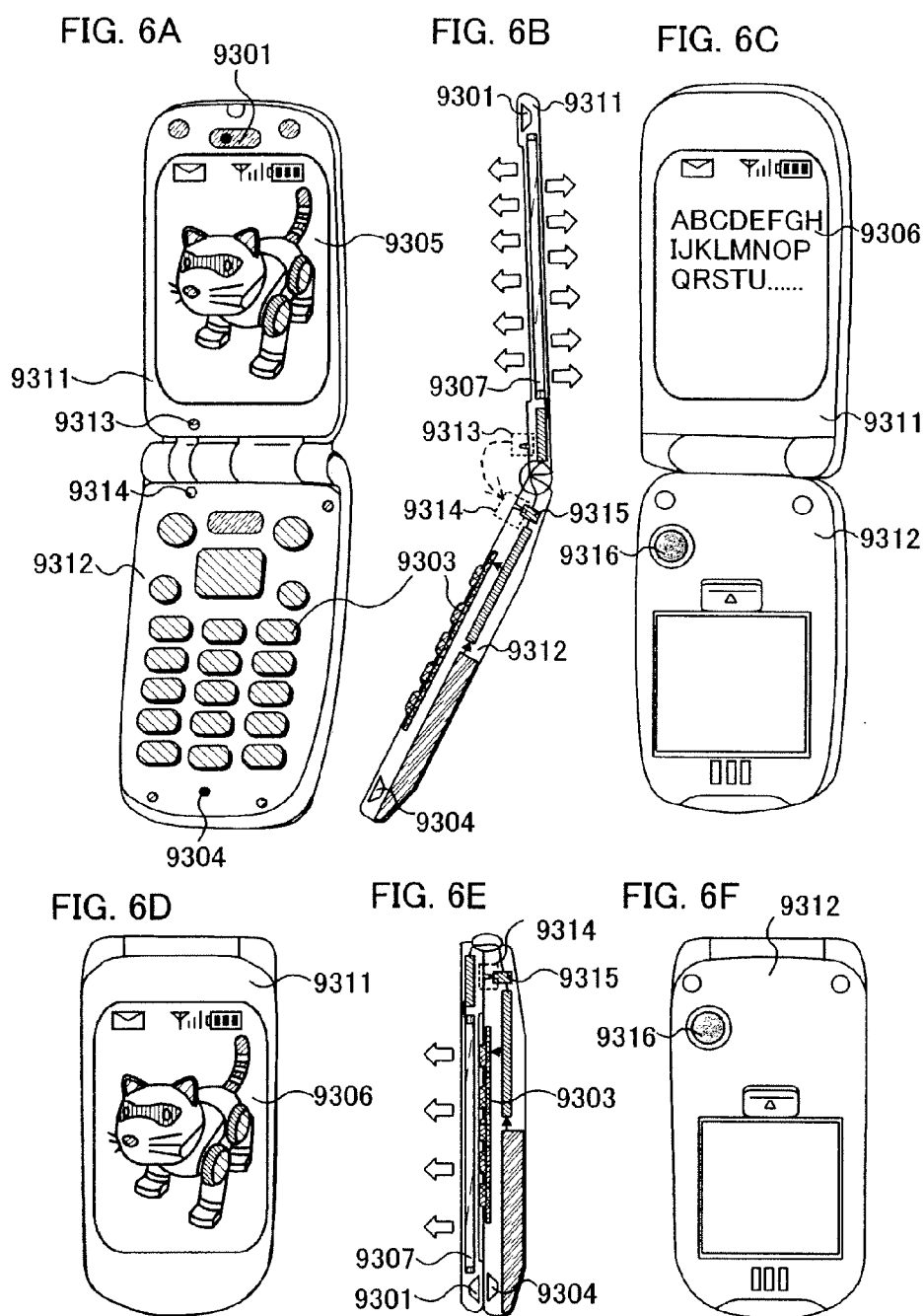


FIG. 7A

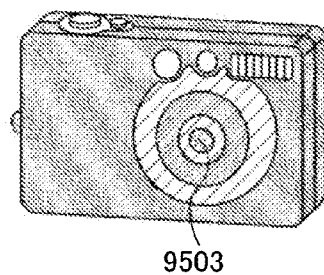


FIG. 7B

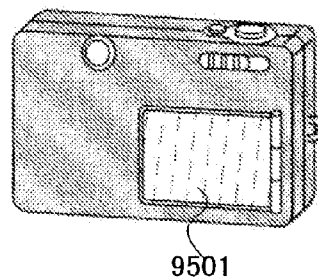


FIG. 7C

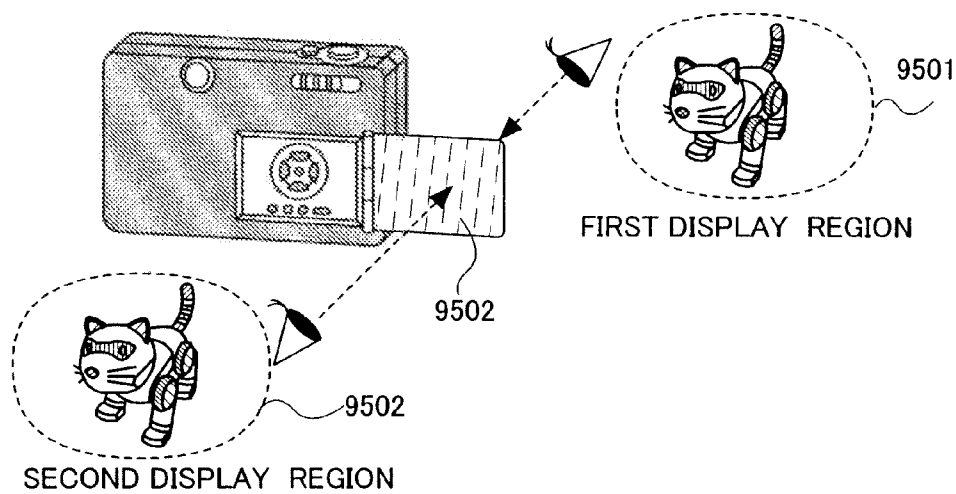
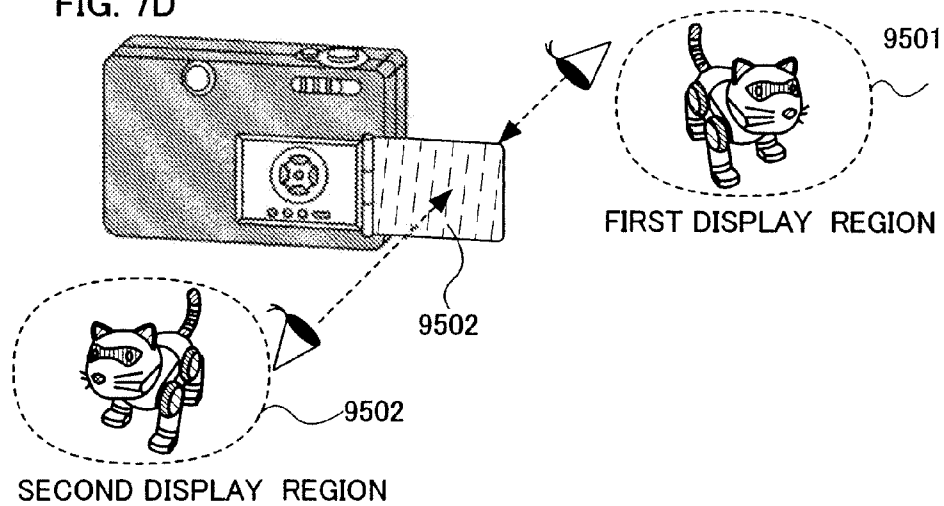


