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(54) **DISPLAY PANEL, DISPLAY DEVICE, INPUT/OUTPUT DEVICE, AND DATA PROCESSING DEVICE**

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(73) Assignee: **Semiconductor Energy Laboratory Co., Ltd.**, Kanagawa-ken (JP)

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(30) **Foreign Application Priority Data**

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Publication Classification

(51) **Int. Cl.**

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G02F 1/1335	(2006.01)
G02F 1/1362	(2006.01)
G06F 3/041	(2006.01)

(52) **U.S. Cl.**

CPC ***G06F 3/044*** (2013.01); ***G02F 1/13338*** (2013.01); ***G02F 1/133526*** (2013.01); *G02F 1/1368* (2013.01); ***G02F 1/133345*** (2013.01); ***G02F 1/136286*** (2013.01); ***G06F 3/0416*** (2013.01); ***G02F 1/133553*** (2013.01)

(57) **ABSTRACT**

To provide a novel display panel with high convenience or high reliability. The display panel includes a pixel including a functional layer, a first display element, and a second display element. The functional layer includes a pixel circuit and includes a region positioned between the first and second display elements. The pixel circuit is electrically connected to the first and second display elements. The first display element includes a reflective film and is configured to control the intensity of light reflected by the reflective film. The reflective film has a shape that does not block light emitted from the second display element. The second display element includes a light-emitting element and is provided such that display using the second display element can be seen from part of a region where display using the first display element can be seen.

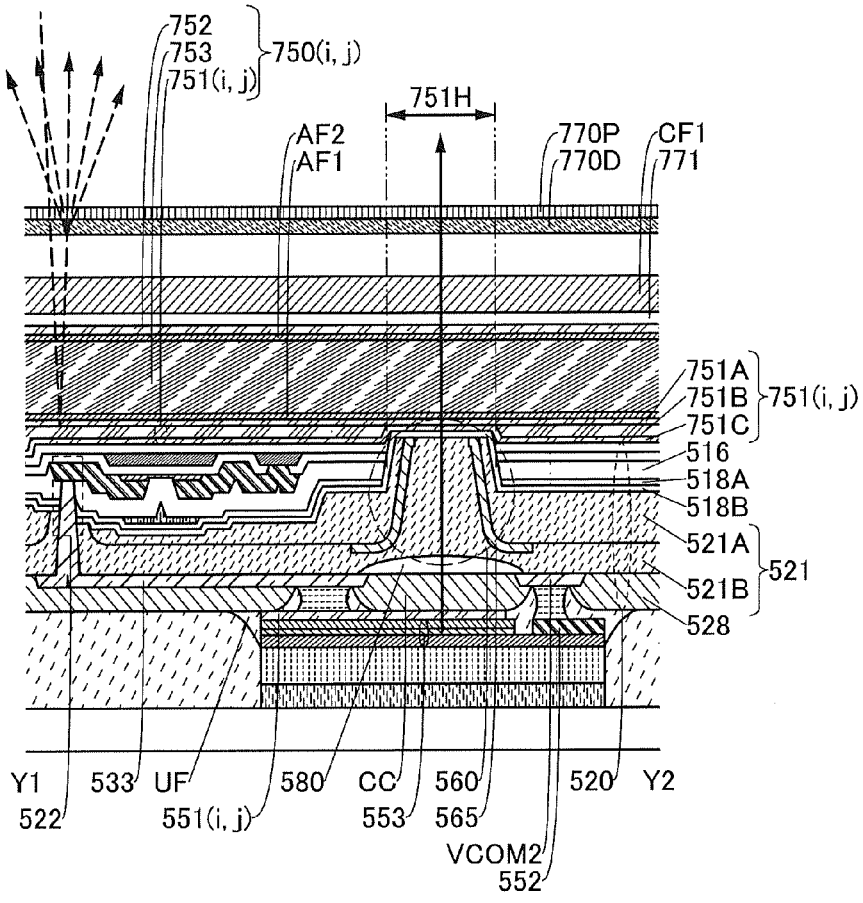


FIG. 1A

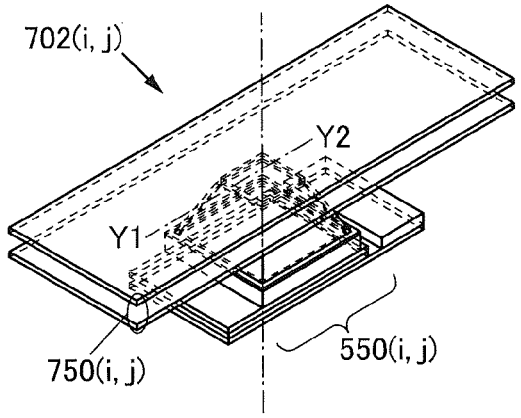


FIG. 1B

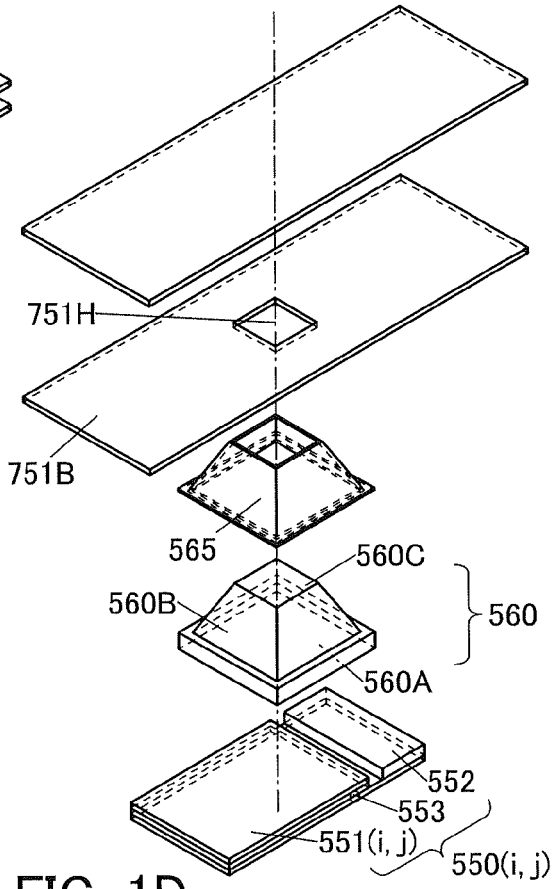


FIG. 1C

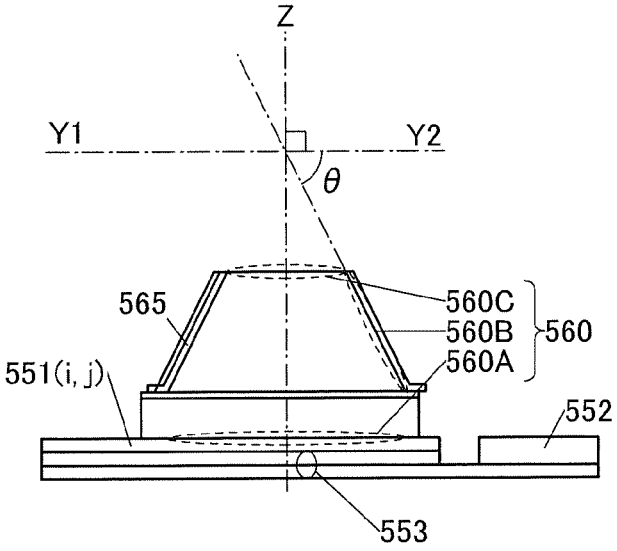


FIG. 1D

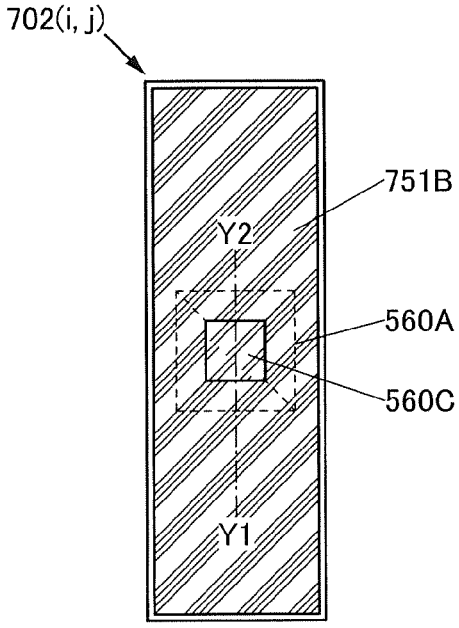


FIG. 2A

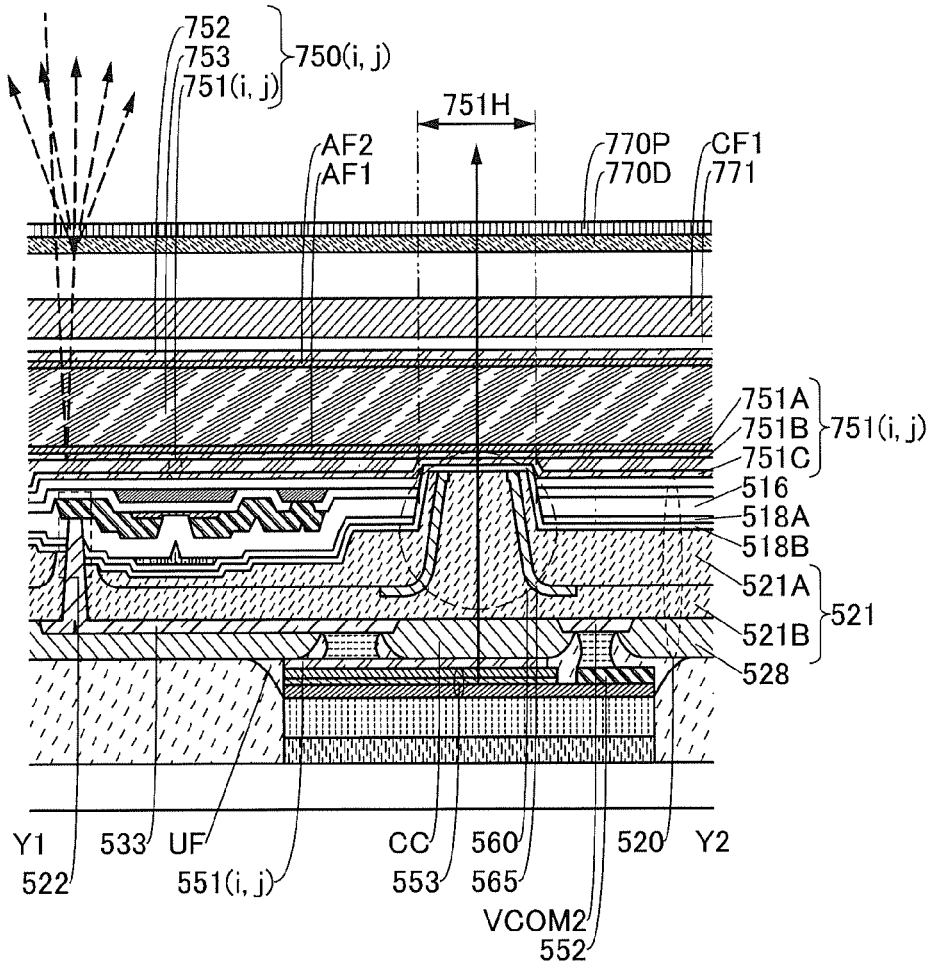

752
753
751(i, j)
750(i, j)
751H
AF2
AF1
770P
770D
CF1
771
751A
751B
751C
751(i, j)
516
518A
518B
521A
521B
521
528
Y1
522
533
UF
551(i, j)
CC
553
560
565
520
Y2
VCOM2
552

FIG. 2B

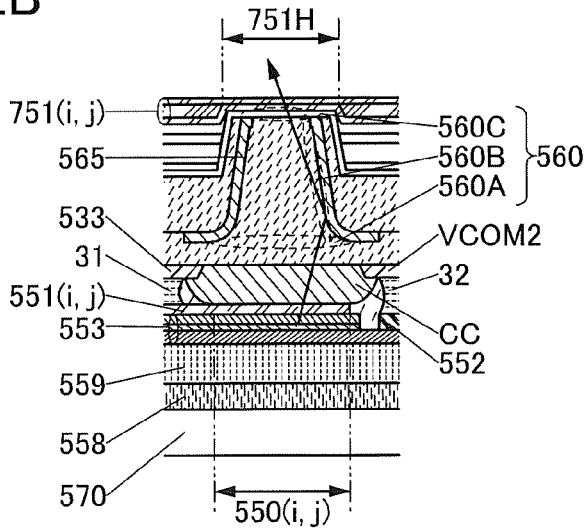

751H
751(i, j)
565
533
31
551(i, j)
553
559
558
570
560C
560B
560A
560
VCOM2
32
CC
552
550(i, j)

FIG. 3A

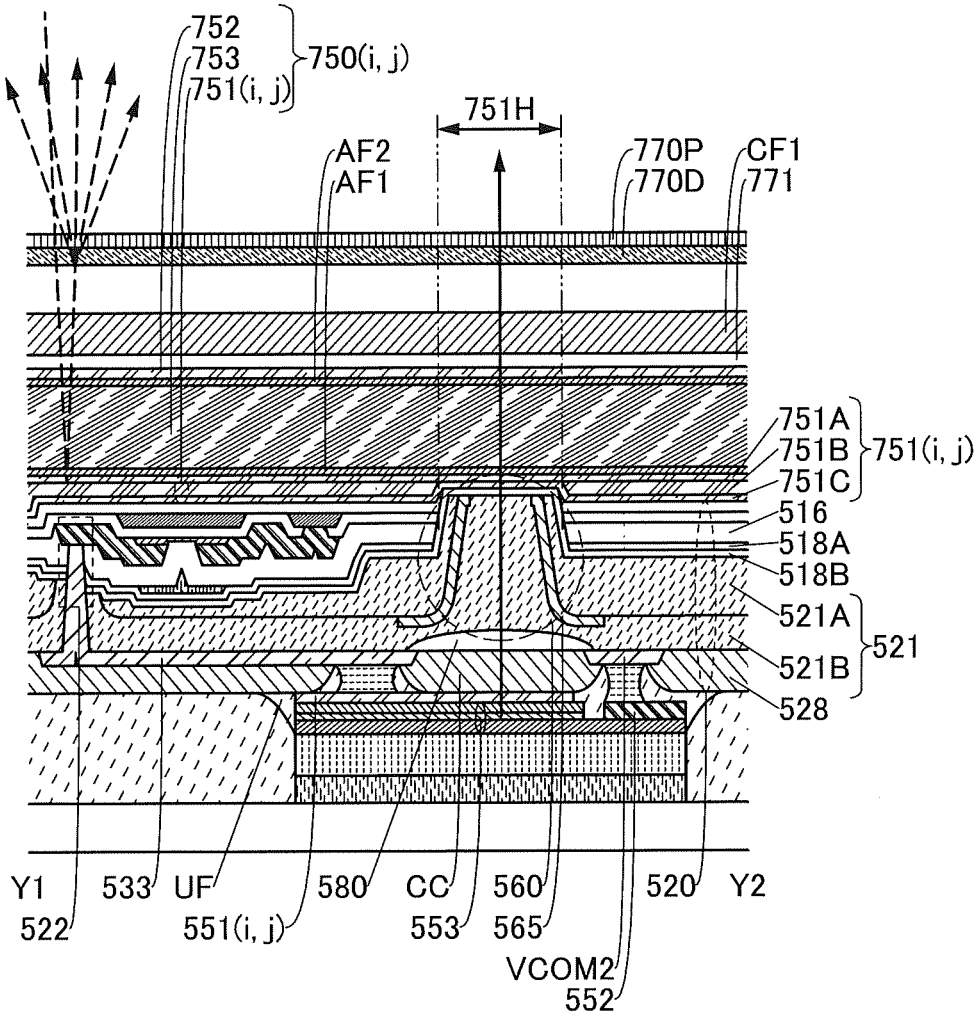

752
753
751(i, j)
750(i, j)
751H
AF2
AF1
770P
770D
CF1
771
751A
751B
751C
751(i, j)
516
518A
518B
521A
521B
521
528
Y1
522
533
UF
551(i, j)
580
CC
553
560
565
520
Y2
VCOM2
552

FIG. 3B

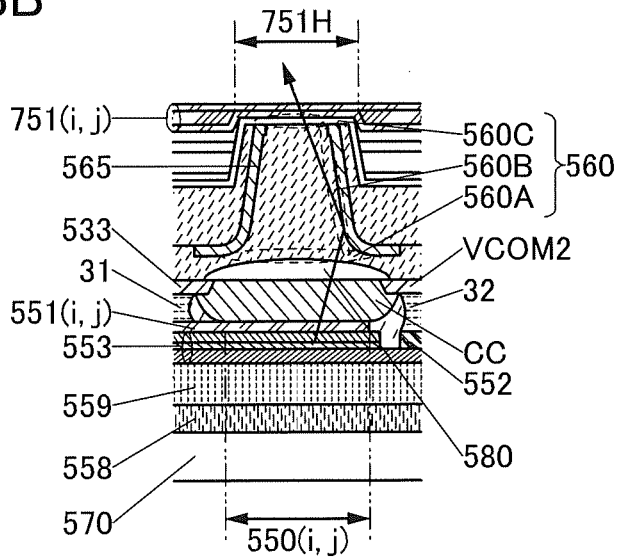

751H
751(i, j)
565
533
31
551(i, j)
553
559
558
570
560C
560B
560A
560
VCOM2
32
CC
552
580
550(i, j)