FIG. 7D



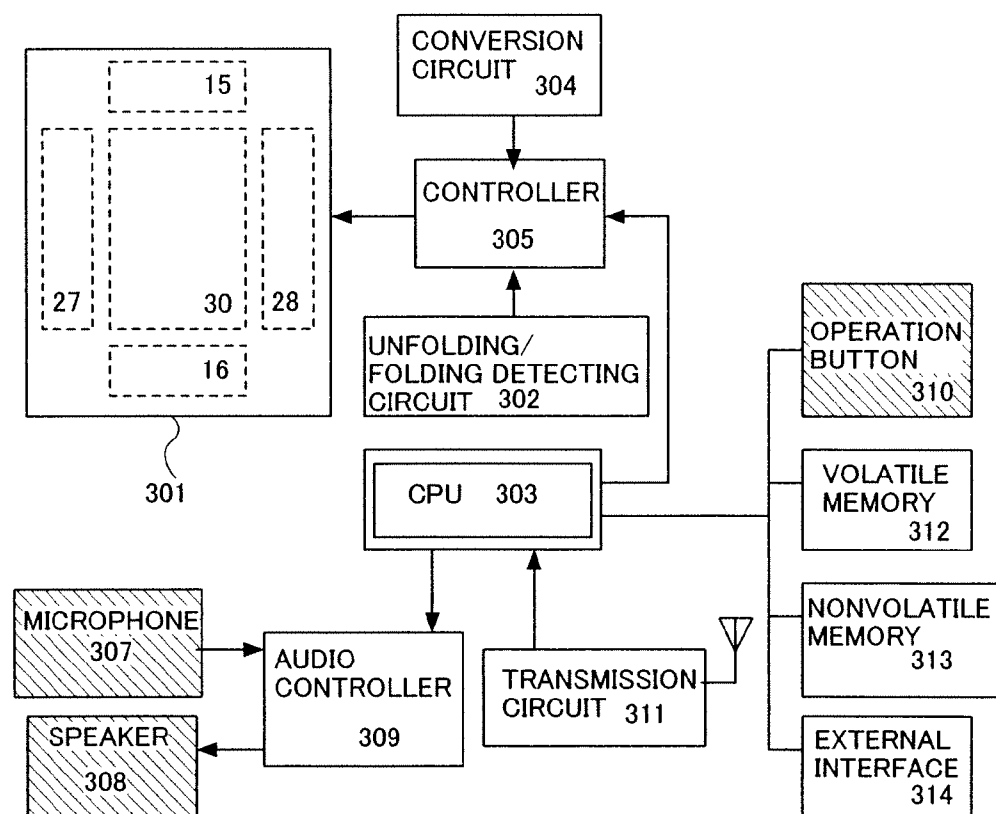


FIG. 8

FIG. 9A

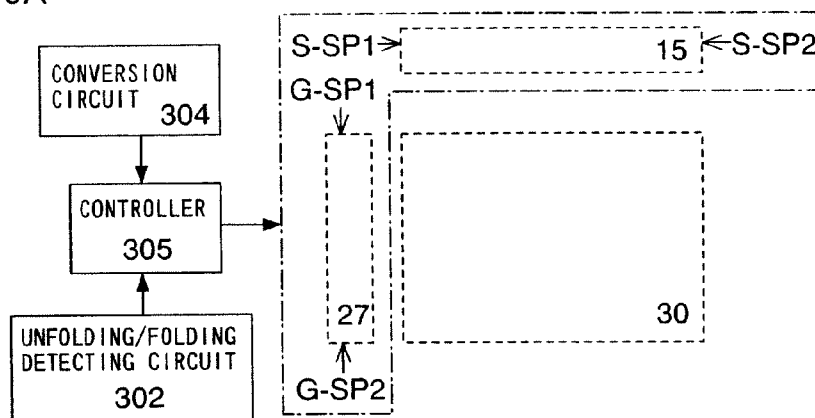


FIG. 9B

ORDINARY DISPLAY

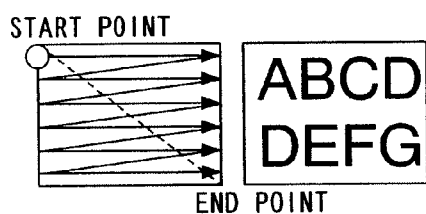


FIG. 9C

HORIZONTALLY REVERSED DISPLAY

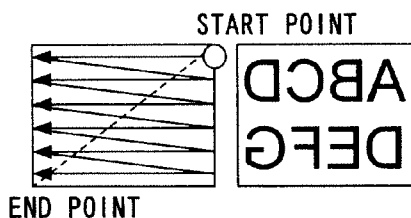


FIG. 9D

180° REVERSED DISPLAY

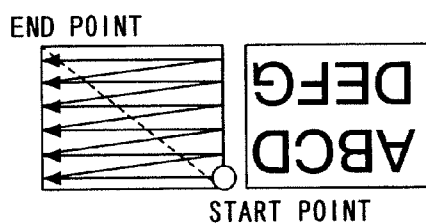


FIG. 9E

VERTICALLY REVERSED DISPLAY

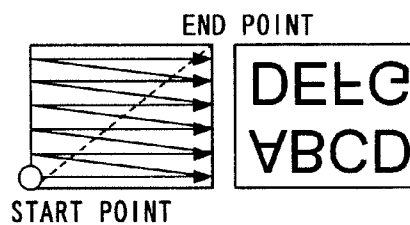


FIG. 10A

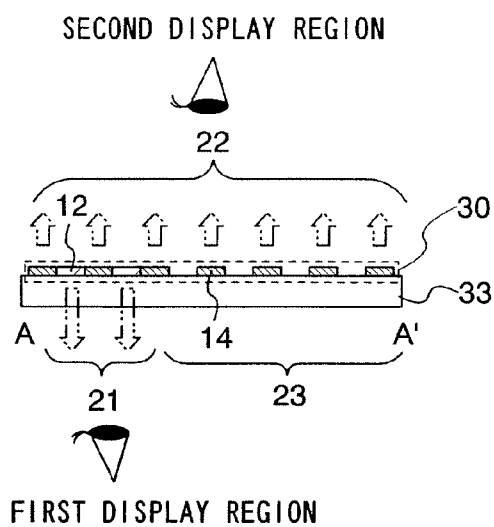


FIG. 10B

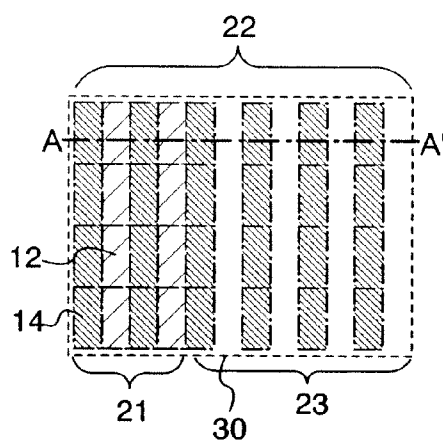


FIG. 10C

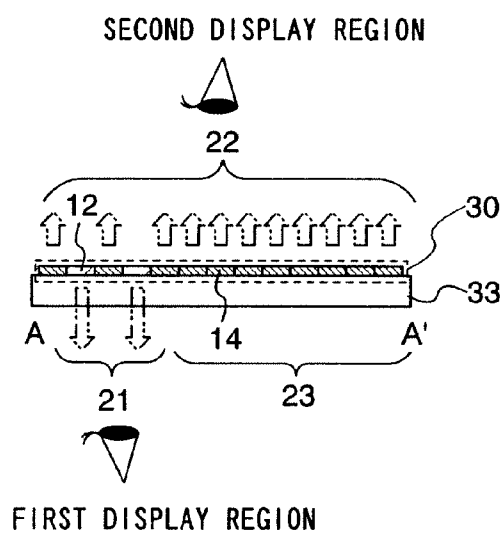
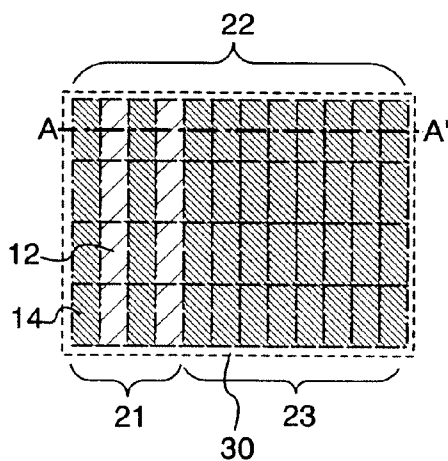