FIG. 4A

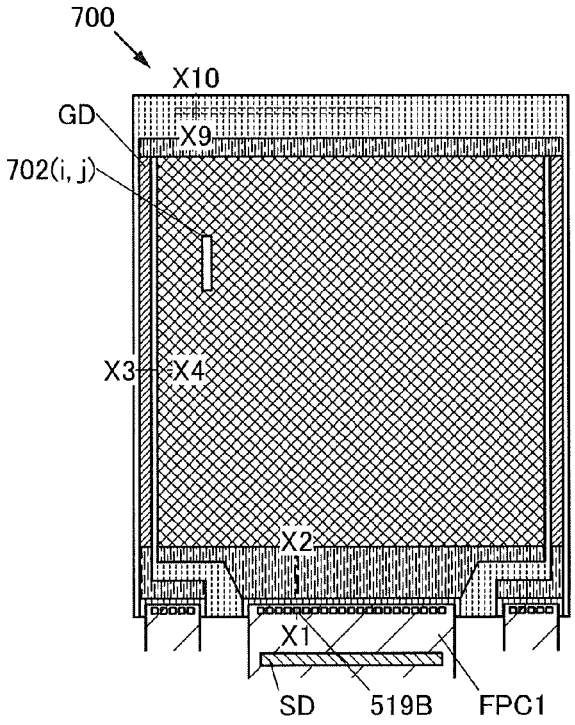


FIG. 4B

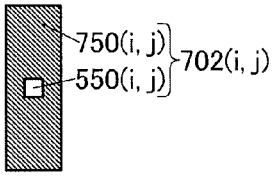


FIG. 4C

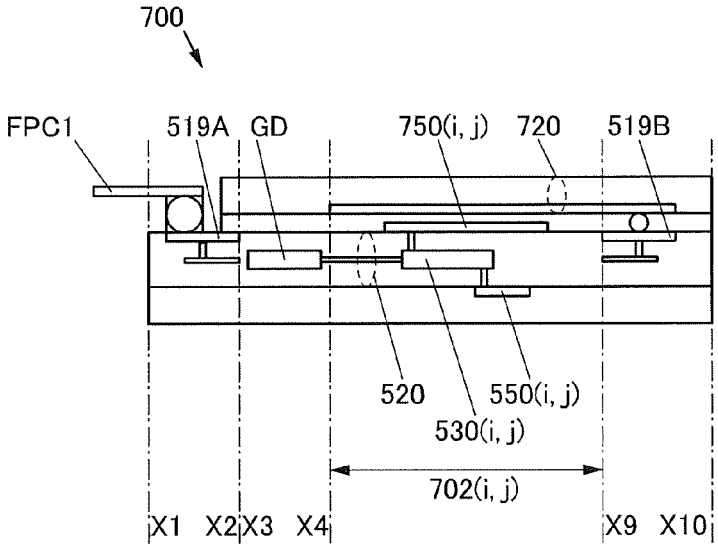


FIG. 5A

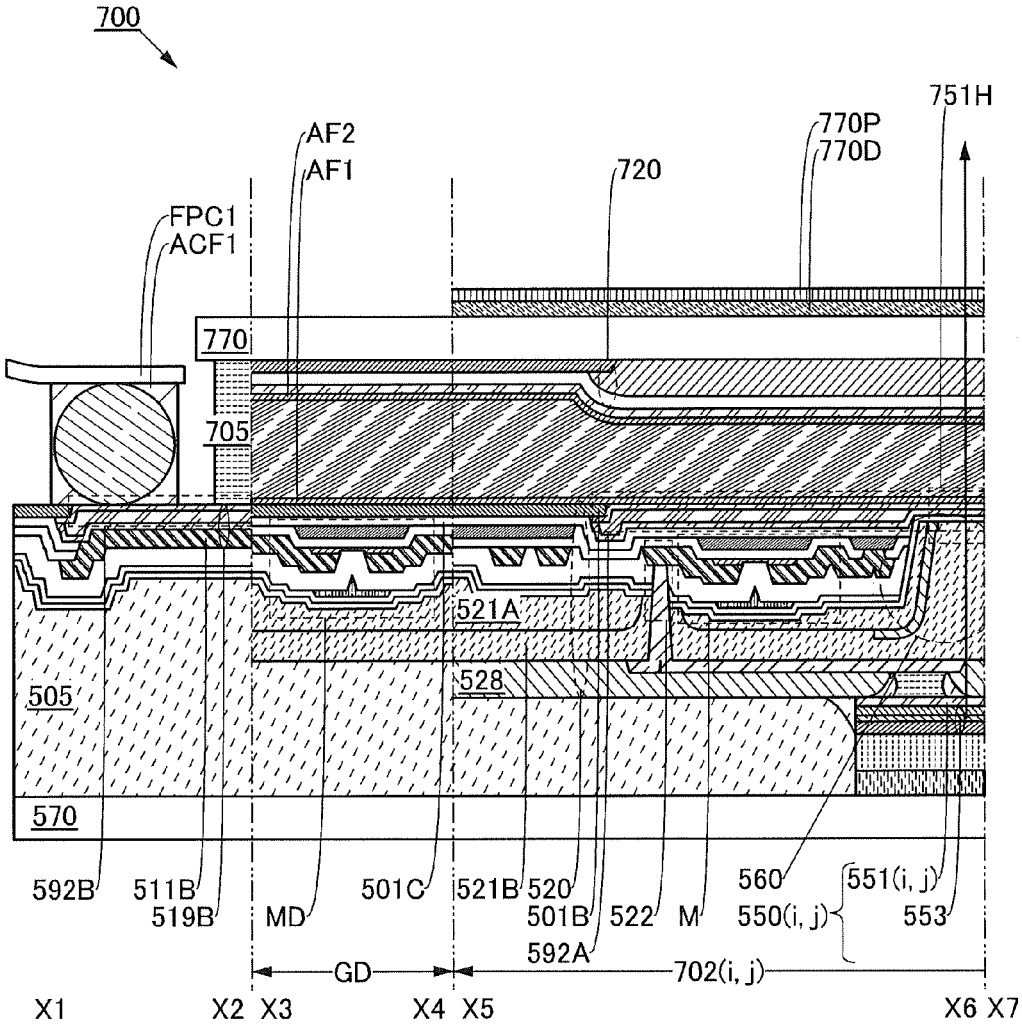

700
751H
AF2
AF1
770P
770D
720
FPC1
ACF1
770
705
521A
528
505
570
592B
511B
519B
MD
501C
521B
520
501B
592A
522
M
560
550(i, j)
551(i, j)
553
GD
702(i, j)
X1
X2
X3
X4
X5
X6
X7

FIG. 5B

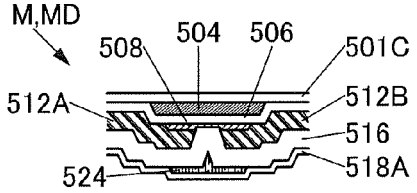

M,MD
508
504
506
501C
512A
512B
516
524
518A

FIG. 6A

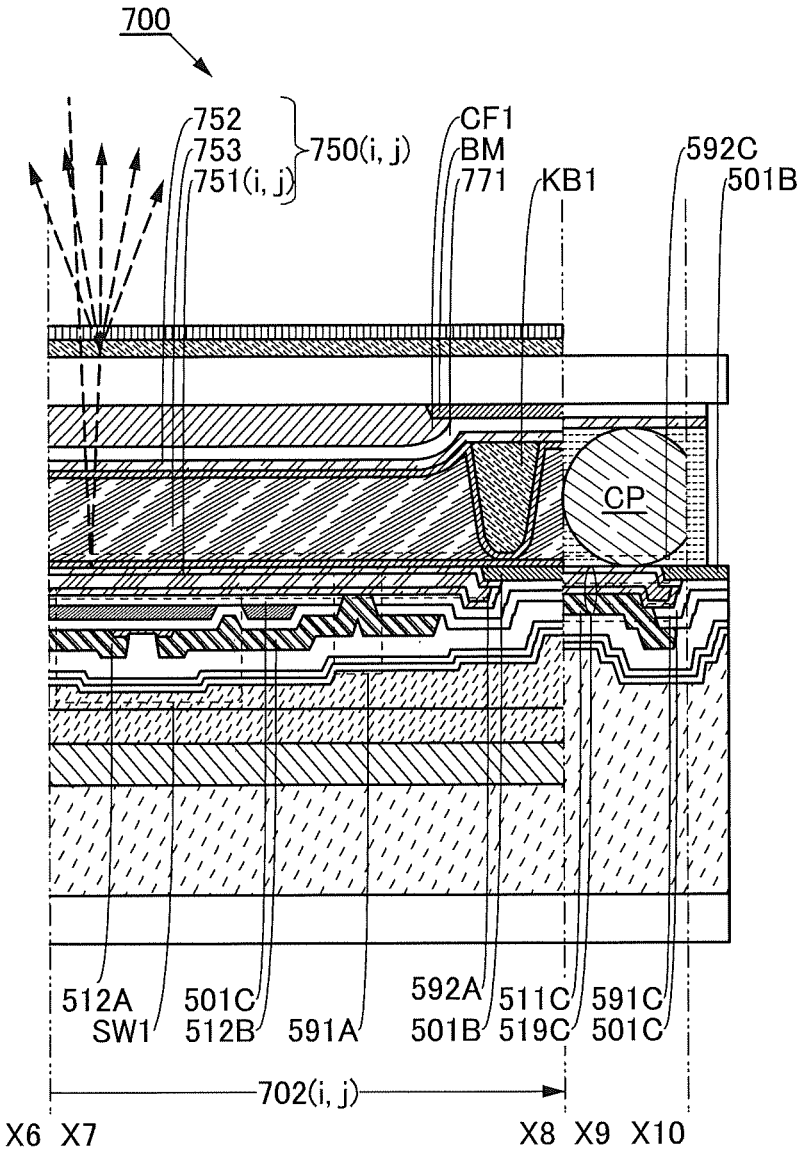

700
752
753
751(i, j)
750(i, j)
CF1
BM
771
KB1
592C
501B
CP
512A
SW1
501C
512B
591A
592A
501B
511C
519C
591C
501C
702(i, j)
X6
X7
X8
X9
X10

FIG. 6B

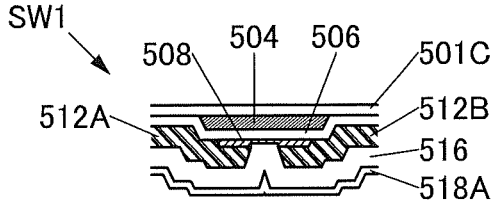

SW1
508
504
506
501C
512A
512B
516
518A

FIG. 7

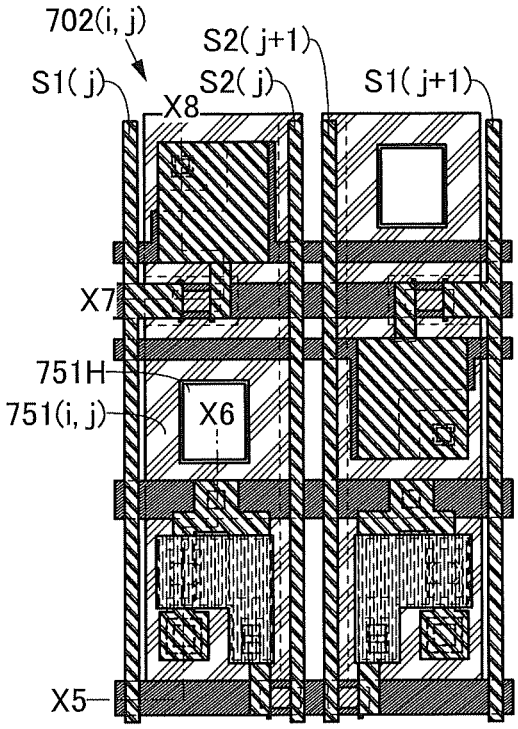


FIG. 8

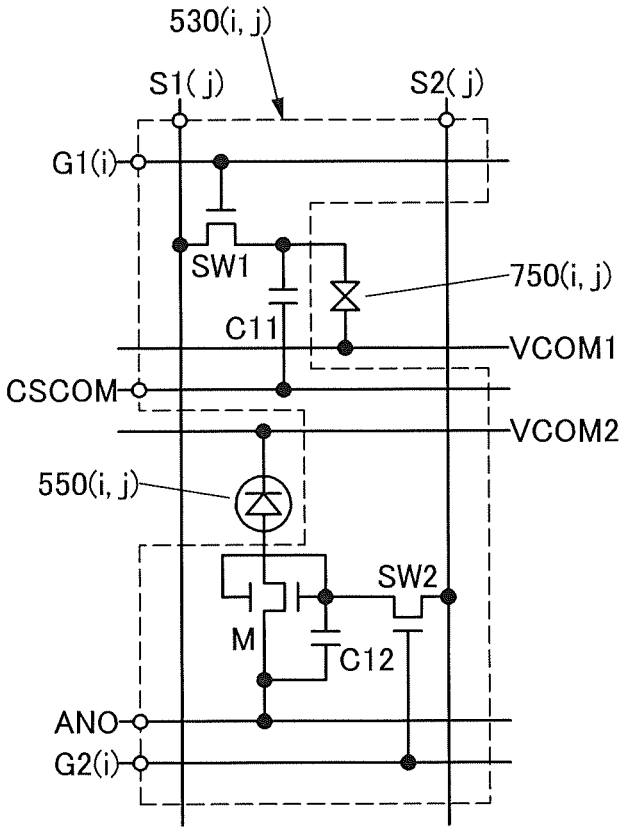

530(i, j)
S1(j)
S2(j)
G1(i)
SW1
750(i, j)
C11
VCOM1
CSCOM
VCOM2
550(i, j)
SW2
M
C12
ANO
G2(i)

FIG. 9A

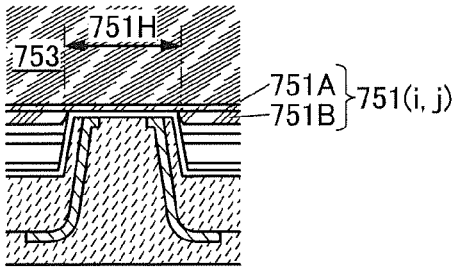


FIG. 9B

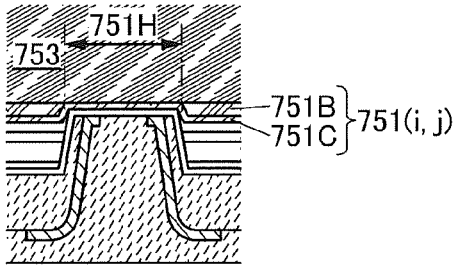


FIG. 9C

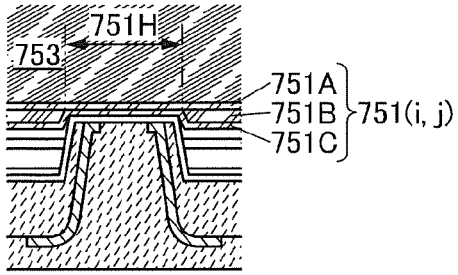


FIG. 9D

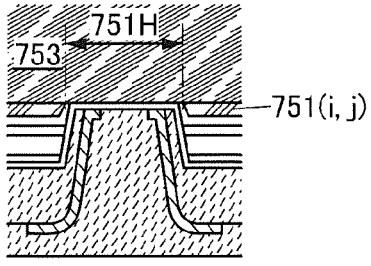


FIG. 10A

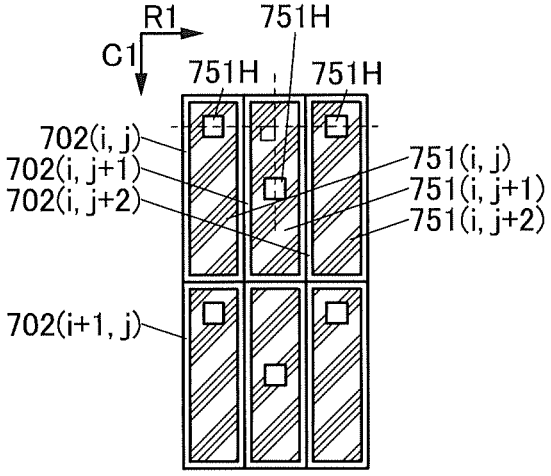


FIG. 10B

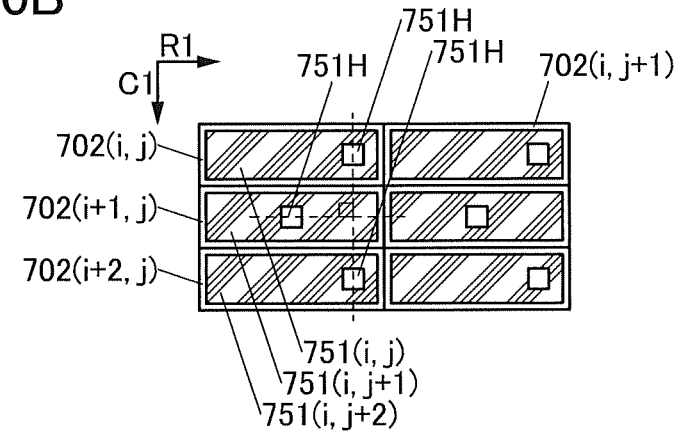


FIG. 10C

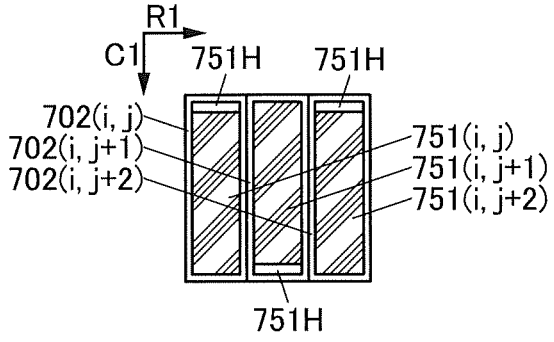


FIG. 11

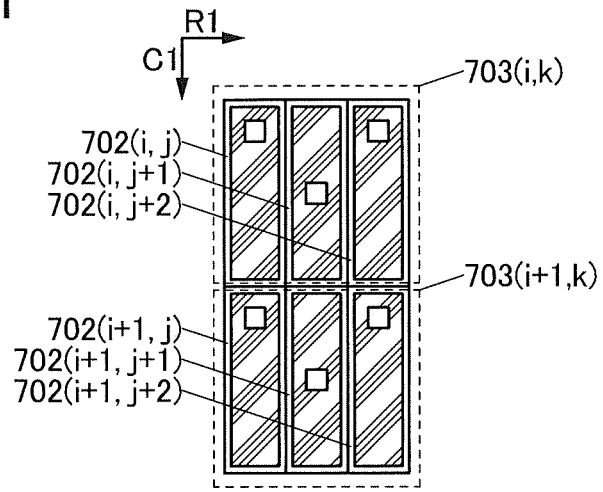

R1
C1
703(i,k)
702(i, j)
702(i, j+1)
702(i, j+2)
703(i+1,k)
702(i+1, j)
702(i+1, j+1)
702(i+1, j+2)

FIG. 12A1

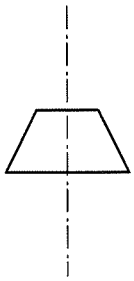


FIG. 12B1

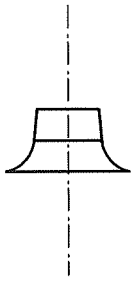


FIG. 12C1

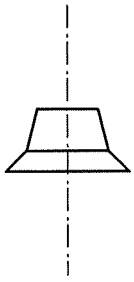


FIG. 12A2

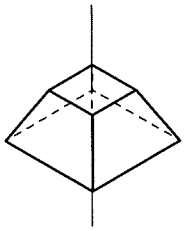


FIG. 12B2

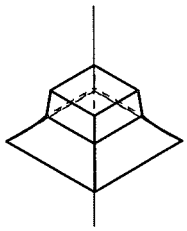


FIG. 12C2

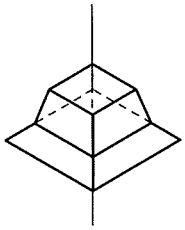


FIG. 12D1

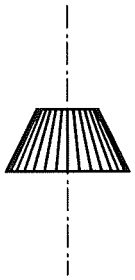


FIG. 12E1

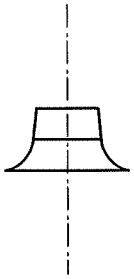


FIG. 12F1

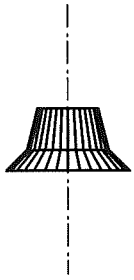


FIG. 12D2

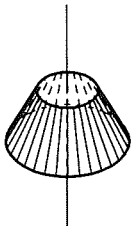


FIG. 12E2

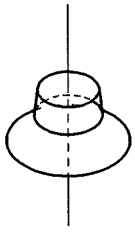


FIG. 12F2

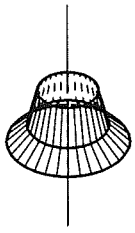


FIG. 13A

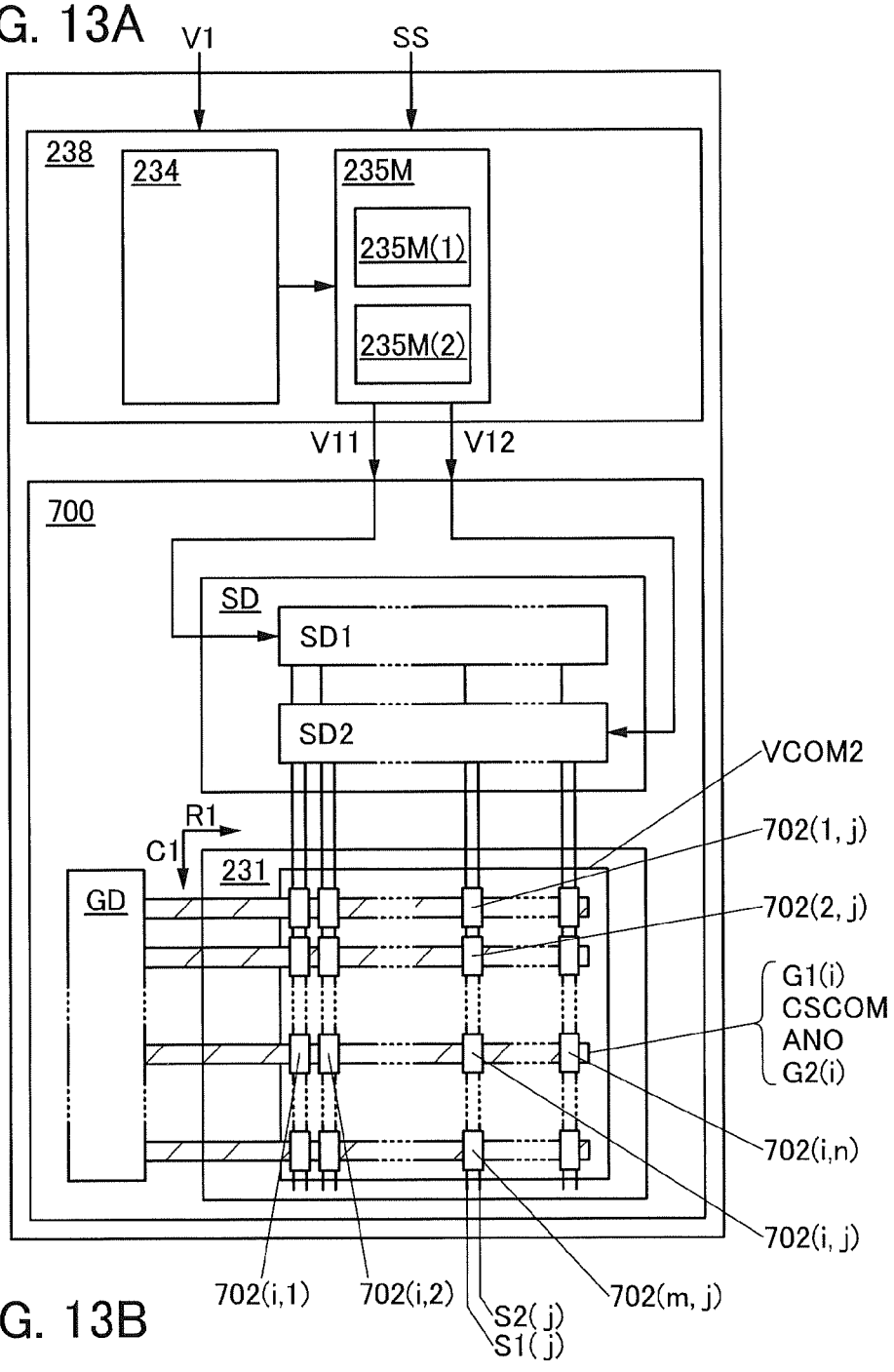


FIG. 13B

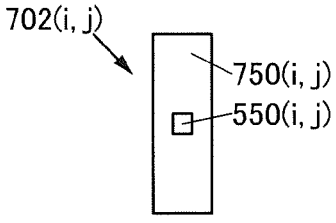


FIG. 14A

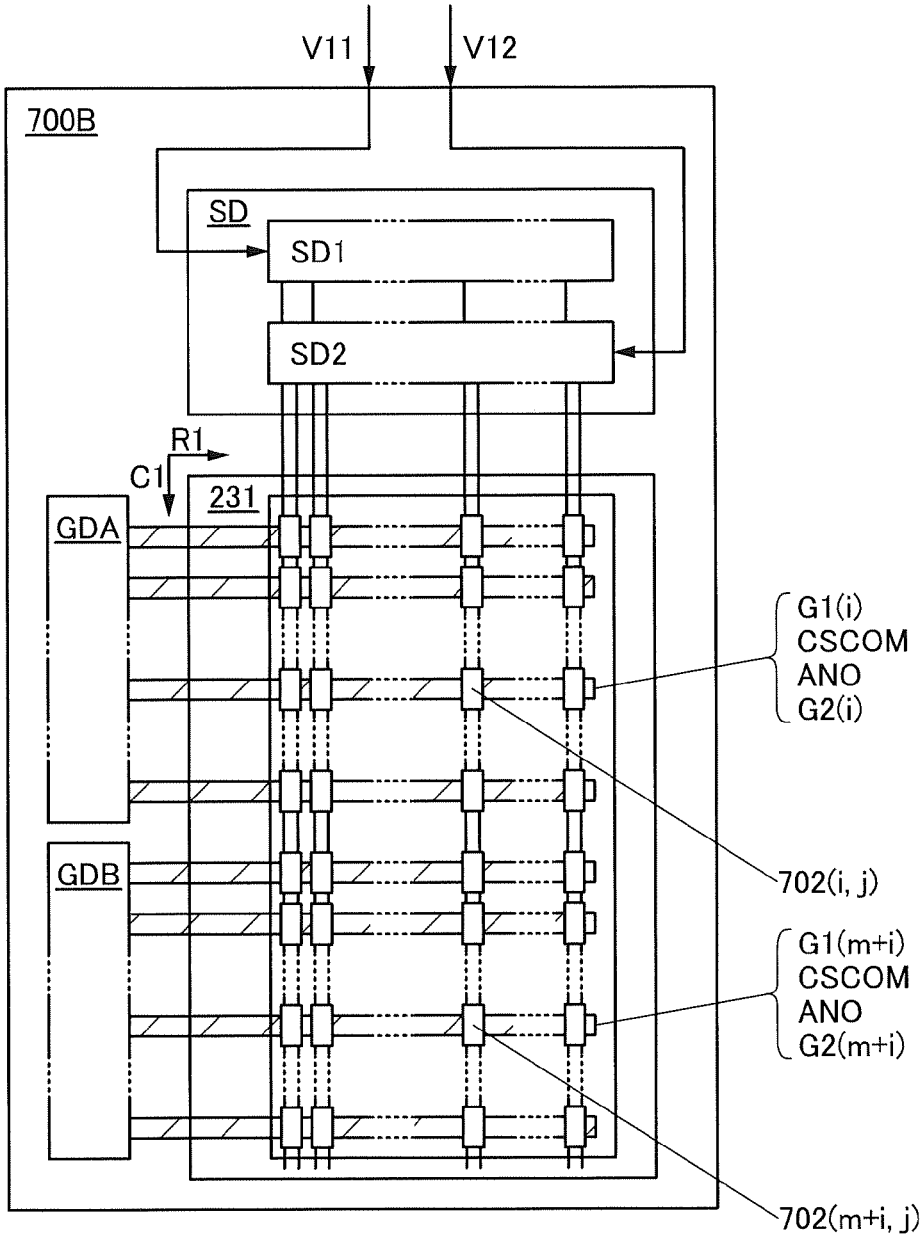


FIG. 14B-1

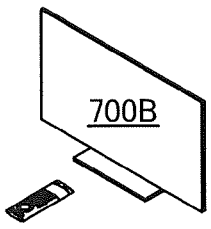


FIG. 14B-2

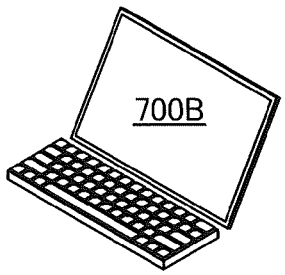


FIG. 14B-3

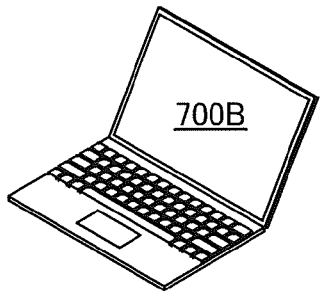


FIG. 15

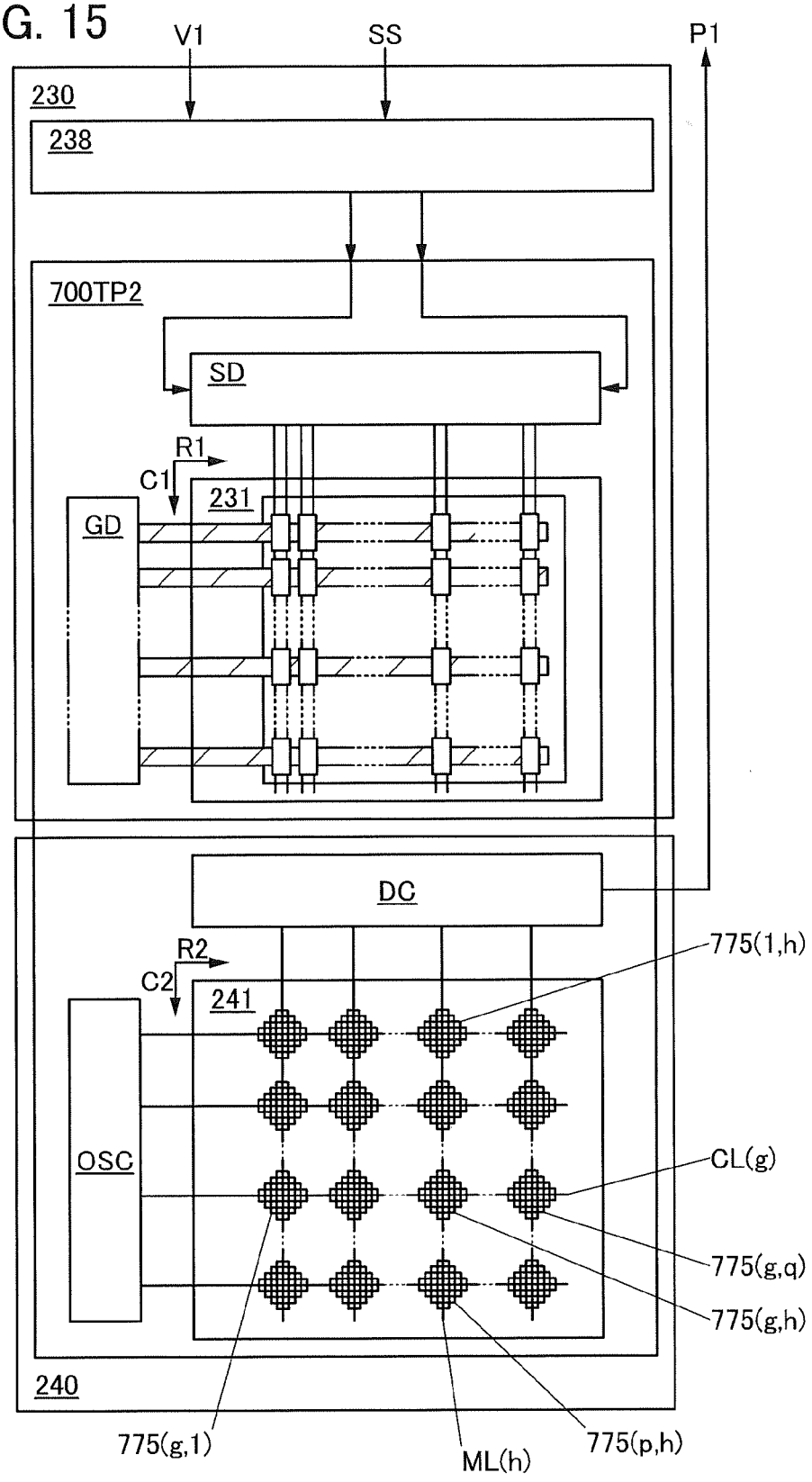

V1
SS
P1
230
238
700TP2
SD
R1
C1
231
GD
DC
R2
C2
241
OSC
240
775(1,h)
CL(g)
775(g,q)
775(g,h)
775(g,1)
ML(h)
775(p,h)