FIG. 10D



DISPLAY DEVICE AND ELECTRONIC APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 12/269,921, filed Nov. 13, 2008, now allowed, which is a divisional of U.S. application Ser. No. 11/032,158, filed Jan. 11, 2005, now U.S. Pat. No. 7,453,426, which claims the benefit of a foreign priority application filed in Japan as Serial No. 2004-007387 on Jan. 14, 2004, all of which are incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a display device having a self-luminous element.

[0004] 2. Description of the Related Art

[0005] In recent years, a display device having a self-luminous element typified by electroluminescence (EL, Electro Luminescence) element or the like has been developed. It is expected that this display device be used widely by making the most of the advantage such as a high image quality and a wide viewing angle because of the self-luminous and thin shape and lightweight without the necessity of a backlight. Incidentally, a high added value of a mobile terminal is required by diversifying the purpose of use. Recently, a mobile terminal equipped with a sub-display surface on the side opposite to the ordinary display surface has been provided (see Reference 1: Japanese Patent Laid-Open No. 2001-285445).

[0006] In a mobile terminal equipped with a sub-display surface in addition to an original display surface, not only capacity occupied by a module including a backlight or the like but also capacity occupied by a printed wiring board or the like on which control ICs for driving the original display surface and the sub-display surface is mounted cannot be ignored. Particularly a mobile terminal that is recently provided is remarkably made lighter and more compact, which is a trade-off with a tendency to heighten the added value.

SUMMARY OF THE INVENTION

[0007] Accordingly, in view of the above situation, an object of the present invention is to provide a display device that realizes a high added value by using a panel capable of downsizing the capacity. In addition, an object of the invention is to provide a display device that realizes sophistication.

[0008] The following means is taken according to the invention to solve the above-mentioned conventional problem.

[0009] According to one of features of the invention, a display device comprises a pixel including a first sub-pixel having a first light-emitting element and a second sub-pixel having a second light-emitting element, a first source driver connected to a first source line included in the first sub-pixel, and a second source driver connected to a second source line included in the second sub-pixel. The first source driver supplies a first video signal for the first sub-pixel, and the second source driver supplies a second video signal for the second sub-pixel.

[0010] A pixel electrode and an opposite electrode of a first light-emitting element have light-transmitting properties, a pixel electrode of a second light-emitting element has reflec-

tiveness, an opposite electrode of the second light-emitting element has light-transmitting properties, electroluminescent layers of the first light-emitting element and the second light-emitting element are provided in the same layer, the opposite electrodes of the first light-emitting element and the second light-emitting element are provided in the same layer, and a reflective layer overlapping with the opposite electrode of the first light-emitting element is provided.

[0011] In addition, according to one of features of the invention, pixel electrodes and opposite electrodes of a first light-emitting element and a second light-emitting element have light-transmitting properties; electroluminescent layers of the first light-emitting element and the second light-emitting element are provided in the same layer; the opposite electrodes of the first light-emitting element and the second light-emitting element are provided in the same layer; and a first reflective layer overlapping with the opposite electrode of the first light-emitting element, and a second reflective layer overlapping with the pixel electrode of the second light-emitting element are provided.

[0012] In addition to the above structures, according to another feature of the invention, a display device comprises a gate driver connected to a first gate line included in a first sub-pixel, and a second gate line included in a second sub-pixel. This gate driver controls operation of a transistor which controls supply of a video signal for the first sub-pixel and the second sub-pixel. Alternatively, according to another feature of the invention, a first gate driver that is connected to a first gate line included in the first sub-pixel and a second gate driver that is connected to a second gate line included in the second sub-pixel are provided. The first gate driver controls operation of a transistor which controls supply of a first video signal for the first sub-pixel. The second gate driver controls operation of a transistor which controls supply of a second video signal for the second sub-pixel.

[0013] According to another feature of a display device of the invention, a first sub-pixel and a second sub-pixel are provided over one surface of a light-transmitting substrate, and a first display region with the use of the first sub-pixel over one surface of the substrate and a second display region with the use of the second sub-pixel over the surface opposite to the one surface of the substrate are provided.

[0014] In addition, according to another feature of the invention, the numbers of TFTs included in each of the first sub-pixel and the second sub-pixel are the same. Alternatively, the numbers of TFTs included in each of the first sub-pixel and the second sub-pixel are different. Furthermore, according to another feature of the invention, the first source driver is connected to a digital data line or an analog data line, and the second source driver is connected to a digital data line or an analog data line.

[0015] In addition, according to another feature of the invention, the first light-emitting element and the second light-emitting element emit red, green, or blue light. Alternatively, according to another feature of the invention, the first light-emitting element and the second light-emitting element emit white light, or the first light-emitting element and the second light-emitting element emit blue light.

[0016] In addition, according to another feature of the invention, a color display is performed in the first display region, and a color display is performed in the second display region. Alternatively, according to another feature of the invention, a color display is performed in the first display region and a monochrome display is performed in the second

display region, or a monochrome display is performed in the first display region and a monochrome display is performed in the second display region.

[0017] In addition, according to another feature of the invention, a counter substrate which is opposed to the substrate is provided, and a color filter is provided for one or both of one surface of the substrate and one surface of the counter substrate. Moreover, according to another feature of the invention, a counter substrate which is opposed to the substrate is provided, and a color conversion layer is provided for one or both of one surface of the substrate and one surface of the counter substrate.

[0018] According to the invention having the above-mentioned features, it is possible to provide a display device that realizes sophistication and a high added value, which includes a display region in each of the opposite sides. Capacity of the module can be downsized compared with the case in which two panels are used to equip each of the opposite sides with a display region. Therefore, a display device in which small size, thin shape, and lightweight are realized can be provided.

[0019] These and other objects, features and advantages of the present invention will become more apparent upon reading of the following detailed description along with the accompanied drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIGS. 1A and 1B are each a diagram illustrating Embodiment Mode according to certain aspects of the present invention;

[0021] FIGS. 2A to 2C are each a view illustrating Embodiment Mode according to certain aspects of the invention;

[0022] FIGS. 3A and 3B are each a diagram illustrating Embodiment 1 according to certain aspects of the invention;

[0023] FIGS. 4A and 4B are each a view illustrating Embodiment 2 according to certain aspects of the invention;

[0024] FIGS. 5A to 5D are each a view illustrating Embodiment 4 according to certain aspects of the invention;

[0025] FIGS. 6A to 6F are each a view illustrating Embodiment 4 according to certain aspects of the invention;

[0026] FIGS. 7A to 7D are each a view illustrating Embodiment 4 according to certain aspects of the invention;

[0027] FIG. 8 is a diagram illustrating Embodiment 5 according to a certain aspect of the invention;

[0028] FIGS. 9A to 9E are each a diagram illustrating Embodiment 6 according to certain aspects of the invention and

[0029] FIGS. 10A to 10D are each a diagram illustrating Embodiment Mode according to certain aspects of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0030] Embodiment Mode of the present invention will be described in detail with reference to the accompanying drawings. However, the invention is not limited to the following explanations, and those skilled in the art easily understand that the mode and details can be variously changed without departing from the content and scope of the invention. Therefore, the invention is not interpreted with limiting to the description in this embodiment mode. Note that, in the following explanations, reference numeral denoting the same parts is used in common among different drawings.