FIG. 16A

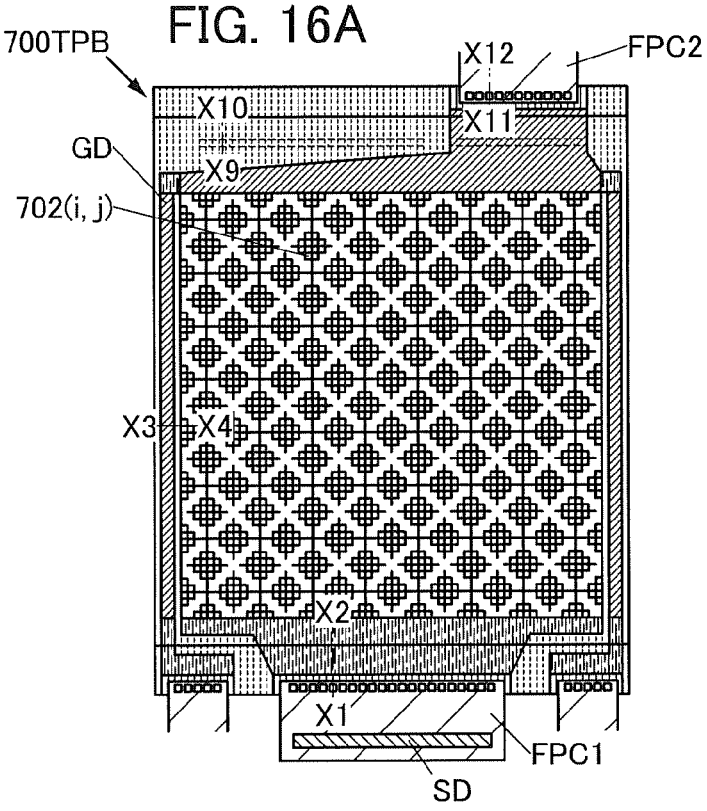


FIG. 16B

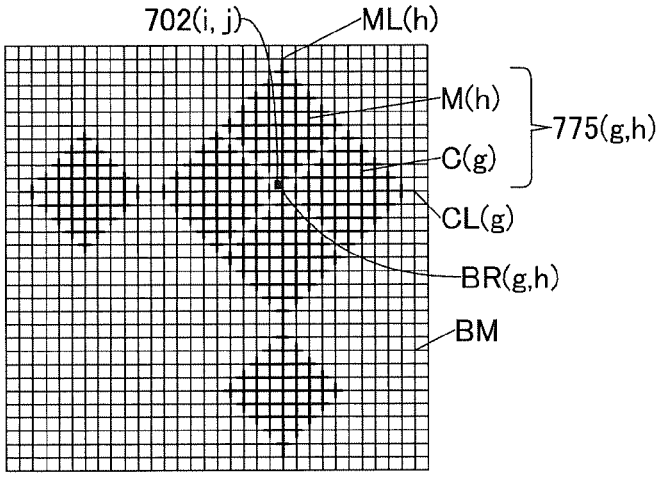


FIG. 16C

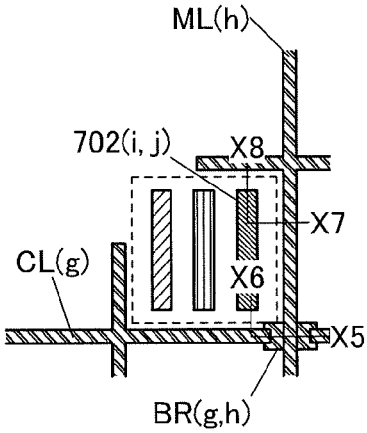


FIG. 17A

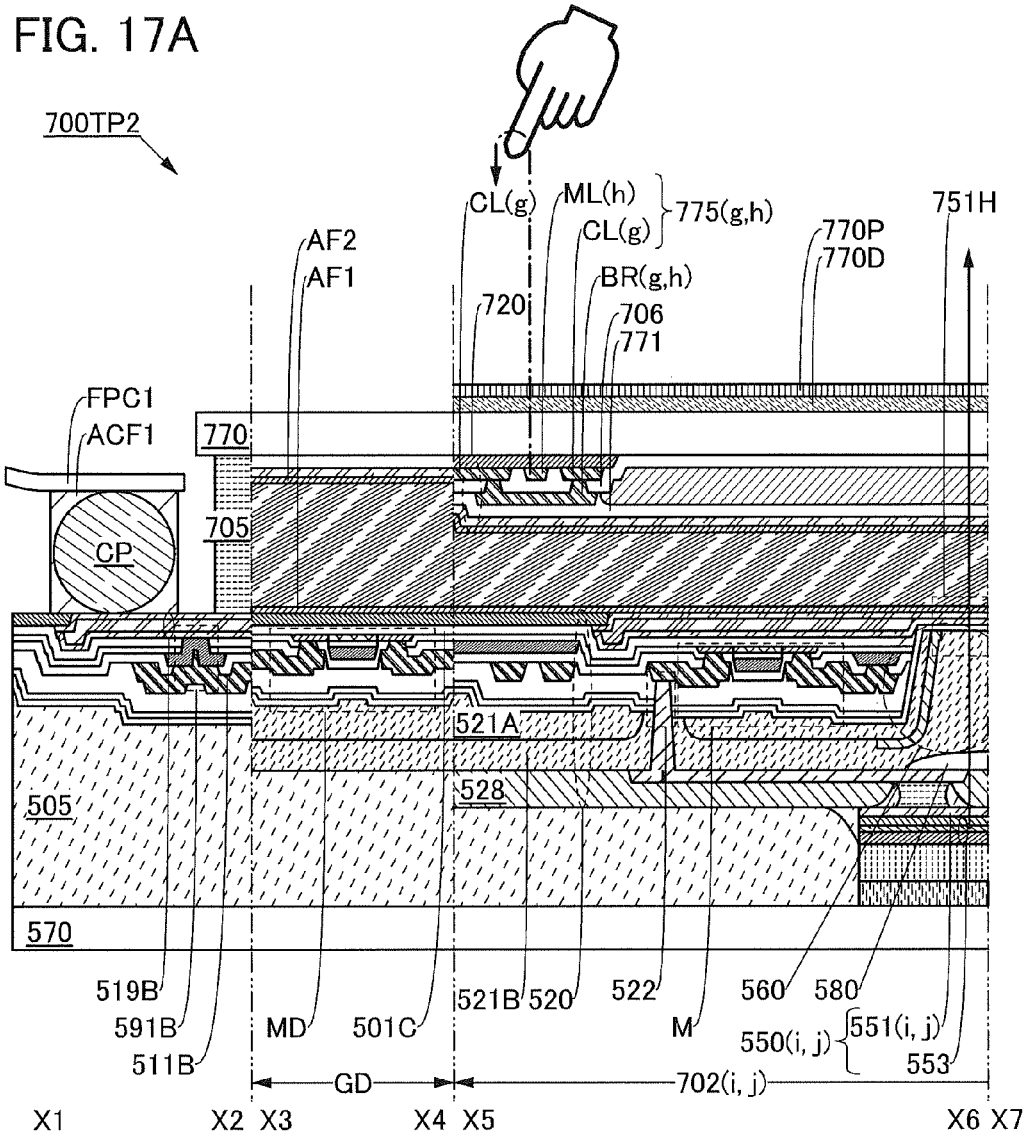


FIG. 17B

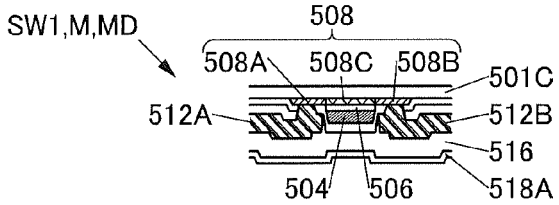


FIG. 18

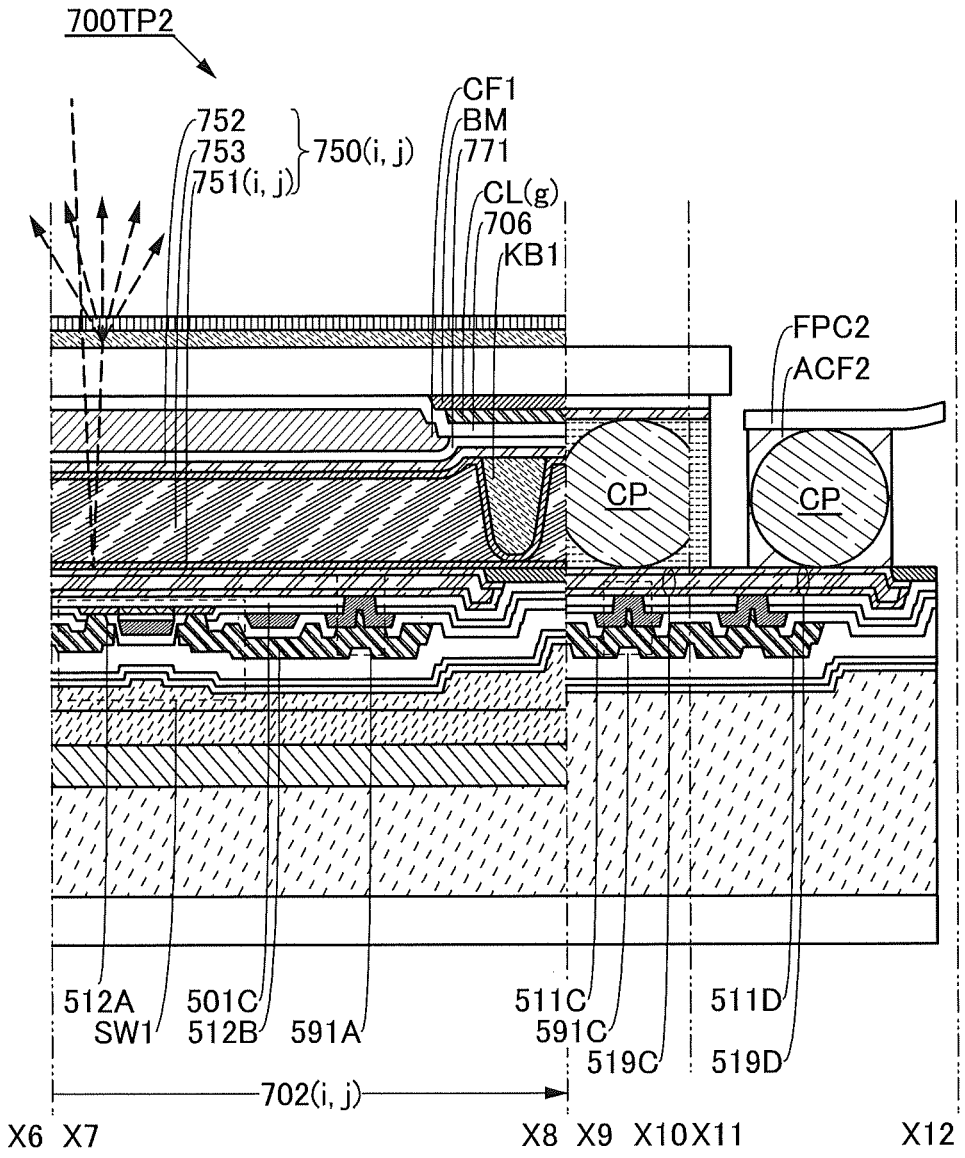

700TP2
752
753
751(i, j)
750(i, j)
CF1
BM
771
CL(g)
706
KB1
FPC2
ACF2
CP
CP
512A
SW1
501C
512B
591A
511C
591C
519C
511D
519D
702(i, j)
X6
X7
X8
X9
X10
X11
X12

FIG. 19

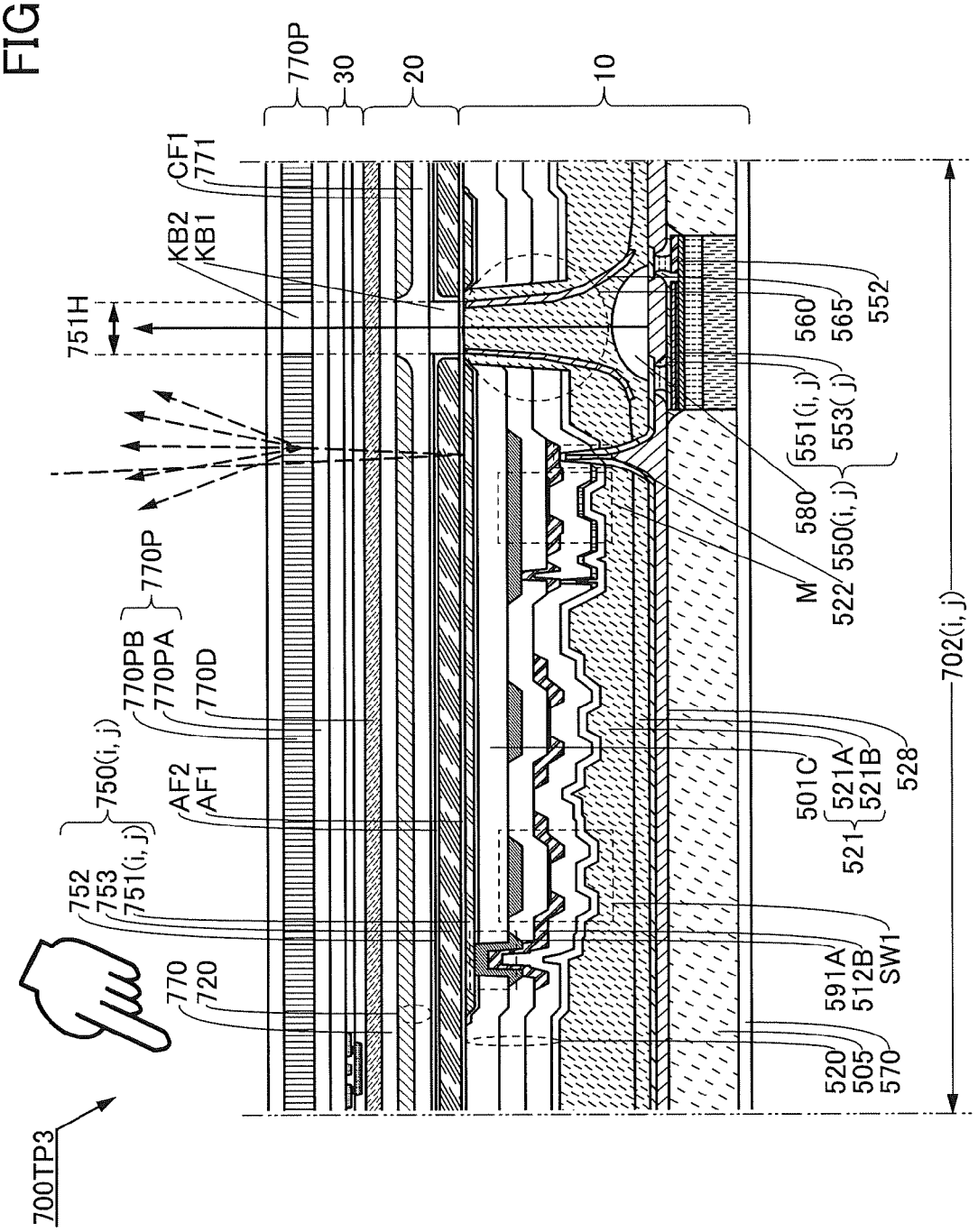

770P
30
20
10
CF1
771
KB2
KB1
751H
552
560
565
551(i, j)
553(j)
580
550(i, j)
M
522
770P
770PB
770PA
770D
750(i, j)
AF2
AF1
752
753
751(i, j)
501C
521A
521B
528
521
770
720
591A
512B
SW1
520
505
570
702(i, j)
700TP3

FIG. 20A

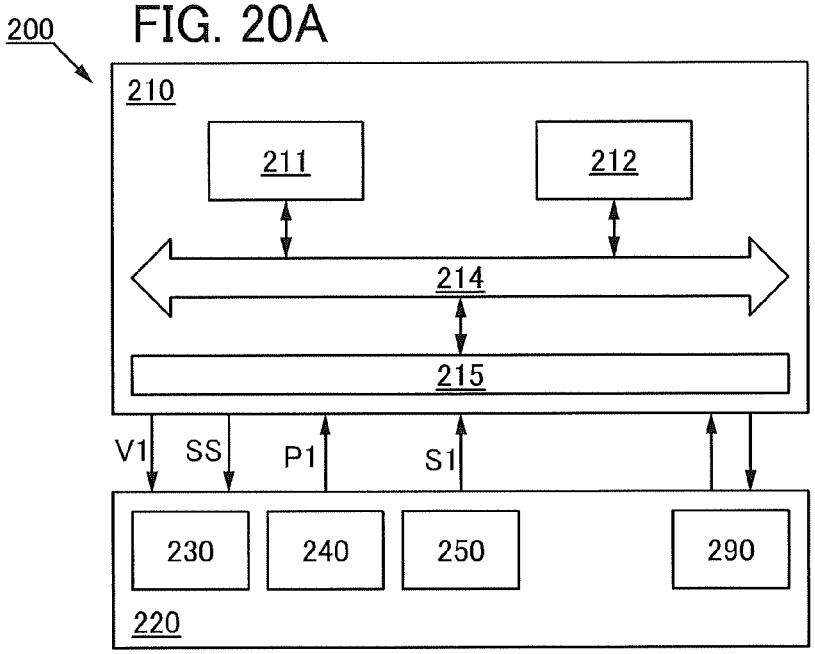


FIG. 20B

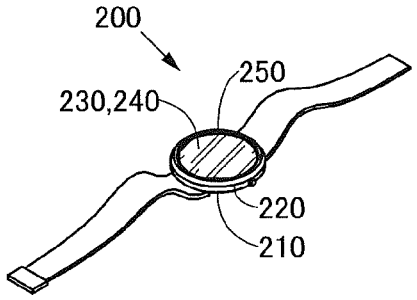


FIG. 20C

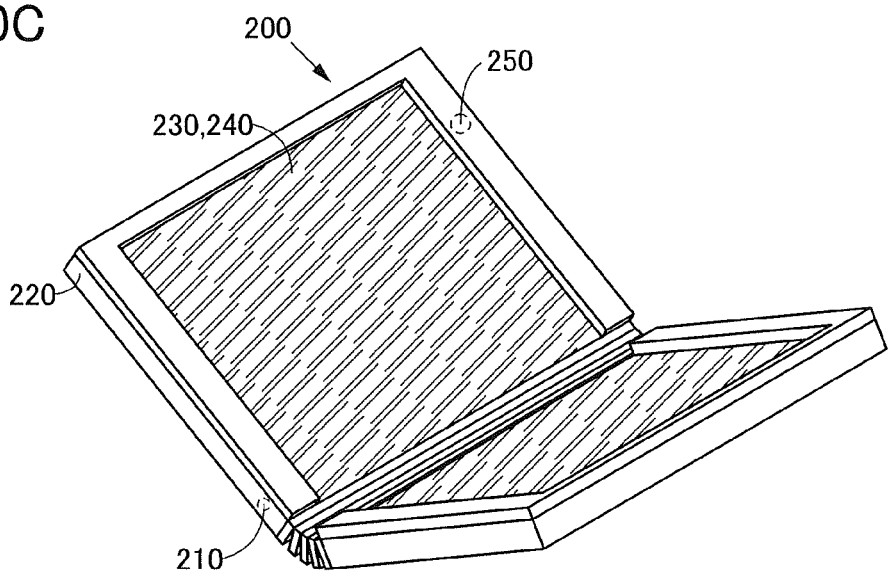


FIG. 21A

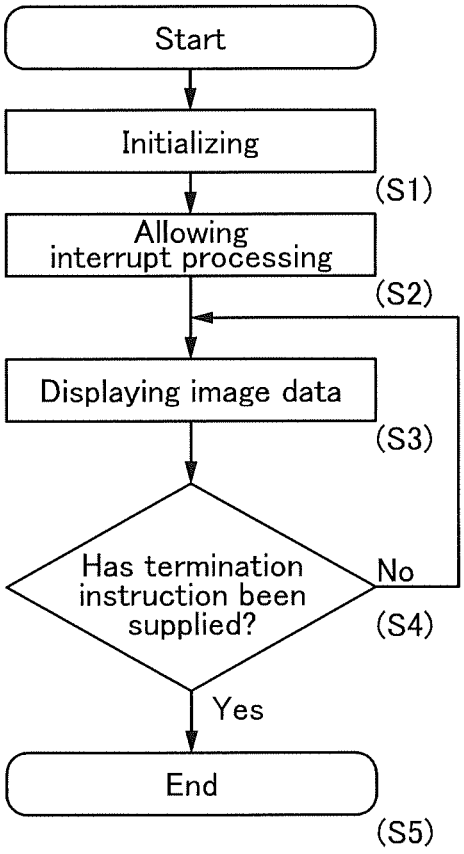


FIG. 21B

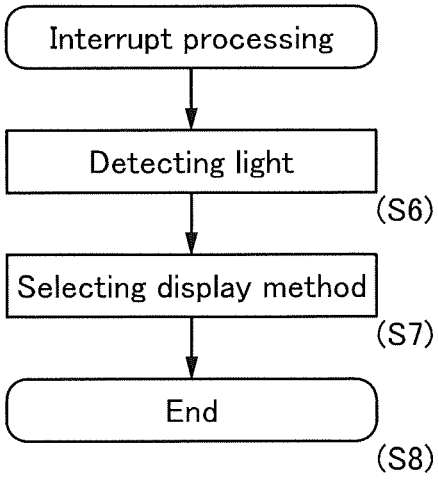


FIG. 22

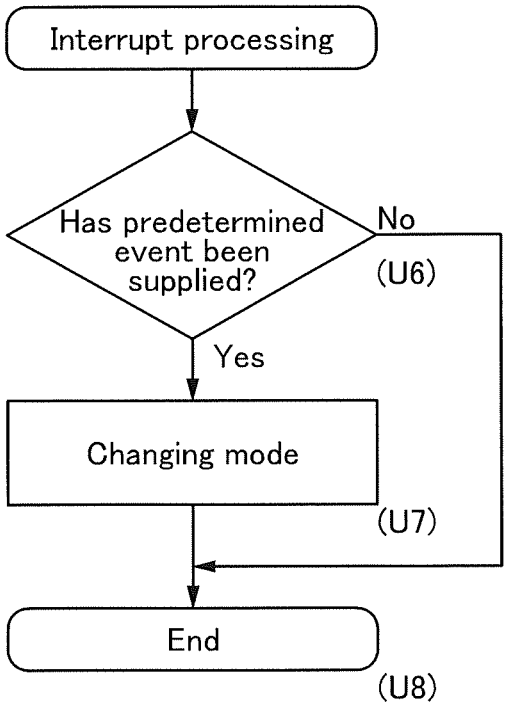

Interrupt processing
Has predetermined event been supplied?
No
(U6)
Yes
Changing mode
(U7)
End
(U8)

FIG. 23A

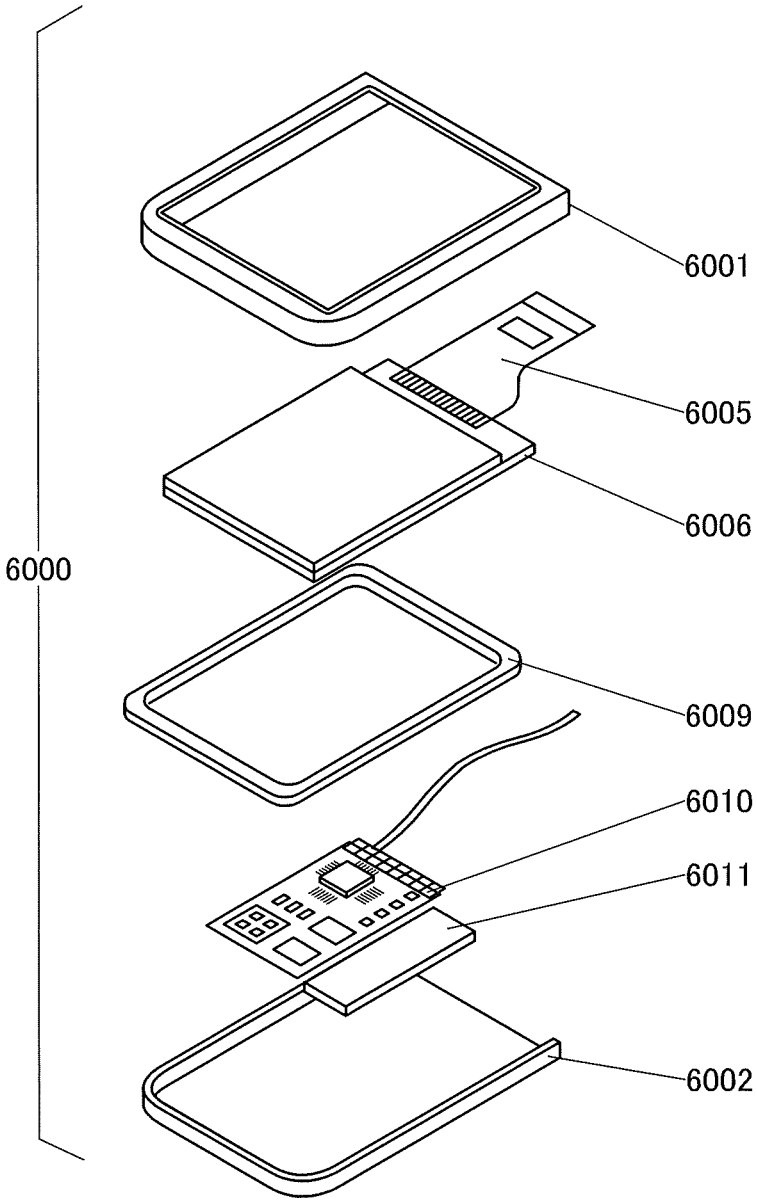


FIG. 23B

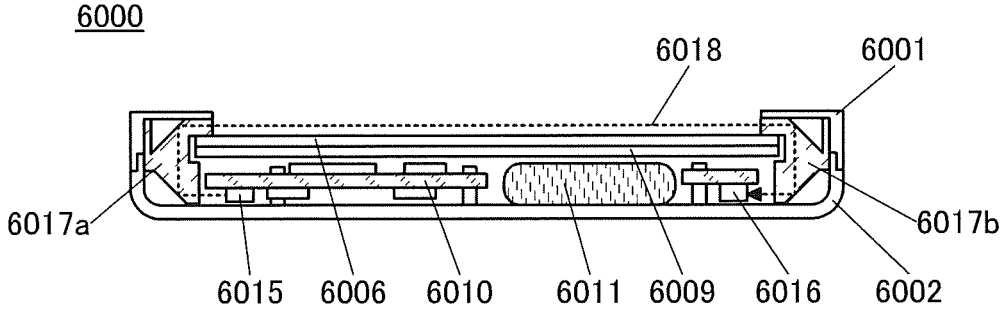


FIG. 24A

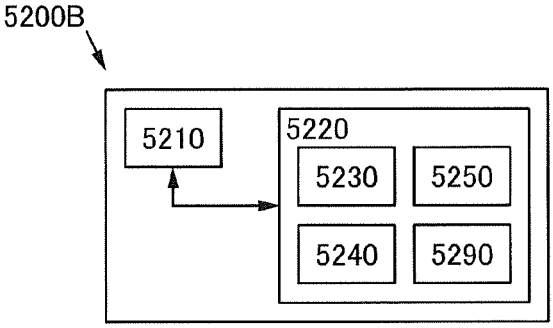


FIG. 24B

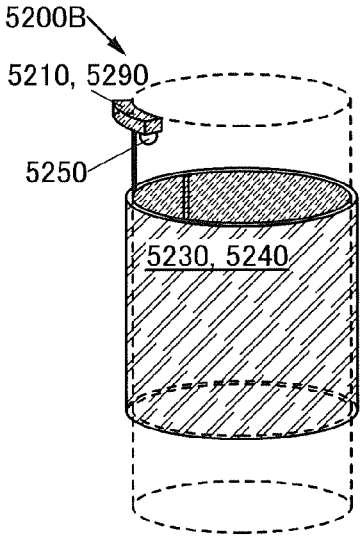


FIG. 24C

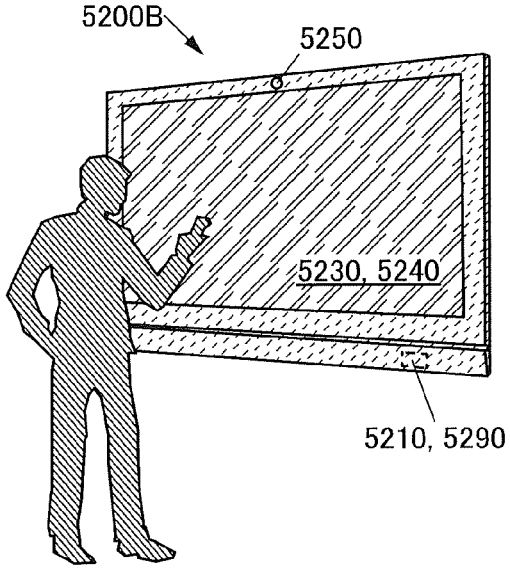


FIG. 24D

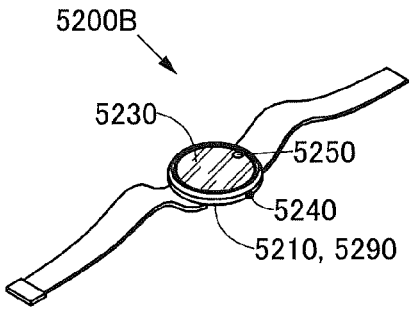


FIG. 24E

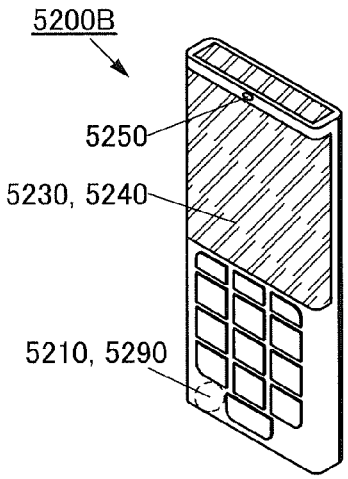


FIG. 25A

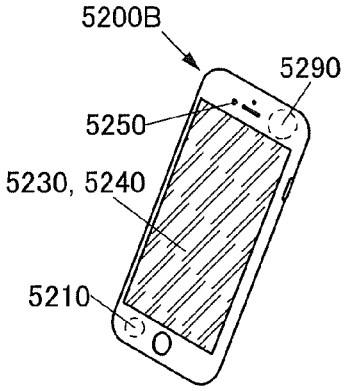


FIG. 25B

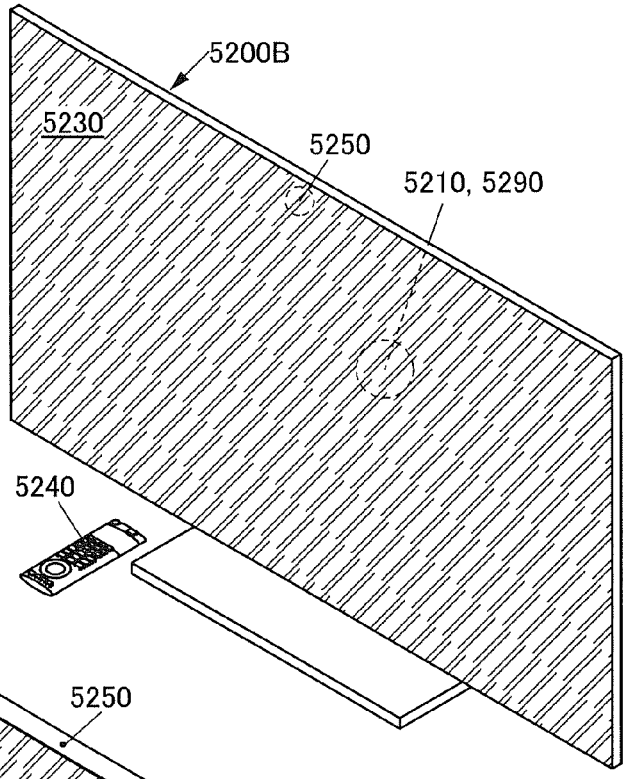


FIG. 25C

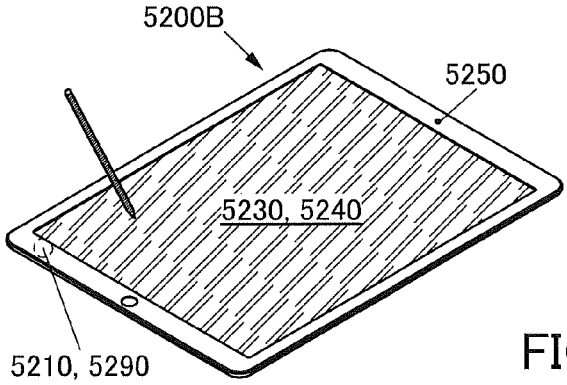


FIG. 25D

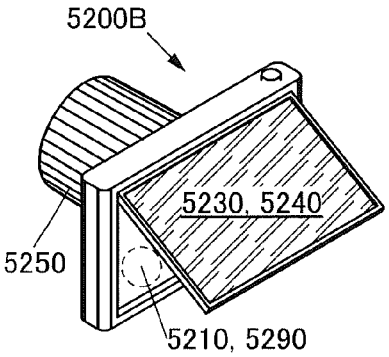


FIG. 25E

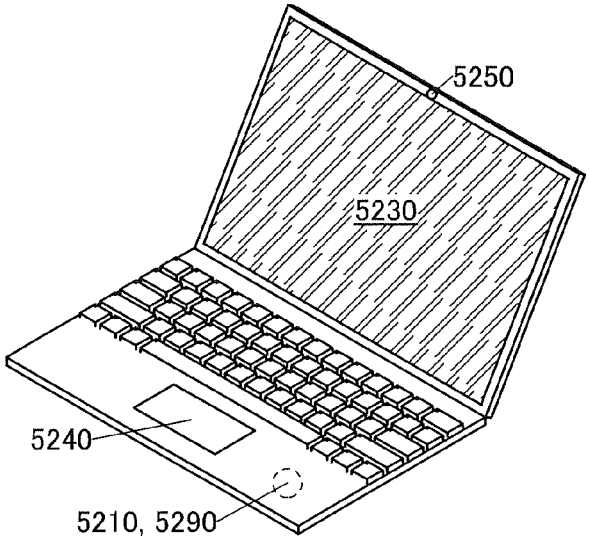


FIG. 26A

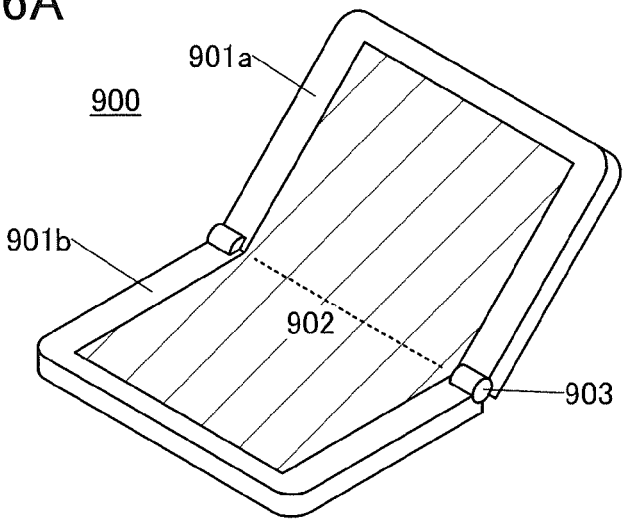


FIG. 26B

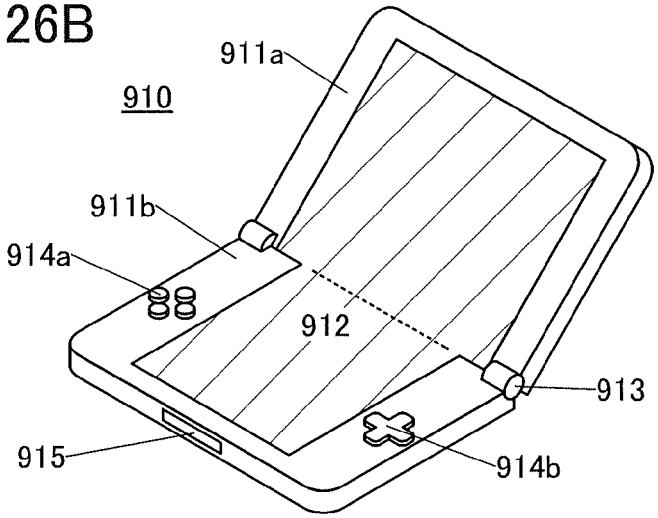
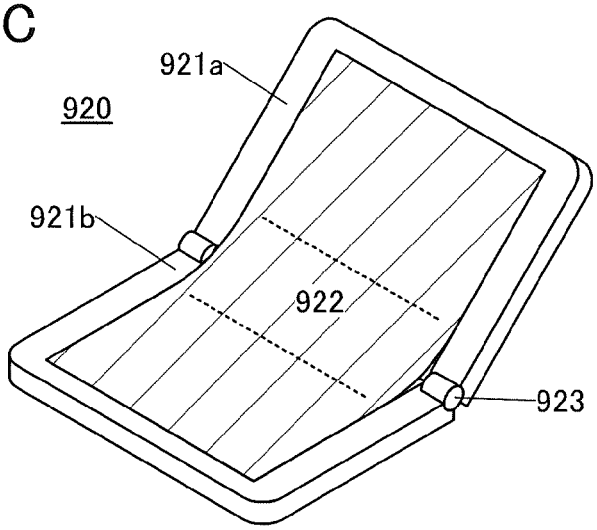


FIG. 26C



DISPLAY PANEL, DISPLAY DEVICE, INPUT/OUTPUT DEVICE, AND DATA PROCESSING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] Embodiments of the present invention relate to a display panel, a display device, an input/output device, and a data processing device.