Embodiment Mode

[0031] A display device of the invention has a pixel portion 30 in which a plurality of first source lines Sa1 to Sam (hereinafter referred to as source lines Sa1 to Sam, and “m” indicates a natural number), a plurality of second source lines Sb1 to Sbm (hereinafter referred to as source lines Sb1 to Sbm), a plurality of first gate lines Ga1 to Gan (hereinafter referred to as gate lines Ga1 to Gan, and “n” indicates a natural number), and a plurality of second gate lines Gb1 to Gbn (hereinafter referred to as gate lines Gb1 to Gbn) are arranged in a matrix (see FIG. 1A). The pixel portion 30 comprises a plurality of pixels 29 equipped with a first sub-pixel 12 (hereinafter referred to as a sub-pixel 12) in which a plurality of elements is included in a region where a source line Sax (“x” indicates a natural number, which satisfies $1 \leq x \leq m$) and a gate line Gay (“y” indicates a natural number, which satisfies $1 \leq y \leq n$) are intersected through an insulator, and a second sub-pixel 14 (hereinafter referred to as a sub-pixel 14) in which a plurality of elements is included in a region where a source line Sbx and a gate line Gby are intersected through an insulator.

[0032] The display device of the invention includes a first source driver 15 (hereinafter referred to as a source driver 15) to be connected to the plurality of source lines Sa1 to Sam, a second source driver 16 (hereinafter referred to as a source driver 16) to be connected to the plurality of source lines Sb1 to Sbm, a first gate driver 27 (hereinafter referred to as a gate driver 27) to be connected to the plurality of gate lines Ga1 to Gan, and a second gate driver 28 (hereinafter referred to as a gate driver 28) to be connected to the plurality of gate lines Gb1 to Gbn. The source driver 15 supplies the sub-pixel 12 with a video signal, and the source driver 16 supplies the sub-pixel 14 with a video signal. In addition, the gate driver 27 supplies the sub-pixel 12 with a gate selection signal, and the gate driver 28 supplies the sub-pixel 14 with a gate selection signal. The source drivers 15 and 16 and the gate drivers 27 and 28 comprise a shift register, a latch, a buffer, a sampling circuit, and the like.

[0033] According to the above-mentioned structure, the gate driver 27 that controls the sub-pixel 12 and the gate driver 28 that controls the sub-pixel 14 are provided; however, the invention is not limited to this structure. In other words, both the sub-pixels 12 and 14 may be controlled by one gate driver. Thus, a gate driver to be connected to the plurality of gate lines Ga1 to Gan and the plurality of gate lines Gb1 to Gbn may be provided.

[0034] The sub-pixel 12 includes a first light-emitting element 11 (hereinafter referred to as a light-emitting element 11), a switching transistor 17 (hereinafter referred to as a TFT 17), and a driving transistor 18 (hereinafter referred to as a TFT 18) in a region where the source line Sax and the gate line Gay are intersected through an insulator (see FIG. 1B). The sub-pixel 14 includes a second light-emitting element 13 (hereinafter referred to as a light-emitting element 13), a switching transistor 19 (hereinafter referred to as a TFT 19), and a driving transistor 20 (hereinafter referred to as a TFT 20) in a region where the source line Sbx and gate line Gby are intersected through an insulator. Since the sub-pixels 12 and 14 having the above-mentioned structure have two TFTs, respectively, of which number is small, enhancement of a yield during the manufacturing process is achieved. In addition, the pixels have advantage in terms of layout, and enhancement of an aperture ratio is achieved.

[0035] The light-emitting elements 11 and 13 each have a structure in which an electroluminescent layer is sandwiched

between a pair of electrodes. Among the pairs of electrodes included in each of the light-emitting elements **11** and **13**, one electrode is connected to a power supply **31** through the TFT **18** or the TFT **20** and a power supply line **Vx**, and the other electrode is connected to an opposite power supply **32**. Among the pairs of electrodes included in each of the light-emitting elements **11** and **13**, the electrodes connected to the TFT **18** and **20** are referred to as pixel electrodes, and the other electrodes are referred to as opposite electrodes. Note that, in the above structure, the sub-pixels **12** and **14** have the power supply line **Vx** in common. This structure achieves further enhancement of the aperture ratio. However, the invention is not limited to the above structure, and the power supply lines may be provided separately in each of the sub-pixels **12** and **14**.

[0036] The TFTs **17** and **19** each have the function of controlling input of the video signals to each of the sub-pixels **12** and **14**. The signals are transmitted from the gate drivers **27** and **28** to the gate electrodes of the TFTs **17** and **19** through the gate lines **G₁** and **G₂**. Based on the signals transmitted from the gate drivers **27** and **28**, each of the sub-pixels **12** and **14** are supplied with the video signals from the source drivers **15** and **16** when the TFTs **17** and **19** are turned ON.

[0037] The TFTs **18** and **20** each have the function of controlling each lighting or non-lighting of the sub-pixels **12** and **14**. The gate electrodes of the TFTs **18** and **20** are supplied with the video signals through the TFTs **17** and **19**. Based on the video signals, the potential of the power supply line **Vx** is transmitted to the pixel electrodes of the light-emitting elements **11** and **13** when the TFTs **18** and **20** are turned ON. Accordingly, a voltage of a forward bias is applied between the both electrodes of the light-emitting elements **11** and **13**. Consequently, current flows to the light-emitting elements **11** and **13**, and thus, the luminescence is obtained.

[0038] Although it is not shown in the figure, the sub-pixels **12** and **14** may be provided with a capacitor element that holds the gate-source voltage (hereinafter referred to as **VGS**) of the TFTs **18** and **20**. However, the capacitor that holds the **VGS** of the TFTs **18** and **20** may use a gate capacitor or a wiring capacitor. In addition, the conductivity types of the TFTs **17** to **20** are not particularly limited, and either N-type conductivity or P-type conductivity may be accepted. Moreover, the circuit configuration of the sub-pixels **12** and **14** are not limited to the above, and various circuit configurations are applicable. The structure except the above is hereinafter described in Embodiments.

[0039] The display device of the invention are equipped with a pixel portion **30** comprising a plurality of pixels including sub-pixels **12** and **14** on one side of a light-transmitting substrate **33** (see FIG. 2A). A light-emitting element **11** included in the sub-pixel **12** emits light in the direction of the substrate **33**, and a light-emitting element **13** included in the sub-pixel **14** emits light in the opposite direction of the substrate **33**. Accordingly, a first display region using the sub-pixel **12** is provided on one side of the substrate **33**, and a second display region using the sub-pixel **14** is provided on the side opposite to one side of the substrate **33**. In other words, the display device of the invention has the display regions on one and the opposite sides of the light-transmitting substrate **33**, respectively.

[0040] The sub-pixel **12** is controlled by the source driver **15** and the gate driver **27**, and the sub-pixel **14** is controlled by the source driver **16** and the gate driver **28**. In other words, although the sub-pixels **12** and **14** are provided over the

substrate **33**, the sub-pixels are controlled by different drivers. Consequently, different images can be displayed in the first display region and the second display region, respectively. Of course, the same images can be also displayed in the first display region and the second display region.