[0002] Note that one embodiment of the present invention is not limited to the above technical field. The technical field of one embodiment of the invention disclosed in this specification and the like relates to an object, a method, or a manufacturing method. One embodiment of the present invention relates to a process, a machine, manufacture, or a composition of matter. Specifically, examples of the technical field of one embodiment of the present invention disclosed in this specification include a semiconductor device, a display device, a light-emitting device, a power storage device, a memory device, a method for driving any of them, and a method for manufacturing any of them.

2. Description of the Related Art

[0003] The following liquid crystal display devices are known: a liquid crystal display device in which a light-condensing means and a pixel electrode are provided on the same surface side of a substrate and a region transmitting visible light in the pixel electrode is provided to overlap with an optical axis of the light-condensing means; and a liquid crystal display device that includes an anisotropic light-condensing means having a condensing direction X and a non-condensing direction Y that is along the longitudinal direction of a region transmitting visible light in the pixel electrode (Patent Document 1).

[0004] The structure is known in which a region that reflects incident light through a liquid crystal layer to perform display (reflective region) and a region through which light from a backlight passes to perform display (transmissive region) are provided in one pixel, and an image can be displayed in both modes: the reflective mode where external light is used as an illumination light source; and the transmissive mode where the backlight is used as an illumination light source (Patent Document 2). In addition, two transistors connected to respective pixel electrode layers are provided in one pixel, and the two transistors are separately operated, whereby display in the reflective region and display in the transmissive region can be controlled independently.

REFERENCE

[0005] [Patent Document]

[0006] [Patent Document 1] Japanese Published Patent Application No. 2011-191750

[0007] [Patent Document 2] Japanese Published Patent Application No. 2011-154356

SUMMARY OF THE INVENTION

[0008] An object of one embodiment of the present invention is to provide a novel display panel with high convenience or high reliability. Another object is to provide a novel display device with high convenience or high reliability. Another object is to provide a novel input/output device with high convenience or high reliability. Another object is to provide a novel data processing device with high convenience or high reliability. Another object is to provide a novel display panel, a novel display device, a novel input/output device, a novel data processing device, or a novel semiconductor device.

[0009] Note that the description of these objects does not disturb the existence of other objects. In one embodiment of the present invention, there is no need to achieve all the objects. Other objects will be apparent from and can be derived from the description of the specification, the drawings, the claims, and the like.

[0010] (1) One embodiment of the present invention is a display panel including a pixel.

[0011] The pixel includes a functional layer, a first display element, and a second display element.

[0012] The functional layer includes a pixel circuit and includes a region positioned between the first display element and the second display element.

[0013] The pixel circuit is electrically connected to the first display element and the second display element.

[0014] The first display element includes a reflective film and is configured to control intensity of light reflected by the reflective film. The reflective film has a shape that does not block light emitted from the second display element.

[0015] The second display element includes a light-emitting element and is provided such that display using the second display element can be seen from part of a region where display using the first display element can be seen. Note that a light-emitting diode can be used as the second display element.

[0016] With such a structure, display can be performed by controlling the intensity of light reflected by the reflective film with the use of the first display element. Alternatively, display using the first display element can be complemented using a light-emitting diode as the second display element. Consequently, a novel display panel with high convenience or high reliability can be provided.

[0017] (2) Another embodiment of the present invention is the above display panel in which the pixel includes an optical element and a covering film.

[0018] The optical element has a light-transmitting property and includes a first region, a second region, and a third region.

[0019] The first region includes a region to which light is supplied, the second region includes a region in contact with the covering film, and the third region is configured to emit part of the light and has an area smaller than or equal to an area of the region of the first region to which the light is supplied.

[0020] The covering film has light reflectivity and is configured to reflect the part of the light and supply the part of the light to the third region.

[0021] The reflective film has a shape that does not block light emitted from the third region of the optical element.

[0022] The second display element is configured to supply the light.

[0023] (3) Another embodiment of the present invention is the above display panel in which the optical element has an optical axis.

[0024] The optical axis passes through a center of a region of the first region to which the light is supplied and a center of the third region. The second region includes an inclined

portion with an inclination of 45° or more with respect to a plane orthogonal to the optical axis.

[0025] With such a structure, display can be performed by controlling the intensity of light reflected by the reflective film with the use of the first display element. Alternatively, display using the first display element can be complemented using the second display element. Alternatively, the light supplied to the first region can be efficiently emitted from the third region. Alternatively, the light supplied to the first region can be gathered and emitted from the third region. For example, an area of the light-emitting diode used as the second display element can be larger than an area of the third region. Alternatively, light supplied from the light-emitting diode having an area larger than the area of the third region can be gathered in the third region. Alternatively, density of a current supplied to the light-emitting diode can be decreased while the intensity of light emitted from the third region is maintained. Alternatively, reliability of the light-emitting diode can be increased. Consequently, a novel display panel with high convenience or high reliability can be provided.

[0026] (4) Another embodiment of the present invention is the above display panel further including a lens.

[0027] The lens includes a region positioned between the optical element and the second display element, includes a material with a refractive index of 1.5 or more and 2.5 or less, and is a convex lens.

[0028] With such a structure, light emitted from the second display element can be gathered toward the optical axis of the optical element, for example. Alternatively, light emitted from the second display element can be used efficiently. Alternatively, the density of a current supplied to the light-emitting diode can be decreased. Alternatively, the area of the second display element can be increased. Alternatively, the reliability of the light-emitting diode can be increased. Consequently, a novel display panel with high convenience or high reliability can be provided.

[0029] (5) Another embodiment of the present invention is the above display panel in which the pixel includes a first conductive film, a second conductive film, and an insulating film.

[0030] The insulating film includes a region positioned between the first conductive film and the second conductive film. The insulating film has an opening.

[0031] The first conductive film is electrically connected to the first display element.

[0032] The second conductive film includes a region overlapping with the first conductive film, is electrically connected to the first conductive film in the opening, and is electrically connected to the pixel circuit.

[0033] The second display element is electrically connected to the pixel circuit and is configured to emit light toward the insulating film.

[0034] (6) Another embodiment of the present invention is the above display panel including a display region.

[0035] The display region includes one group of pixels, another group of pixels, a scan line, and a signal line.

[0036] The one group of pixels include the pixel. The pixels of the one group are arranged in a row direction.

[0037] The another group of pixels include the pixel. The pixels of the another group are arranged in a column direction intersecting with the row direction.

[0038] The scan line is electrically connected to the one group of pixels. The signal line is electrically connected to the another group of pixels.

[0039] Thus, the first display element and the second display element that displays an image by a method different from that of the first display element can be driven using pixel circuits that can be formed in the same process. Furthermore, with the insulating film, impurity diffusion between the first display element and the second display element or between the first display element and the pixel circuit can be inhibited.

[0040] Consequently, a novel display device with high convenience or high reliability can be provided.

[0041] (7) Another embodiment of the present invention is a display device including the above display panel and a control portion.

[0042] The control portion is configured to receive image data and control data, generate first data and second data on the basis of the image data, and supply the first data and the second data.

[0043] The display panel is configured to receive the first data and the second data.

[0044] The first display element is configured to display an image on the basis of the first data, and the second display element is configured to display an image on the basis of the second data.

[0045] With such a structure, image data can be displayed using the first display element. Furthermore, image data can be displayed using the second display element. Furthermore, image data can be displayed using the second display element such that the image data overlaps with the image data displayed using the first display element. Furthermore, the image data displayed using the first display element can be complemented using the second display element. Consequently, a novel display device with high convenience or high reliability can be provided.

[0046] (8) Another embodiment of the present invention is an input/output device including an input portion and a display portion.

[0047] The display portion includes the above display panel.

[0048] The input portion includes a sensing region and is configured to sense an object approaching the sensing region.

[0049] The sensing region includes a region overlapping with the pixel.

[0050] (9) Another embodiment of the present invention is the above input/output device in which the sensing region includes a control line, a sensor signal line, and a sensor element.

[0051] The sensor element is electrically connected to the control line and the sensor signal line.

[0052] The control line is configured to supply a control signal. The sensor signal line is configured to receive a sensor signal.

[0053] The sensor element is configured to supply the sensor signal that varies in accordance with the control signal and a distance between a region overlapping with the pixel and an object approaching the region. The sensor element includes a first electrode and a second electrode.

[0054] The first electrode includes a light-transmitting region in the region overlapping with the pixel and is electrically connected to the control line.

[0055] The second electrode includes a light-transmitting region in the region overlapping with the pixel and is electrically connected to the sensor signal line. The second electrode is located such that an electric field part of which is blocked by an object approaching the region overlapping with the pixel is generated between the second electrode and the first electrode.

[0056] With such a structure, an object approaching the region overlapping with the display portion can be sensed while image data is displayed by the display portion. Alternatively, a finger or the like that approaches the display portion can be used as a pointer to input positional data. Alternatively, positional data can be associated with image data displayed on the display portion. Consequently, a novel input/output device with high convenience or high reliability can be provided.

[0057] (10) Another embodiment of the present invention is a data processing device including at least one of a keyboard, a hardware button, a pointing device, a touch sensor, an illuminance sensor, an imaging device, an audio input device, a viewpoint input device, and an attitude determination device, and the above display panel.

[0058] With such a structure, the arithmetic device can generate the image data or the control data on the basis of the data supplied using a variety of input devices. Consequently, a novel data processing device with high convenience or high reliability can be provided.

[0059] Although the block diagram attached to this specification shows components classified by their functions in independent blocks, it is difficult to classify actual components according to their functions completely and it is possible for one component to have a plurality of functions.

[0060] In this specification, the terms "source" and "drain" of a transistor interchange with each other depending on the polarity of the transistor or the levels of potentials supplied to the terminals. In general, in an n-channel transistor, a terminal to which a lower potential is supplied is called a source, and a terminal to which a higher potential is supplied is called a drain. In a p-channel transistor, a terminal to which a lower potential is supplied is called a drain, and a terminal to which a higher potential is supplied is called a source. In this specification, although the connection relation of the transistor is described assuming that the source and the drain are fixed for convenience in some cases, actually, the names of the source and the drain interchange with each other depending on the relation of the potentials.

[0061] In this specification, a "source" of a transistor means a source region that is part of a semiconductor film functioning as an active layer or a source electrode connected to the semiconductor film. Similarly, a "drain" of a transistor means a drain region that is part of the semiconductor film or a drain electrode connected to the semiconductor film. A "gate" means a gate electrode.

[0062] In this specification, a state in which transistors are connected to each other in series means, for example, a state in which only one of a source and a drain of a first transistor is connected to only one of a source and a drain of a second transistor. In addition, a state in which transistors are connected in parallel means a state in which one of a source and a drain of a first transistor is connected to one of a source and a drain of a second transistor and the other of the source and the drain of the first transistor is connected to the other of the source and the drain of the second transistor.

[0063] In this specification, the term "connection" means electrical connection and corresponds to a state where current, voltage, or potential can be supplied or transmitted. Accordingly, connection means not only direct connection but also indirect connection through a circuit element such as a wiring, a resistor, a diode, or a transistor so that current, potential, or voltage can be supplied or transmitted.

[0064] In this specification, even when different components are connected to each other in a circuit diagram, there is actually a case where one conductive film has functions of a plurality of components, such as a case where part of a wiring serves as an electrode. The term "connection" also means such a case where one conductive film has functions of a plurality of components.

[0065] Further, in this specification, one of a first electrode and a second electrode of a transistor refers to a source electrode and the other refers to a drain electrode.

[0066] One embodiment of the present invention can provide a novel display panel with high convenience or high reliability. Another embodiment can provide a novel display device with high convenience or high reliability. Another embodiment can provide a novel input/output device with high convenience or high reliability. Another embodiment can provide a novel data processing device with high convenience or high reliability. Another embodiment can provide a novel display panel, a novel display device, a novel input/output device, a novel data processing device, or a novel semiconductor device.

[0067] Note that the description of these effects does not preclude the existence of other effects. One embodiment of the present invention does not necessarily have all the effects listed above. Other effects will be apparent from and can be derived from the description of the specification, the drawings, the claims, and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] FIGS. **1**A to **1**D are schematic views illustrating the structure of a pixel in a display panel of an embodiment.

[0069] FIGS. **2**A and **2**B are cross-sectional views illustrating the structure of a pixel in a display panel of an embodiment.

[0070] FIGS. **3**A and **3**B are cross-sectional views illustrating the structure of a pixel in a display panel of an embodiment.

[0071] FIGS. **4**A to **4**C are top views and a cross-sectional view illustrating the structure of a display panel of an embodiment.

[0072] FIGS. **5**A and **5**B are cross-sectional views illustrating the structure of a display panel of an embodiment.

[0073] FIGS. **6**A and **6**B are cross-sectional views illustrating the structure of a display panel of an embodiment.

[0074] FIG. **7** is a bottom view illustrating the structures of pixels in a display panel of an embodiment.

[0075] FIG. **8** is a circuit diagram illustrating a pixel circuit in a display panel of an embodiment.

[0076] FIGS. **9**A to **9**D are cross-sectional views illustrating the structures of reflective films of display panels of embodiments.

[0077] FIGS. **10**A to **10**C are top views illustrating pixels and subpixels of display panels of embodiments.

[0078] FIG. **11** is a top view illustrating pixels and subpixels in a display panel of an embodiment.

[0079] FIGS. **12**A**1**, **12**A**2**, **12**B**1**, **12**B**2**, **12**C**1**, **12**C**2**, **12**D**1**, **12**D**2**, **12**E**1**, **12**E**2**, **12**F**1**, and **12**F**2** are cross-sec-

tional views and perspective views illustrating the shapes of optical elements of display panels of embodiments.

[0080] FIGS. **13**A and **13**B are block diagrams illustrating the structure of a display device using a display panel of an embodiment.

[0081] FIGS. **14**A, **14**B**1**, **14**B**2**, and **14**B**3** are a block diagram and perspective views illustrating the structures of display panels of embodiments.

[0082] FIG. **15** is a block diagram illustrating the structure of an input/output device of an embodiment.

[0083] FIGS. **16**A to **16**C are top views illustrating the structure of an input/output device of an embodiment.

[0084] FIGS. **17**A and **17**B are cross-sectional views illustrating the structure of an input/output device of an embodiment.

[0085] FIG. **18** is a cross-sectional view illustrating the structure of an input/output device of an embodiment.

[0086] FIG. **19** is a cross-sectional view illustrating the structure of an input/output device of an embodiment.

[0087] FIGS. **20**A to **20**C are a block diagram and projection views illustrating the structures of data processing devices of embodiments.

[0088] FIGS. **21**A and **21**B are flow charts each showing a driving method of a data processing device of an embodiment.

[0089] FIG. **22** is a flow chart showing a driving method of a data processing device of an embodiment.

[0090] FIGS. **23**A and **23**B illustrate the structure of a module of an embodiment.

[0091] FIGS. **24**A to **24**E illustrate the structures of data processing devices of embodiments.

[0092] FIGS. **25**A to **25**E illustrate the structures of data processing devices of embodiments.

[0093] FIGS. **26**A to **26**C illustrate the structures of electronic devices of embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0094] A display panel of one embodiment of the present invention includes a pixel. The pixel includes a functional layer, a first display element, and a second display element. The functional layer includes a pixel circuit and includes a region positioned between the first display element and the second display element. The pixel circuit is electrically connected to the first display element and the second display element. The first display element includes a reflective film and is configured to control the intensity of light reflected by the reflective film. The reflective film has a shape that does not block light emitted from the second display element. The second display element includes a light-emitting diode and is provided such that display using the second display element can be seen from part of a region where display using the first display element can be seen.

[0095] With such a structure, display can be performed by controlling the intensity of light reflected by the reflective film with the use of the first display element. Furthermore, display using the first display element can be complemented using a light-emitting diode as the second display element. Consequently, a novel display panel with high convenience or high reliability can be provided.

[0096] Embodiments will be described in detail with reference to the drawings. Note that the present invention is not limited to the following description. It will be readily appreciated by those skilled in the art that modes and details of the present invention can be modified in various ways without departing from the spirit and scope of the present invention. Thus, the present invention should not be construed as being limited to the description of the following embodiments. Note that in structures of the invention described below, the same portions or portions having similar functions are denoted by the same reference numerals in different drawings, and the description thereof is not repeated.

Embodiment 1

[0097] In this embodiment, the structure of a display panel of one embodiment of the present invention will be described with reference to FIGS. **1**A to **1**D to FIG. **8**.

[0098] FIGS. **1**A to **1**D illustrate the structure of the display panel of one embodiment of the present invention. FIG. **1**A is a projection view of a pixel, and FIG. **1**B is an exploded view for illustrating part of the structure of the pixel in FIG. **1**A. FIG. **1**C is a cross-sectional view that is taken along line Y**1**-Y**2** in FIG. **1**A and for illustrating part of the structure of the pixel. FIG. **1**D is a top view of the pixel in FIG. **1**A.