[0041] In the case of the structure illustrated in above FIG. 2A, the first display region using the sub-pixel **12** and the second display region using the sub-pixel **14** are the same in size. However, the invention is not limited to this structure. A pixel portion **30** may be divided into a plurality of regions (two regions in FIG. 10A), either a sub-pixel **12** or a sub-pixel **14** (only the sub-pixel **14** in FIG. 10A) may be provided in a region **23**, and the both the sub-pixels **12** and **14** may be provided in a region **21** (see FIGS. 10A and 10B). According to this structure, the size of the first display region equals to the size shown in the region **21**, and the size of the second display region equals to the size shown in a region **22**. In other words, the first display region and the second display region can be formed in different size from each other.

[0042] In addition, in the case of the structures shown in FIGS. 10A and 10B, only the sub-pixel **14** is provided without providing the sub-pixel **12** in the region **23**; however, the invention is not limited to this structure. In a region **23**, the sub-pixel **14** may be formed in the place where the sub-pixel **12** is to be formed (see FIGS. 10C and 10D). In this structure, also, the size of the first display region equals to the size shown in a region **21**, and the size of the second display region equals to the size shown in a region **22**. In other words, the first display region and the second display region can be formed in different size with each other. However, according to this structure, the second display region has different pixel density in the regions **21** and **23**. Therefore, the images displayed in the regions **21** and **23** may be appropriately changed by, for example, providing an icon showing a remaining battery level, wave intensity, or the like in the region **21** and providing an e-mail message or the like in the region **23** of the second display region.

[0043] Hereinafter, the structures of the light-emitting element **11** which emits light in the direction of the substrate **33** and the light-emitting element **13** which emits light in the opposite direction of the substrate **33** are explained with reference to cross-sectional views by taking the two cases as examples (FIGS. 2B and 2C). Note that, in the both cases, an electroluminescent layer **43** and an opposite electrode **41** of the light-emitting elements **11** and **13** are provided in the same layer.

[0044] First, as the first structure, the case in which both a pixel electrode **40** and the opposite electrode **41** of the light-emitting element **11** have light-transmitting properties, a pixel electrode **42** of the light-emitting element **13** has reflectiveness, and the opposite electrode **41** of the light-emitting element **13** has light-transmitting properties is shown (see FIG. 2B). This structure has a feature that a reflecting layer **45** overlapping with the opposite electrode **41** of the light-emitting element **11** is provided. According to the above feature, the light-emitting element **11** emits light in the direction of the substrate **33**, and the light-emitting element **13** emits light in the opposite direction of the substrate **33**.

[0045] Next, a structure in which both a pixel electrode **40** and an opposite electrode **41** of a light-emitting element **11** have light-transmitting properties, and both a pixel electrode **51** and the opposite electrode **41** of a light-emitting element **13** have light-transmitting properties is shown (see FIG. 2C). This structure has a feature that a first reflecting layer **50**

overlapping with the opposite electrode **41** of the light-emitting element **11** and a second reflecting layer **52** overlapping with the pixel electrode **51** of the second light-emitting element **13** are provided. According to the above feature, the light-emitting element **11** emits light in the direction of a substrate **33**, and the light-emitting element **13** emits light in the opposite direction of the substrate **33**.

[0046] Note that materials having reflectiveness may be used for the pixel electrode **42** having reflectiveness, the reflecting layer **45**, the first reflecting layer **50**, and the second reflecting layer **52**. However, aluminum, which is superior in terms of reflectiveness and which is inexpensive or a material containing the aluminum, is preferably used. In addition, although FIG. 2B shows a structure in which an insulating layer **44** which functions as a protective layer is sandwiched between the opposite electrode **41** and the reflecting layer **45**, the invention is not limited to this structure. As shown in FIG. 2C, the reflecting layer **45** may be provided to be in contact with the opposite electrode **41**. Moreover, the structure shown in FIG. 2C uses a conductive layer in the same layer as gate electrodes of TFTs **18** and **20** as the second reflecting layer **52**; however, the invention is not limited to this structure. In other words, the second reflecting layer **52** may be provided in any layer as long as it is formed below the pixel electrode **51**. However, when the second reflecting layer **52** is formed in a place apart from the pixel electrode **51**, unnecessary reflected light increases inside the panel. Thus, in terms of efficiency in extracting light, the second reflecting layer **52** may be formed to be in contact with the pixel electrode **51**, or the pixel electrode **51** may be formed from a reflective material.

[0047] According to the invention having the above-mentioned features, it is possible to provide a display device that realizes sophistication and a high added value, which includes a display region in each of one and the opposite sides. Capacity of the module can be downsized compared with the case in which two panels are provided on each of one and the opposite sides. Therefore, a display device in which small size, thin shape, and lightweight are realized can be provided.

Embodiment 1

[0048] In this embodiment, circuit configurations of the sub-pixels are explained with reference to drawings. First, a structure comprising three TFT's in a sub-pixel (3 TFT/Cell) is explained (see FIG. 3A). This is a structure in which TFTs (erase TFTs) **61** and **62**, gate lines Gcy (which satisfies $1 \leq y \leq n$, and "n and y" indicate a natural number) and Gdy (which satisfies $1 \leq y \leq m$, and "y" indicates a natural number), and gate drivers **63** and **64** are newly arranged in the structure shown in FIG. 1B. Current can be compulsorily made not to flow to light-emitting elements **11** and **13** by arranging the TFTs **61** and **62**. Therefore, a lighting period can be started at the same time as or just after a start of a writing period without waiting for writing a signal in all sub-pixels. As a result, the duty ratio can be improved and a favorable moving image display can be performed.

[0049] Next, a structure comprising four TFTs in a sub-pixel (4 TFT/Cell) is explained (see FIG. 3B). This is a structure in which TFTs **65** and **66**, a power supply line Vax (which satisfies $1 \leq x \leq m$, and "y" indicates a natural number), and a power supply **67** are newly arranged in a structure shown in FIG. 3A. The gate electrodes of the TFTs **65** and **66** are connected to the power supply line Vax which is held in a constant potential. In other words, the potentials of the gate

electrodes of the TFTs **65** and **66** are fixed. The TFTs **65** and **66** are operated in a saturation region to make current flow constantly. TFTs **18** and **20** are operated in a linear region. According to the above-mentioned structure, the value of a source-drain voltage (VDS) of the TFTs **18** and **20** operated in a linear region is small. Therefore, slight variation between a gate-source voltage (VGS) of the driving TFTs **18** and **20** does not affect the values of current flown to the light-emitting elements **11** and **13**. Thus, the current values flown to the light-emitting elements **11** and **13** depend on a source-drain current of the TFTs **65** and **66** operated in a saturation region. Consequently, luminance unevenness of the TFTs **65** and **66** due to variation in characteristics of the TFTs **18** and **20** can be improved to enhance the image quality. Note that a channel length L_1 and a channel width W_1 of the TFTs **18** and **20** and a channel length L_2 and a channel width W_2 of the TFTs **65** and **66** may be set to satisfy $L_1/W_1:L_2/W_2=5$ to $6000:1$ in order to operate each TFT in a linear region or a saturation region.

[0050] Note that circuit configurations of sub-pixels **12** and **14** included in a pixel **29** may have the same structures (the same number of TFTs) or may have different structures (the different number of TFTs) from each other. In the case of the structures different from each other, for example, 4 TFT/Cell may be employed for sub-pixels which is included in a main display region for displaying moving image or an image of high-definition is performed, and 2 TFT/Cell may be employed for sub-pixels which is included in a sub display region in which a still image display is performed. In this manner, the circuit configurations may be separately formed depending on the application of the display regions. This embodiment can be arbitrarily combined with the above-mentioned embodiment mode.

Embodiment 2

[0051] A panel, which is one mode of a display device of the present invention, is explained with reference to drawings. Here, a panel in which a pixel portion and a driver are integrally formed is explained. The panel comprises a pixel portion **30**, source drivers **15** and **16**, gate drivers **27** and **28**, a connection terminal **72**, and a connection film **71** provided over a substrate **33** (see FIGS. 4A and 4B). The connection terminal **72** is connected to the connection film **71** through conductive particles. The connection film **71** is connected to an IC chip (not shown in the figure).

[0052] FIG. 4B shows a cross-sectional view taken along a line A-A' of the panel and shows TFTs **18** and **20** and light-emitting elements **11** and **13** included in the pixel portion **30**. In addition, elements **73** included in the source driver **15** and elements **74** included in the source driver **16** are shown. A sealant **75** is provided in a periphery of the pixel portion **30** and the drivers **15**, **16**, **27**, and **28**, and the light-emitting elements **11** and **13** are sealed by sealant **75** and a counter substrate **34**. This sealing process is a process to protect the light-emitting elements **11** and **13** from the substance that becomes deteriorating factor, for example, moisture. Although a method for sealing with the use of a cover material (glass, ceramics, plastics, metal, or the like) is used here, a method for sealing with the use of thermosetting resin or ultraviolet curable resin may be used. Alternatively, a method for sealing with the use of a thin film of which barrier ability is high, for example, metal oxide, nitride, or the like may be used.

[0053] A TFT in which any one of an amorphous semiconductor, a microcrystal semiconductor, a crystalline semiconductor, and an organic semiconductor is employed for the channel portion is acceptable to the elements formed over the substrate **33**. However, the elements are preferably formed from the crystalline semiconductor superior in characteristics such as mobility in comparison with the amorphous semiconductor. Accordingly, monolithic device over one surface is achieved. Since the drivers are integrally formed in the panel having the above structure, the number of external ICs to be connected is decreased, and thus, a small-size, thin-shaped, and lightweight display device is realized.

[0054] Note that, in FIG. 4B, light emitted from the light-emitting element **11** is emitted in the direction of the substrate **33** as indicated by an arrow. Such a structure is referred to as a bottom emission type. On the other hand, light emitted from the light-emitting element **13** is emitted in the direction of the counter substrate **34** as indicated by an arrow. Such a structure is referred to as a top emission type. In addition, in FIG. 4B, each of source electrodes or drain electrodes of the TFTs **18**

the amorphous semiconductor serves as a channel portion, and the drivers **15**, **16**, **27**, and **28** may comprise IC chips. The IC chips may be attached to the substrate **33** by a COG method or may be attached to the connection film **71** connected to the substrate **33**. The amorphous semiconductor can provide an inexpensive panel since it can be easily formed over a large-sized substrate by using a CVD method and a crystallization step is unnecessary. In addition, when a drop-let discharge method such as an ink-jet method is used in conjunction in forming a conductive layer, a more inexpensive panel can be provided. This embodiment can be arbitrarily combined with the above-mentioned embodiment mode and embodiment.

Embodiment 3

[0057] According to the present invention, there are a first display region on the side of a substrate **33** and a second display region on the side of a counter substrate **34**, and display in each display region is explained with reference to Tables 1 and 2.

TABLE 1

Light Emitting Element	Substrate 33 Side (First Display Region)		Counter Substrate 34 Side (Second Display Region)	
RGB Light Emission	Color Display		Color Display	
White Light Emission	CF	Color Display	CF	Color Display
	CF	Color Display	No CF	Monochrome Display
	No CF	Monochrome Display	CF	Color Display
Blue Light Emission	Color Conversion Layer	Color Display	Color Conversion Layer	Color Display
	Color Conversion Layer	Color Display	No Color Conversion Layer	Monochrome Display
	No Color Conversion Layer	Monochrome Display	Color Conversion Layer	Color Display
Monochromatic Light Emission	Monochrome Display		Monochrome Display	

and **20** and the pixel electrodes of the light-emitting elements **11** and **13** are laminated in the same layer without sandwiching an insulating layer therebetween. According to this structure, regions where the pixel electrodes of the light-emitting elements **11** and **13** are formed are identical with a region excluding a region where the TFTs **18** and **20** are arranged. Accordingly, the decrease of aperture ratio is inevitable due to high definition or the like of the pixel. Therefore, an interlayer film may be additionally provided to provide the pixel electrodes in the separated layer. Thus, enhancement of the aperture ratio is achieved by effectively utilizing the region where the TFTs are arranged.

[0055] In addition, an optical film such as a half-wave plate, a quarter-wave plate, and a polarizing plate may be provided over one surface of the substrate **33** and one surface of the counter substrate **34**. When a wave plate or a polarizing plate is provided, unnecessary light generated due to reflection inside the panel is reduced, and thus, a fine black display and a high contrast are realized. An angle between two pieces of polarizing plates may be range from 40° to 90°, preferably from 70° to 90°, and more preferably it may be set to 90°.

[0056] Note that the structure of the display device according to the invention is not limited to the above description. For example, the pixel portion **30** may comprise a TFT in which

[0058] In Table 1, RGB light emission indicates the case when light emitted from a light-emitting element included in a pixel is red, green, or blue. White light emission indicates the case when light emitted from a light-emitting element included in a pixel is white. Blue light emission indicates the case when light emitted from a light-emitting element included in a pixel is blue. Monochromatic light emission indicates the case when light emitted from a light-emitting element included in a pixel is one color of red, green, and the like. CF indicates a color filter. When the RGB light emission is employed for a light-emitting element, enhancement of light usage efficiency is achieved. In addition, when white light emission or blue light emission is employed for the light-emitting element, enhancement of a yield is achieved since there is no necessity to color an electroluminescent layer separately. Furthermore, when a CF or a color conversion layer is employed, enhancement of a color purity or contrast is achieved.

[0059] When the color filter and the color conversion layer are employed, the color filter and the color conversion layer are provided over one or both of one surface of the substrate **33** and one surface of the counter substrate **34**.

[0060] In both the first display region and the second display region of a light-emitting element included in a pixel,

color display is performed in the case of RGB light emission or monochrome display is performed in the case of monochromatic light emission. When RGB light emission or monochromatic light emission is performed in a light-emitting element included in a pixel, color display or monochrome display is performed in both the first display region and the second display region. When white light emission or blue light emission is performed in a light-emitting element included in a pixel, color display or monochrome display is performed depending on existence or non-existence of the CF or the color conversion layer. When the CF or the color conversion layer is provided on one side of the substrate **33** and the counter substrate **34**, one of the substrates can perform color display and the other can provide monochrome display.

TABLE 2

First Source Driver 15 (Substrate 33 Side, First Display Region)		Second Source Driver 16 (Counter Substrate 34 Side, Second Display Region)	
Analog Video Signal	Analog Display	Analog Video Signal	Analog Display
Analog Video Signal	Analog Display	Digital Video Signal	Digital Display
Digital Video Signal	Digital Display	Analog Video Signal	Analog Display
Digital Video Signal	Digital Display	Digital Video Signal	Digital Display

[0061] In Table 2, when both source drivers **15** and **16** supply each sub-pixel with an analog video signal or a digital video signal, the source drivers **15** and **16** are connected to an analog data line which transmits the analog video signal or a digital data line which transmits the digital video signal. Then, analog display or digital display is performed in the first display region and the second display region. In addition, when one of the source drivers **15** and **16** supplies an analog video signal and the other source driver supplies a digital video signal, one of the source drivers **15** and **16** is connected to an analog data line and the other source driver is connected to a digital data line. Then, analog display is performed in one of the first display region and the second display region, and digital display is performed in the other display region.

[0062] Accordingly, analog display can be performed in one display region and digital display can be performed in the other display region by separately using signals that are supplied to each sub-pixel by the source drivers **15** and **16**. The display regions can be separately formed in such a manner, for example, when a main display region for displaying moving image or an image of high-definition is provided by digital display, and a sub display region for displaying a still image is provided by analog display. Since the number of times of writing the signal is small in the display region in which analog display is performed, power consumption of the source drivers can be inhibited. In addition, since the number of times of writing the signal is small, the frequency of the source drivers can be reduced enough, and thus, the signal writings can be performed accurately.