[0099] FIGS. **2**A and **2**B illustrate the structure of the display panel of one embodiment of the present invention. FIG. **2**A is a cross-sectional view of the pixel taken along line Y**1**-Y**2** in FIG. **1**A. FIG. **2**B is a cross-sectional view illustrating part of the structure of the pixel in FIG. **2**A.

[0100] FIGS. **4**A to **4**C illustrate the structure of the display panel of one embodiment of the present invention. FIG. **4**A is a top view of the display panel. FIG. **4**B is a top view illustrating part of the pixel of the display panel in FIG. **4**A. FIG. **4**C is a schematic view illustrating a cross-sectional structure of the display panel in FIG. **4**A.

[0101] FIGS. **5**A and **5**B and FIGS. **6**A and **6**B are cross-sectional views illustrating the structure of the display panel. FIG. **5**A is a cross-sectional view taken along line X**1**-X**2** and line X**3**-X**4** in FIG. **4**A, and line X**5**-X**6** in FIG. **7**. FIG. **5**B illustrates part of FIG. **5**A.

[0102] FIG. **6**A is a cross-sectional view taken along line X**7**-X**8** in FIG. **7** and line X**9**-X**10** in FIG. **4**A. FIG. **6**B illustrates part of FIG. **6**A.

[0103] FIG. **7** is a bottom view illustrating some pixels of the display panel in FIG. **4**A.

[0104] FIG. **8** is a circuit diagram illustrating the configuration of a pixel circuit included in a display panel of one embodiment of the present invention.

[0105] Note that in this specification, an integral variable of 1 or more may be used for reference numerals. For example, "(p)" where p is an integral value of 1 or more may be used for part of a reference numeral that specifies any one of components (up to p components). For another example, "(m,n)" where m and n are each an integral value of 1 or more may be used for part of a reference numeral that specifies any one of components (up to m×n components).

<Structural Example 1 of Display Panel>

[0106] A display panel **700** described in this embodiment includes a pixel **702**(*i*,*j*) (see FIG. **4**A).

<<Structural Example 1 of Pixel>>

[0107] The pixel **702**(*i*,*j*) includes a functional layer **520**, a first display element **750**(*i*,*j*), and a second display element **550**(*i*,*j*) (see FIG. **4**C).

[0108] The functional layer **520** includes a pixel circuit **530**(*i*,*j*). The functional layer **520** includes a region positioned between the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*).

[0109] The pixel circuit **530**(*i*,*j*) is electrically connected to the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*).

<<Structural Example 1 of First Display Element **750**(*i*,*j*)>>

[0110] The first display element **750**(*i*,*j*) includes a reflective film **751**B and has a function of controlling the intensity of light reflected by the reflective film **751**B (see FIGS. **1**A and **1**B). The reflective film **751**B has a shape that does not block light emitted from the second display element **550**(*i*,*j*). For example, the reflective film **751**B can have a shape including a region **751**H where light is not blocked.

<<Structural Example 1 of Second Display Element **550**(*i*,*j*)>>

[0111] The second display element **550**(*i*,*j*) is provided such that display using the second display element **550**(*i*,*j*) can be seen from part of a region where display using the first display element **750**(*i*,*j*) can be seen (see FIG. **1**A). For example, a light-emitting diode can be used as the second display element **550**(*i*,*j*). Specifically, the second display element **550**(*i*,*j*) includes an electrode **551**(*i*,*j*), an electrode **552**, and a multilayer film **553**. For example, a light-emitting diode with a horizontal structure or a vertical structure can be used as the second display element **550**(*i*,*j*).

[0112] With such a structure, display can be performed by controlling the intensity of light reflected by the reflective film with the use of the first display element.

[0113] Furthermore, display using the first display element can be complemented using a light-emitting diode as the second display element. Consequently, a novel display panel with high convenience or high reliability can be provided.

<<Structural Example 2 of Pixel>>

[0114] The pixel **702**(*i*,*j*) includes an optical element **560** and a covering film **565**.

<<Structural Example 1 of Optical Element>>

[0115] The optical element **560** has a light-transmitting property and includes a first region **560**A, a second region **560**B, and a third region **560**C (see FIGS. **1**B and **1**C and FIG. **2**B).

[0116] The first region **560**A includes a region to which light is supplied. For example, the first region **560**A receives light from the second display element **550**(*i*,*j*).

[0117] The second region **560**B includes a region in contact with the covering film **565**.

[0118] The third region **560**C has a function of allowing part of light to be extracted and has an area smaller than or equal to the area of the region of the first region **560**A to which light is supplied.

<<Structural Example of Covering Film>>

[0119] The covering film **565** has light reflectivity and has a function of reflecting part of light and supplying it to the third region **560**C. For example, the covering film **565** can reflect light emitted from the second display element **550**(*i*,*j*) toward the third region **560**C. Specifically, part of light incident on the optical element **560** through the first region **560**A can be reflected by the covering film **565** in contact with the second region **560**B and extracted from the third region **560**C, as shown by a solid arrow (see FIG. **2**B).

<<Structural Example 2 of First Display Element **750**(*i*,*j*)>>

[0120] The reflective film **751**B has a shape that does not block light extracted from the third region **560**C of the optical element **560**.

<<Structural Example 2 of Second Display Element **550**(*i*,*j*)>>

[0121] The second display element **550**(*i*,*j*) has a function of supplying light (see FIG. **1**B and FIG. **2**A). For example, the second display element **550**(*i*,*j*) has a function of supplying light to the first region **560**A.

[0122] With such a structure, display can be performed by controlling the intensity of light reflected by the reflective film with the use of the first display element. Alternatively, display using the first display element can be complemented using the second display element. Alternatively, the light supplied to the first region can be efficiently emitted from the third region. Alternatively, the light supplied to the first region can be gathered and emitted from the third region. For example, the area of the light-emitting diode used as the second display element can be larger than the area of the third region. Alternatively, light supplied from the light-emitting diode having an area larger than the area of the third region can be gathered in the third region. Alternatively, the density of a current supplied to the light-emitting diode can be decreased while the intensity of light emitted from the third region is maintained. Alternatively, the reliability of the light-emitting diode can be increased. Consequently, a novel display panel with high convenience or high reliability can be provided.

[0123] Note that the second display element **550**(*i*,*j*) includes a support **559**. For example, a single crystal substrate such as a sapphire substrate can be used for the support **559**. Alternatively, a material that reflects light or a material with thermal conductivity can be used for the support **559**. Specifically, a material to which the multilayer film **553** separated from a sapphire substrate or the like is transferred can be used for the support **559**.

[0124] The display panel **700** of one embodiment of the present invention can include a heat dissipation material **558** between the second display element **550**(*i*,*j*) and a substrate **570**. This enables heat generated by driving of the second display element **550**(*i*,*j*) to be dissipated to the substrate **570**.

[0125] Specifically, a composite material including a resin and inorganic material particles can be used for the heat dissipation material **558**. For example, for the resin, an epoxy resin or a silicone resin can be used. For the inorganic material particles, aluminum nitride, boron nitride, aluminum oxide, magnesium oxide, silicon oxide, or magnesium hydroxide can be used, for example.

<<Structural Example 3 of Pixel>>

[0126] The pixel **702**(*i*,*j*) includes part of the functional layer **520**, a first display element **750**(*i*,*j*), and a second display element **550**(*i*,*j*) (see FIG. **4**C).

<<Functional Layer **520**>>

[0127] The functional layer **520** includes a first conductive film, a second conductive film, an insulating film **501**C, and the pixel circuit **530**(*i*,*j*). The functional layer **520** includes

the optical element **560** and the covering film **565** (see FIG. **2**A and FIG. **5**A). The pixel circuit **530**(*i*,*j*) includes a transistor M, for example.

[0128] The functional layer **520** includes an insulating film **528**, an insulating film **521**A, an insulating film **521**B, an insulating film **518**A, an insulating film **518**B, and an insulating film **516**.

<<Pixel Circuit>>

[0129] The pixel circuit **530**(*i*,*j*) has a function of driving the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*) (see FIG. **8**).

[0130] Thus, the first display element and the second display element that displays an image by a method different from that of the first display element can be driven using pixel circuits that can be formed in the same process. Specifically, a reflective display element is used as the first display element, whereby power consumption can be reduced. Alternatively, an image with high contrast can be favorably displayed in an environment with bright external light. Alternatively, an image can be favorably displayed in a dark environment with the use of the second display element which emits light. Alternatively, with the insulating film, impurity diffusion between the first display element and the second display element or between the first display element and the pixel circuit can be inhibited. Consequently, a novel display device with high convenience or high reliability can be provided.

[0131] A switch, a transistor, a diode, a resistor, an inductor, a capacitor, or the like can be used in the pixel circuit **530**(*i*,*j*).

[0132] For example, one or a plurality of transistors can be used as a switch. Alternatively, a plurality of transistors connected in parallel, in series, or in combination of parallel connection and series connection can be used as a switch.

[0133] For example, the pixel circuit **530**(*i*,*j*) is electrically connected to a signal line S**1**(*j*), a signal line S**2**(*j*), a scan line G**1**(*i*), a scan line G**2**(*i*), a wiring CSCOM, and a conductive film ANO (see FIG. **8**). Although not illustrated, a conductive film **512**A is electrically connected to the signal line S**1**(*j*).

[0134] The pixel circuit **530**(*i*,*j*) includes a switch SW**1** and a capacitor C**11** (see FIG. **8**).

[0135] The pixel circuit **530**(*i*,*j*) includes a switch SW**2**, a transistor M, and a capacitor C**12**.

[0136] For example, a transistor including a gate electrode electrically connected to the scan line G**1**(*i*) and a first electrode electrically connected to the signal line S**1**(*j*) can be used as the switch SW**1**.

[0137] The capacitor C**11** includes a first electrode electrically connected to a second electrode of the transistor used as the switch SW**1** and a second electrode electrically connected to the wiring CSCOM.

[0138] For example, a transistor including a gate electrode electrically connected to the scan line G**2**(*i*) and a first electrode electrically connected to the signal line S**2**(*j*) can be used as the switch SW**2**.

[0139] The transistor M includes a gate electrode electrically connected to a second electrode of the transistor used as the switch SW**2** and a first electrode electrically connected to the conductive film ANO.

[0140] Note that a transistor including a conductive film provided such that a semiconductor film is positioned between a gate electrode and the conductive film can be used as the transistor M. For example, as the conductive film, a conductive film electrically connected to a wiring that can supply the same potential as that of the gate electrode of the transistor M can be used.

[0141] The capacitor C**12** includes a first electrode electrically connected to the second electrode of the transistor used as the switch SW**2** and a second electrode electrically connected to the first electrode of the transistor M.

[0142] A first electrode of the first display element **750**(*i*,*j*) is electrically connected to the second electrode of the transistor used as the switch SW**1**. A second electrode of the first display element **750**(*i*,*j*) is electrically connected to a wiring VCOM**1**. This enables the first display element **750** to be driven.

[0143] The electrode **551**(*i*,*j*) and the electrode **552** of the second display element **550**(*i*,*j*) are electrically connected to a second electrode of the transistor M and a conductive film VCOM**2**, respectively. This enables the second display element **550**(*i*,*j*) to be driven.

<<Insulating Film **501**C>>

[0144] The insulating film **501**C includes a region positioned between the first conductive film and the second conductive film and has an opening **591**A (see FIG. **6**A). In addition, the insulating film **501**C has an opening **591**C.

<<First Conductive Film>>

[0145] The first conductive film is electrically connected to the first display element **750**(*i*,*j*). Specifically, the first conductive film is electrically connected to an electrode **751**(*i*,*j*) of the first display element **750**(*i*,*j*). The electrode **751**(*i*,*j*) can be used as the first conductive film.

<<Second Conductive Film>>

[0146] The second conductive film includes a region overlapping with the first conductive film. The second conductive film is electrically connected to the first conductive film through the opening **591**A. For example, a conductive film **512**B can be used as the second conductive film.

[0147] Note that the first conductive film electrically connected to the second conductive film in the opening **591**A formed in the insulating film **501**C can be referred to as a through electrode.

[0148] The second conductive film is electrically connected to the pixel circuit **530**(*i*,*j*). For example, a conductive film that functions as a source electrode or a drain electrode of a transistor used as a switch SW**1** of the pixel circuit **530**(*i*,*j*) can be used as the second conductive film.

<<Structural Example 3 of Second Display Element **550**(*i*,*j*)>>

[0149] The second display element **550**(*i*,*j*) is electrically connected to the pixel circuit **530**(*i*,*j*) (see FIG. **5**A and FIG. **8**). The second display element **550**(*i*,*j*) has a function of emitting light toward the functional layer **520**. The second display element **550**(*i*,*j*) has a function of emitting light toward the insulating film **501**C or an opening formed in the insulating film **501**C, for example.

[0150] The second display element **550**(*i*,*j*) is provided such that display using the second display element **550**(*i*,*j*) can be seen from part of a region where display using the first display element **750**(*i*,*j*) can be seen. For example, dashed arrows shown in FIG. **6**A denote the directions in which external light is incident on and reflected by the first

display element **750**(*i,j*) that displays image data by controlling the intensity of external light reflection. In addition, a solid arrow shown in FIG. **5**A denotes the direction in which the second display element **550**(*i,j*) emits light to part of the region where display using the first display element **750**(*i,j*) can be seen.

[0151] Accordingly, display using the second display element can be seen from part of the region where display using the first display element can be seen. Alternatively, users can see display without changing the attitude or the like of the display panel. Alternatively, an object color expressed by light reflected by the first display element and a light source color expressed by light emitted from the second display element can be mixed. Alternatively, an object color and a light source color can be used to display an image like a painting. Thus, a novel display panel with high convenience or high reliability can be provided.

[0152] For example, the second display element **550**(*i,j*) includes the electrode **551**(*i,j*), the electrode **552**, and the multilayer film **553** (see FIG. **2**A or FIG. **5**A).

[0153] The electrode **551**(*i,j*) is electrically connected to the pixel circuit **530**(*i,j*) at a connection portion **522**. Specifically, the electrode **551**(*i,j*) is electrically connected to the pixel circuit **530**(*i,j*) through a conductive material **31** and a conductive film **533** (see FIGS. **2**A and **2**B and FIG. **4**B).

[0154] The electrode **552** is electrically connected to the conductive film VCOM**2**. Specifically, the electrode **552** is electrically connected to the conductive film VCOM**2** through a conductive material **32**.

[0155] Note that a diffusion bonding method can be used for electrical connection between an electrode and a conductive film. Thus, the electrode **551**(*i,j*) can be electrically connected to the conductive film **533** without using the conductive material **31**, and the electrode **552** can be electrically connected to the conductive film VCOM**2** without using the conductive material **32**.

[0156] A sealing material UF can be provided between the second display element **550**(*i,j*) and the insulating film **528**. This can prevent a defect such as separation of the second display element **550**(*i,j*) from the insulating film **528**.

<<Insulating Films **521**, **528**, **518**A, **518**B, and **516**>>

[0157] An insulating film **521** includes a region positioned between the pixel circuit **530**(*i,j*) and the second display element **550**(*i,j*) (see FIGS. **2**A and **2**B and FIG. **4**B).

[0158] For example, a laminated film can be used as the insulating film **521**. For example, a stack of the insulating film **521**A and the insulating film **521**B can be used as the insulating film **521**.

[0159] The insulating film **528** includes a region positioned between the insulating film **521** and the substrate **570** and has an opening in a region overlapping with the second display element **550**(*i,j*). The insulating film **528** that is along the edge of the electrode **551**(*i,j*) can avoid a short circuit between the electrode **551**(*i,j*) and the electrode **552**.

[0160] The insulating film **518**A includes a region positioned between the insulating film **521** and the pixel circuit **530**(*i,j*). For example, the insulating film **518**A includes a region positioned between the insulating film **521** and the transistor M. The insulating film **518**B includes a region positioned between the optical element **560** and the region **751**H.

[0161] The insulating film **516** includes a region positioned between the insulating film **518**A and the pixel circuit **530**(*i,j*). For example, the insulating film **516** includes a region positioned between the insulating film **518**A and the transistor M.

[0162] Furthermore, the display panel **700** can include an insulating film **501**B. The insulating film **501**B has an opening **592**A, an opening **592**B, and an opening **592**C (see FIG. **5**A and FIG. **6**A).

[0163] The opening **592**A includes a region overlapping with the electrode **751**(*i,j*) and a region overlapping with the insulating film **501**C.

[0164] The opening **592**B includes a region overlapping with a conductive film **511**B (see FIG. **5**A).

[0165] The opening **592**C includes a region overlapping with a conductive film **511**C (see FIG. **6**A).

<Structural Example 2 of Display Panel>

[0166] The display panel **700** described in this embodiment includes a display region **231** (see FIG. **13**A).

<<Display Region **231**>>

[0167] The display region **231** includes one group of pixels **702**(*i*,**1**) to **702**(*i,n*), another group of pixels **702**(**1**,*j*) to **702**(*m,j*), a scan line G**1**(*i*), and a signal line S**1**(*j*) (see FIG. **13**A). The display region **231** includes the scan line G**2**(*i*), the wiring CSCOM, the conductive film ANO, and the signal line S**2**(*j*). Note that i is an integer greater than or equal to 1 and less than or equal to m, j is an integer greater than or equal to 1 and less than or equal to n, and each of m and n is an integer greater than or equal to 1.

[0168] The one group of pixels **702**(*i*,**1**) to **702**(*i,n*) include the pixel **702**(*i,j*) and are arranged in the row direction (the direction indicated by the arrow R**1** in the drawing).

[0169] The another group of pixels **702**(**1**,*j*) to **702**(*m,j*) include the pixel **702**(*i,j*) and are arranged in the column direction (the direction indicated by the arrow C**1** in the drawing) that intersects the row direction.