[0063] Note that, as mentioned above, either an analog video signal or a digital video signal may be used in the display device of the invention. However, in the case of using the digital video signal, there are a video signal using the voltage and a video signal using the current. In other words, the constant voltage or the constant current is used for the video signal inputted into the pixel when a light-emitting element emits light. When the constant voltage is used for the video signal, the voltage applied to the light-emitting element is constant, or the current flowing in the light-emitting ele-

ment is constant. On the other hand, when the constant current is used for the video signal, the voltage applied to the light-emitting element is constant, or the current flowing in the light-emitting element is constant. The constant voltage applied to the light-emitting element is referred to as constant voltage driving, and the constant current flow to the light-emitting element is referred to as constant current driving. The constant current driving does not depend on the change of the resistance and the constant current flows. Either the video signal using the voltage or the video signal using the current may be used for the display device of the invention, and either the constant voltage driving or the constant current driving may be used. This embodiment can be arbitrarily combined with the above-mentioned embodiment mode and embodiments.

Embodiment 4

[0064] As an example of an electronic apparatus (electronic device) to which a display device of the present invention is applicable, a television apparatus (also referred to as a television receiver device, a television receiver, a television, or a television device), a camera such as a digital camera or a digital video camera, a cellular phone device (also referred to as a cellular phone handset or a cellular phone), a portable information terminal such as a PDA (Personal Digital Assistant), a portable game machine, a monitor, a personal computer, a tablet PC, an audio reproducing device such as a car audio, an image reproducing device provided with a recording medium such as a home-use game machine, or the like is given. Hereinafter, the specific examples are explained.

[0065] FIGS. **5A** and **5B** illustrate a tablet PC, which includes display regions **9101** and **9102**, buttons **9103**, a rotation axis **9104**, and the like. The display region **9101** is used when the tablet PC is in the unfolded state (FIG. **5A**), and the display region **9102** is used when the tablet PC is in the folded state (FIG. **5B**). In addition, both the display regions **9101** and **9102** may be used both in the unfolded state and in the folded state by rotating the casing with the use of the rotation axis **9104**. The invention is applicable to the display device including the display regions **9101** and **9102**. FIGS. **5C** and **5D** illustrate a wristwatch portable terminal, which includes display regions **9201** and **9202**, a camera **9203**, buttons **9204**, a microphone **9205**, a speaker **9206**, and the like. The invention is applicable to the display device including the display regions **9201** and **9202**.

[0066] FIGS. **6A** to **6F** illustrate a foldable portable terminal, which includes a first casing **9311** having a speaker **9301** and a panel **9307**; a second casing **9312** having a microphone **9304**, buttons **9303**, and a camera **9316**; and the like. In this portable terminal, one or both of display regions **9305** and **9306** are used in the unfolded state, and the display region **9306** is used in the folded state. In addition, this portable terminal includes unfolding/folding detecting means that determines which of the first display region **9305** or the sec-

ond display region **9306** is to be used. The unfolding/folding detecting means includes a protrusion **9313** provided for the first casing **9311**, a hole **9314** and control means **9315** provided for the second casing **9312**, and the like. In the folded state, the protrusion **9313** is in contact with the control means **9315** disposed below the hole **9314**. In this state, the control means **9315** is set so that the ordinary display is performed in the first display region **9305**. On the other hand, in the unfolded state, there is no protrusion **9313** being in contact with the control means **9315**. In this state, the control means **9315** is set so that the ordinary display is performed in the second display region **9306**. Note that the above-mentioned structure of the unfolding/folding detecting means is just an example and is not limited to the above description.

[0067] FIGS. 7A to 7C illustrate a digital camera, which includes a first display region **9501** (hereinafter referred to as a display region **9501**), a second display region **9502** (hereinafter referred to as a display region **9502**), a lens **9503**, and the like. The invention is applicable to the display device including the display regions **9501** and **9502**. FIG. 7B illustrates the state in which a panel including the display regions **9501** and **9502** is closed, and FIGS. 7C and 7D illustrate the opened state. In this digital camera, the display region **9501** is used in the closed state, and one or both of the display regions **9501** and **9502** are used in the opened state. When the same images are displayed as the ordinary display in the display regions **9501** and **9502** in the opened state, both a person who takes a picture and a person of whom picture is taken can simultaneously confirm the photography image (see FIG. 7C). In addition, horizontally reversed display may be performed in the display region **9501**, and the ordinary display may be performed in the display region **9502** (see FIG. 7D). Performing horizontally reversed display in the display region **9501** in such a manner means that the person of whom picture is taken confirms a mirror image. In other words, the person of whom picture is taken can confirm its mirror image which is usually confirmed by using a mirror and thus can have a sense of comfort, and furthermore, it is possible to groom its appearance by using the mirror image. This embodiment can be arbitrarily combined with the above-mentioned embodiment mode and embodiments.

Embodiment 5

[0068] The components of a display device of the present invention and their relations are explained with reference to FIG. 8. As the components of the display device of the invention, a panel **301** including a pixel portion **30**, source drivers **15** and **16**, and gate drivers **27** and **28**; a conversion circuit **304**; and a controller **305** are given. The conversion circuit **304** controls which of a first display region and a second display region disposed on the opposite sides are to be used to perform the ordinary display. In addition, if necessary, it controls to perform display selected from horizontally reversed display, 180° reversed display, and vertically reversed display. The controller **305** controls the operation of the panel **301**.

[0069] An operation button **310**, a volatile memory **312**, a nonvolatile memory **313**, and an external interface **314** are given as another components besides the above. These components are controlled by a CPU (Central Processing Unit) **303**. Data such as a video signal is stored in the volatile memory **312** and nonvolatile memory **313**.

[0070] When the invention is applied to a foldable electronic device, unfolding/folding detecting means **302** is pro-

vided as the components besides the above. The unfolding/folding detecting means **302** detects the folded state and the unfolded state and supplies the conversion circuit **304** with the information of the detection of the folded and unfolded states. The conversion circuit **304** controls which of a first display region and a second display region disposed on the opposite sides are to be used to perform the ordinary display based on the information supplied from the unfolding/folding detecting means **302**. In addition, when the invention is applied to a cellular phone handset, a transmission circuit **311**, a microphone **307** which is a transmitter portion, a speaker **308** which is a receiver portion, an audio controller **309**, and the like are provided as the components besides the above.

[0071] Note that the invention is not limited to the above structure and may be equipped with other components. In addition, this embodiment can be arbitrarily combined with the above-mentioned embodiment mode and embodiments.

Embodiment 6

[0072] A display device of the present invention has a feature having display regions on the opposite sides. When both of the display regions on the opposite sides are used, the ordinary display is preferably performed in one display region, and horizontally reversed display is preferably performed in the other display region (see FIG. 7C). In such a manner, both persons who see a first display region and who see a second display region can confirm the same image simultaneously. Accordingly, switching of the display to be the ordinary display, the horizontally reversed display, or the like is explained in this embodiment with reference to FIGS. 9A to 9E.

[0073] As mentioned above, a panel includes a pixel portion **30** having (mxn) number of pixels, source drivers **15** and **16**, and gate drivers **27** and **28**. Here, the source driver **15** and the gate driver **27** are shown in the figure for simplicity to explain display in a first display region with the use of a first sub-pixel (see FIG. 9A).

[0074] A controller **305** determines a point where a start pulse is supplied according to a signal supplied from a conversion circuit **304** or unfolding/folding detecting means **302**. Specifically, S-SP1 is provided when a sub-pixel is selected from the first column, S-SP2 is provided when a sub-pixel is selected from the m-th column, G-SP1 is provided when a sub-pixel is selected from the first row, and G-SP2 is provided when a sub-pixel is selected from the n-th row.

[0075] Then, in the case of performing the ordinary display, start pulses (S-SP1 and G-SP1) are supplied so that a sub-pixel arranged in the first column and first row is selected first (see FIG. 9B). In the case of performing horizontally reversed display, start pulses (S-SP2 and G-SP1) are supplied so that a sub-pixel arranged in the m-th column and the first row is selected first (see FIG. 9C). In the case of performing 180° reversed display, start pulses (S-SP2 and G-SP2) are supplied so that a sub-pixel arranged in the m-th column and the n-th row is selected first (see FIG. 9D). In the case of performing vertically reversed display, start pulses (S-SP1 and G-SP2) are supplied so that a sub-pixel arranged in the first column and the n-th row is selected first (see FIG. 9E). In such a manner, a point where a start pulse is supplied is changed depending on each display. In addition, the video signals supplied to the sub-pixels from the source driver **15** are appropriately changed.

[0076] Note that, in the case of applying a time gray scale method, a video signal is loaded into a recording medium and then converted into a video signal for a time gray scale as a method for expressing a gray scale. Therefore, in the case of applying the time gray scale method, the order of loading a video signal of the ordinary display may be changed depending on the video signals for displaying each of horizontally reversed display, 180° reversed display, and vertically reversed display, and these display stored in a recording medium to correspond to each display.

[0077] In addition, the switching of display may be performed according to button operation by the user. In other words, the direction of the ordinary display is set at an initial setup and, if necessary, the direction of the display may be changed by the user. In addition, in the case of a foldable electronic device, it is preferable to set at an initial setup so that the ordinary display is performed in an internal display region in the unfolded state and that the ordinary display is performed in an external display region in the folded state.

[0078] In addition, an acceleration sensor that senses inclination is provided, and a signal is supplied from the acceleration sensor. Based on the supplied signal, which one of four sides of the display region is the bottom is determined, and display may be switched based on the decision. This embodiment can be arbitrarily combined with the above-mentioned embodiment mode and embodiments.

Embodiment 7

[0079] A light-emitting element, which is one of the components of the present invention, corresponds to a lamination body of a first conductive layer, an electroluminescent layer, and a second conductive layer provided over a surface of a substrate having an insulating surface such as glass, quartz, metal or an organic matter, and having light-transmitting properties. The light-emitting element may be any one of a lamination type in which the electroluminescent layer is made from a plurality of layers, a single-layer type in which the electroluminescent layer is made from a single layer, or a mixed type in which the electroluminescent layer is made from a plurality of layers of which boundary is indefinite. In addition, as a laminated structure of the light-emitting layer, there are a sequentially laminated structure in which a conductive layer which corresponds to an anode/an electroluminescent layer/a conductive layer which corresponds to a cathode are laminated from the bottom, and a reversely laminated structure in which a conductive layer which corresponds to a cathode/an electroluminescent layer/a conductive layer which corresponds to an anode are laminated from the bottom. An appropriate structure may be selected depending on a conductivity type of a TFT that drives the light-emitting element or the direction of a current flown to the light-emitting element. Any one of organic materials (low molecular, middle molecular, and high molecular weight materials), inorganic materials, a singlet material, a triplet material, or a material in which one or a plurality of materials selected from the above four materials are combined may be used for the electroluminescent layer. Light emitted from the light-emitting element includes fluorescence and phosphorescence, and either or both are used for the display device of the invention. The light-emitting element provides a wide viewing angle and realizes a small-size, thin-shaped, and lightweight display device since a backlight is not necessary, moreover, is applicable to moving image. A display device that realizes sophistication and a high added value can be provided. This

embodiment can be arbitrarily combined with the above-mentioned embodiment mode and embodiments.

[0080] This application is based on Japanese Patent Application serial no. 2004-007387 filed in Japanese Patent Office on Jan. 14 2004, the contents of which are hereby incorporated by reference.

1. (canceled)
2. A device for displaying images comprising:
 - a first body comprising a display device; and
 - a second body comprising an input device,
 wherein the first body and the second body are connected each other and rotatable around an axis,
 - wherein the display device comprises a first substrate, a second substrate, an electroluminescent layer between the first substrate and the second substrate and a sealant,
 - wherein the first substrate and the second substrate have light-transmitting properties and are bonded to each other by the sealant,
 - wherein the display device is configured to display a first image from the first substrate and a second image from the second substrate, and
 - wherein the first image and the second image is configured to be determined and changeable by operating the input device.
3. The device for displaying images, according to claim 2, further comprising a color filter on one or both of the first substrate and the second substrate.
4. The device for displaying images, according to claim 2, further comprising a color conversion layer on one or both of the first substrate and the second substrate.
5. The device for displaying images, according to claim 2, selected from the group consisting of a television apparatus, a digital camera, a digital video camera, a cellular phone device, a portable information terminal, a portable game machine, a monitor, a personal computer, a tablet PC, an audio reproducing device, and an image reproducing device provided with a recording medium.
6. The device for displaying images, according to claim 2, the display device further comprising:
 - a pixel comprising a first sub-pixel having a first pixel electrode and a second sub-pixel having a second pixel electrode;
 - an opposite electrode overlapping with the first pixel electrode and the second pixel electrode with the electroluminescent layer interposed therebetween;
 - a first reflective layer;
 - a second reflective layer;
 - a first source driver which supplies a first video signal for the first sub-pixel; and
 - a second source driver which is different from the first source driver and supplies a second video signal for the second sub-pixel,
 wherein there is the opposite electrode between the first pixel electrode and the first reflective layer,
 - wherein there is the second reflective layer between the second pixel electrode and the first substrate, and
 - wherein the first pixel electrode, the second pixel electrode and the opposite electrode have light-transmitting properties.
7. The device for displaying images, according to claim 6, wherein the first sub-pixel and the second sub-pixel is configured to emit one of red, green, and blue light.

8. The device for displaying images, according to claim 6, wherein the first sub-pixel and the second sub-pixel is configured to emit white light.

9. The device for displaying images, according to claim 6, wherein the first source driver is connected to a first digital data line and the second source driver is connected to a second digital data line.

10. The device for displaying images, according to claim 6, wherein the first source driver is connected to a digital data line and the second source driver is connected to an analog data line.

11. The device for displaying images, according to claim 6, wherein the first source driver is connected to a first analog data line and the second source driver is connected to a second analog data line.

12. The device for displaying images, according to claim 2, the display device further comprising:

- a pixel comprising a first sub-pixel having a first pixel electrode and a second sub-pixel having a second pixel electrode;
- an opposite electrode overlapping with the first pixel electrode and the second pixel electrode with the electroluminescent layer interposed therebetween;
- a reflective layer;
- a first source driver which supplies a first video signal for the first sub-pixel; and

a second source driver which is different from the first source driver and supplies a second video signal for the second sub-pixel;

wherein there is the opposite electrode between the first pixel electrode and the reflective layer, wherein the second pixel electrode has reflectiveness, and wherein the first pixel electrode and the opposite electrode have light-transmitting properties.

13. The device for displaying images, according to claim 12, wherein the first sub-pixel and the second sub-pixel is configured to emit one of red, green, and blue light.

14. The device for displaying images, according to claim 12, wherein the first sub-pixel and the second sub-pixel is configured to emit white light.

15. The device for displaying images, according to claim 12, wherein the first source driver is connected to a first digital data line and the second source driver is connected to a second digital data line.

16. The device for displaying images, according to claim 12, wherein the first source driver is connected to a digital data line and the second source driver is connected to an analog data line.

17. The device for displaying images, according to claim 12, wherein the first source driver is connected to a first analog data line and the second source driver is connected to a second analog data line.

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