[0170] The scan line G**1**(*i*) and the scan line G**2**(*i*) are electrically connected to the group of pixels **702**(*i*,**1**) to **702**(*i,n*) arranged in the row direction.

[0171] The signal line S**1**(*i*) and the signal line S**2**(*j*) are electrically connected to the another group of pixels **702**(**1**,*j*) to **702**(*m,j*) arranged in the column direction.

<Structural Example 3 of Display Panel>

[0172] The display panel **700** described in this embodiment can include a plurality of pixels having functions of representing colors with different hues. Furthermore, colors with hues that cannot be represented by the plurality of pixels capable of representing colors with different hues can be represented by additive color mixing with the use of the pixels.

[0173] Note that when a plurality of pixels capable of representing colors with different hues are used for color mixture, each of the pixels can be referred to as a subpixel. In addition, a set of subpixels can be referred to as a pixel. Specifically, the pixel **702**(*i,j*) can be referred to as a subpixel, and the pixel **702**(*i,j*) a pixel **702**(*i,j*+1), and a pixel **702**(*i,j*+2) can be collectively referred to as a pixel **703**(*i,k*) (see FIG. **11**).

[0174] For example, a subpixel that represents blue, a subpixel that represents green, and a subpixel that represents red can be collectively used as the pixel **703**(*i,k*).

[0175] Alternatively, for example, a subpixel that represents cyan, a subpixel that represents magenta, and a subpixel that represents yellow can be collectively used as the pixel **703**(*i,k*).

[0176] Alternatively, for example, the above set to which a subpixel that represents white is added can be used as the pixel.

[0177] Alternatively, for example, a set of the following subpixels can be used as the pixel **703**(*i,k*): a subpixel including the first display element **750**(*i,j*) that represents cyan and the second display element **550**(*i,j*) that represents blue; a subpixel including a first display element **750**(*i,j*+1) that represents yellow and a second display element **550**(*i, j*+1) that represents green; and a subpixel including a first display element **750**(*i,j*+2) that represents magenta and a second display element **550**(*i,j*+2) that represents red. This allows bright display using the first display elements **750**(*i,j*) to **750**(*i,j*+2) or clear display using the second display elements **550**(*i,j*) to **550**(*i,j*+2).

<Structural Example 4 of Display Panel>

[0178] The display panel **700** described in this embodiment can include a driver circuit GD or a driver circuit SD (see FIG. **4**A and FIG. **13**A).

<<Driver Circuit GD>>

[0179] The driver circuit GD has a function of supplying a selection signal on the basis of control data.

[0180] For example, the driver circuit GD has a function of supplying a selection signal to one scan line at a frequency of 30 Hz or higher, preferably 60 Hz or higher, on the basis of control data. Accordingly, moving images can be smoothly displayed.

[0181] For example, the driver circuit GD has a function of supplying a selection signal to one scan line at a frequency of lower than 30 Hz, preferably lower than 1 Hz, more preferably less than once per minute, on the basis of control data. Accordingly, a still image can be displayed with reduced flickering.

[0182] A display panel can include a plurality of driver circuits. For example, a display panel **700**B includes a driver circuit GDA and a driver circuit GDB (see FIG. **14**A).

[0183] For example, in the case where a plurality of driver circuits are provided, the driver circuits GDA and GDB may supply the selection signals at different frequencies. Specifically, the selection signal can be supplied at a higher frequency to a region on which moving images are displayed than to a region on which a still image is displayed. Accordingly, a still image can be displayed in a region with reduced flickering, and moving images can be smoothly displayed in another region.

<<Driver Circuit SD>>

[0184] The driver circuit SD includes a driver circuit SD**1** and a driver circuit SD**2**. The driver circuit SD**1** has a function of supplying an image signal on the basis of the data V**11**. The driver circuit SD**2** has a function of supplying an image signal on the basis of the data V**12** (see FIG. **13**A).

[0185] The driver circuit SD**1** or the driver circuit SD**2** has a function of generating an image signal and a function of supplying the image signal to a pixel circuit electrically connected to a display element. Specifically, the driver circuit SD**1** or the driver circuit SD**2** has a function of generating a signal whose polarity is inverted. Thus, for example, a liquid crystal display element can be driven.

[0186] For example, any of a variety of sequential circuits, such as a shift register, can be used as the driver circuit SD.

[0187] For example, an integrated circuit in which the driver circuit SD**1** and the driver circuit SD**2** are integrated can be used as the driver circuit SD. Specifically, an integrated circuit formed on a silicon substrate can be used as the driver circuit SD.

[0188] An integrated circuit can be mounted on a terminal by a chip on glass (COG) method or a chip on film (COF) method, for example. Specifically, an anisotropic conductive film can be used to mount an integrated circuit on the terminal.

<Structural Example 5 of Display Panel>

[0189] Moreover, the display panel **700** described in this embodiment includes a functional layer **720**, a terminal **519**B, a terminal **519**C, the substrate **570**, a substrate **770**, a bonding layer **505**, a sealing material **705**, a structure body KB**1**, a functional film **770**P, a functional film **770**D, and the like (see FIG. **5**A and FIG. **6**A).

<<Functional Layer **720**>>

[0190] The functional layer **720** includes a region positioned between the substrate **770** and the insulating film **501**C. The functional layer **720** includes a light-blocking film BM, an insulating film **771**, and a coloring film CF**1** (see FIG. **5**A and FIG. **6**A).

[0191] The light-blocking film BM has an opening in a region overlapping with the first display element **750**(*i,j*) (see FIG. **6**A).

[0192] The coloring film CF**1** includes a region positioned between the substrate **770** and the first display element **750**(*i,j*).

[0193] The insulating film **771** includes a region between the coloring film CF**1** and the layer **753** containing a liquid crystal material and a region between the light-blocking film BM and the layer **753** containing a liquid crystal material. The insulating film **771** can reduce unevenness due to the thickness of the coloring film CF**1**. Alternatively, impurities can be prevented from being diffused from the light-blocking film BM, the coloring film CF**1**, or the like to the layer **753** containing a liquid crystal material.

<<Terminals **519**B and **519**C>>

[0194] The display panel described in this embodiment includes a terminal **519**B and a terminal **519**C (see FIG. **5**A and FIG. **6**A).

[0195] The terminal **519**B includes the conductive film **511**B. The terminal **519**B is electrically connected to the signal line S**1**(*j*), for example.

[0196] The terminal **519**C includes the conductive film **511**C. The conductive film **511**C is electrically connected to the wiring VCOM**1**, for example.

[0197] A conductive material CP is sandwiched between the terminal **519**C and the electrode **752**, and has a function of electrically connecting the terminal **519**C and the electrode **752**. For example, a conductive particle can be used as the conductive material CP.

<<Substrate **570** and Substrate **770**>>

[0198] In addition, the display panel described in this embodiment includes the substrate **570** and the substrate **770**.

[0199] The substrate **770** includes a region overlapping with the substrate **570**. The substrate **770** includes a region positioned such that the functional layer **520** is sandwiched between the substrate **770** and the substrate **570**.

[0200] The substrate **770** includes a region overlapping with the first display element **750**(*i*,*j*). For example, a material with low birefringence can be used for the region.

<<Bonding Layer **505**, Sealing Material **705**, and Structure Body KB**1**>>

[0201] The display panel described in this embodiment includes the bonding layer **505**, the sealing material **705**, and the structure body KB**1**.

[0202] The bonding layer **505** includes a region positioned between the functional layer **520** and the substrate **570**, and has a function of bonding the functional layer **520** and the substrate **570** to each other.

[0203] The sealing material **705** includes a region positioned between the functional layer **520** and the substrate **770**, and has a function of bonding the functional layer **520** and the substrate **770** to each other.

[0204] The structure body KB**1** has a function of providing a certain space between the functional layer **520** and the substrate **770**.

<<Functional Films **770**P and **770**D>>

[0205] The display panel described in this embodiment includes the functional film **770**P and the functional film **770**D.

[0206] The functional film **770**P includes a region overlapping with the first display element **750**(*i*,*j*).

[0207] The functional film **770**D includes a region overlapping with the first display element **750**(*i*,*j*). The functional film **770**D is provided such that a substrate **770** lies between the functional film **770**D and the first display element **750**(*i*,*j*). Thus, for example, light reflected by the first display element **750**(*i*,*j*) can be diffused.

<Example of Components>

[0208] The display panel **700** includes the substrate **570**, the substrate **770**, the structure body KB**1**, the sealing material **705**, and the bonding layer **505**.

[0209] The display panel **700** also includes the functional layer **520**, the optical element **560**, the covering film **565**, the insulating film **521**, and the insulating film **528**.

[0210] The display panel **700** also includes the signal line S**1**(*j*), the signal line S**2**(*j*), the scan line G**1**(*i*), the scan line G**2**(*i*), the wiring CSCOM, and the conductive film ANO.

[0211] The display panel **700** also includes the first conductive film and the second conductive film.

[0212] The display panel **700** also includes the terminal **519**B, the terminal **519**C, the conductive film **511**B, and the conductive film **511**C.

[0213] The display panel **700** also includes the pixel circuit **530**(*i*,*j*) and the switch SW**1**.

[0214] The display panel **700** also includes the first display element **750**(*i*,*j*), the electrode **751**(*i*,*j*), the reflective film, the opening, the layer **753** containing a liquid crystal material, and the electrode **752**.

[0215] The display panel **700** also includes an alignment film AF**1**, an alignment film AF**2**, the coloring film CF**1**, the light-blocking film BM, the insulating film **771**, the functional film **770**P, and the functional film **770**D.

[0216] The display panel **700** also includes the second display element **550**(*i*,*j*), the electrode **551**(*i*,*j*), the electrode **552**, and the multilayer film **553**.

[0217] The display panel **700** also includes the insulating film **501**B and the insulating film **501**C.

[0218] The display panel **700** also includes the driver circuit GD and the driver circuit SD.

<<Substrate **570**>>

[0219] The substrate **570** or the like can be formed using a material having heat resistance high enough to withstand heat treatment in the manufacturing process. For example, a material with a thickness greater than or equal to 0.1 mm and less than or equal to 0.7 mm can be used for the substrate **570**. Specifically, a material polished to a thickness of approximately 0.1 mm can be used.

[0220] For example, a large-sized glass substrate having any of the following sizes can be used as the substrate **570** or the like: the 6th generation (1500 mm×1850 mm), the 7th generation (1870 mm×2200 mm), the 8th generation (2200 mm×2400 mm), the 9th generation (2400 mm×2800 mm), and the 10th generation (2950 mm×3400 mm). Thus, a large-sized display device can be manufactured.

[0221] For the substrate **570** or the like, an organic material, an inorganic material, a composite material of an organic material and an inorganic material, or the like can be used. For example, an inorganic material such as glass, ceramic, or metal can be used for the substrate **570** or the like.

[0222] Specifically, non-alkali glass, soda-lime glass, potash glass, crystal glass, aluminosilicate glass, tempered glass, chemically tempered glass, quartz, sapphire, or the like can be used for the substrate **570** or the like. Specifically, an inorganic oxide film, an inorganic nitride film, an inorganic oxynitride film, or the like can be used for the substrate **570** or the like. For example, a silicon oxide film, a silicon nitride film, a silicon oxynitride film, an aluminum oxide film, or the like can be used for the substrate **570** or the like. Stainless steel, aluminum, or the like can be used for the substrate **570** or the like.

[0223] For example, a single crystal semiconductor substrate or a polycrystalline semiconductor substrate of silicon or silicon carbide, a compound semiconductor substrate of silicon germanium or the like, or an SOI substrate can be used as the substrate **570** or the like. Thus, a semiconductor element can be provided over the substrate **570** or the like.

[0224] For example, an organic material such as a resin, a resin film, or plastic can be used for the substrate **570** or the like. Specifically, a resin film or resin plate of polyester, polyolefin, polyamide, polyimide, polycarbonate, an acrylic resin, or the like can be used for the substrate **570** or the like.

[0225] For example, a composite material formed by attaching a metal plate, a thin glass plate, or a film of an inorganic material to a resin film or the like can be used for the substrate **570** or the like. For example, a composite material formed by dispersing a fibrous or particulate metal,

glass, inorganic material, or the like into a resin film can be used for the substrate **570** or the like. For example, a composite material formed by dispersing a fibrous or particulate resin, organic material, or the like into an inorganic material can be used for the substrate **570** or the like.

[0226] Furthermore, a single-layer material or a layered material in which a plurality of layers are stacked can be used for the substrate **570** or the like. For example, a layered material in which a base, an insulating film that prevents diffusion of impurities contained in the base, and the like are stacked can be used for the substrate **570** or the like. Specifically, a layered material in which glass and one or more of a silicon oxide layer, a silicon nitride layer, a silicon oxynitride layer, and the like that prevent diffusion of impurities contained in the glass are stacked can be used for the substrate **570** or the like. Alternatively, a layered material in which a resin and a film for preventing diffusion of impurities that penetrate the resin, such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film are stacked can be used for the substrate **570** or the like.

[0227] Specifically, a resin film, a resin plate, a layered material, or the like containing polyester, polyolefin, polyamide, polyimide, polycarbonate, an acrylic resin, or the like can be used for the substrate **570** or the like.

[0228] Specifically, a material containing polyester, polyolefin, polyamide (e.g., nylon or aramid), polyimide, polycarbonate, polyurethane, an acrylic resin, an epoxy resin, or a resin having a siloxane bond, such as silicone can be used for the substrate **570** or the like.

[0229] Specifically, polyethylene terephthalate (PET), polyethylene naphthalate (PEN), polyethersulfone (PES), acrylic, or the like can be used for the substrate **570** or the like. Alternatively, a cyclo olefin polymer (COP), a cyclo olefin copolymer (COC), or the like can be used.

[0230] Alternatively, paper, wood, or the like can be used for the substrate **570** or the like.

[0231] For example, a flexible substrate can be used as the substrate **570** or the like.

[0232] Note that a transistor, a capacitor, or the like can be directly formed on the substrate. Alternatively, a transistor, a capacitor, or the like formed on a substrate for use in manufacturing processes that can resist heat applied in the manufacturing process can be transferred to the substrate **570** or the like. Thus, a transistor, a capacitor, or the like can be formed over a flexible substrate, for example.

<<Substrate **770**>>

[0233] For example, a material that can be used for the substrate **570** can be used for the substrate **770**. For example, a light-transmitting material that can be used for the substrate **570** can be used for the substrate **770**. Alternatively, a material having a surface provided with an antireflective film with a thickness of 1 μm or less can be used for the substrate **770**. Specifically, a stack of 3 or more, preferably 5 or more, more preferably 15 or more dielectrics can be used for the substrate **770**. This allows visible light reflectivity to be as low as 0.5% or less, preferably 0.08% or less.

[0234] Alternatively, a material with low birefringence that can be used for the substrate **570** can be used for the substrate **770**.

[0235] For example, aluminosilicate glass, tempered glass, chemically tempered glass, sapphire, or the like can be favorably used for the substrate **770** that is on the side closer to a user of the display panel. This can prevent breakage or damage of the display panel caused by the use.

[0236] For example, a resin film of a cyclo olefin polymer (COP), a cyclic olefin copolymer (COC), or triacetyl cellulose (TAC) can be favorably used as the substrate **770**, in which case the substrate **770** can be lightweight. Alternatively, for example, the display device can be made less likely to suffer from damage by dropping.

[0237] A material with a thickness greater than or equal to 0.1 mm and less than or equal to 0.7 mm can be used for the substrate **770**, for example. Specifically, a substrate polished to be reduced in the thickness can be used. In that case, the functional film **770**D can be close to the first display element **750**(*i*,*j*). As a result, image blur can be reduced, and an image can be displayed clearly.

<<Structure Body KB**1**>>

[0238] The structure body KB**1** or the like can be formed using an organic material, an inorganic material, or a composite material of an organic material and an inorganic material, for example. Accordingly, a predetermined space can be provided between components between which the structure body KB**1** and the like are provided.

[0239] Specifically, for the structure body KB**1**, polyester, polyolefin, polyamide, polyimide, polycarbonate, polysiloxane, an acrylic resin, or the like, or a composite material of a plurality of resins selected from these can be used. Alternatively, a photosensitive material may be used.

<<Sealing Materials **705** and UF>>

[0240] For the sealing material **705**, the sealing material UF, or the like, an inorganic material, an organic material, a composite material of an inorganic material and an organic material, or the like can be used.

[0241] For example, an organic material such as a thermally fusible resin or a curable resin can be used for the sealing material **705**, the sealing material UF, or the like.

[0242] For example, an organic material such as a reactive curable adhesive, a light curable adhesive, a thermosetting adhesive, and/or an anaerobic adhesive can be used for the sealing material **705** or the like.

[0243] Specifically, an adhesive containing an epoxy resin, an acrylic resin, a silicone resin, a phenol resin, a polyimide resin, an imide resin, a polyvinyl chloride (PVC) resin, a polyvinyl butyral (PVB) resin, or an ethylene vinyl acetate (EVA) resin, or the like can be used for the sealing material **705**, the sealing material UF, or the like.

<<Bonding Layer **505**>>

[0244] For example, any of the materials that can be used for the sealing material **705** can be used for the bonding layer **505**.

<<Insulating Film **521**>>

[0245] For example, an insulating inorganic material, an insulating organic material, an insulating composite material containing an inorganic material and an organic material can be used for the insulating film **521** or the like.

[0246] Specifically, for example, an inorganic oxide film, an inorganic nitride film, an inorganic oxynitride film, or a material obtained by stacking any of these films can be used as the insulating film **521** or the like. For example, a film including any of a silicon oxide film, a silicon nitride film,

a silicon oxynitride film, and an aluminum oxide film, or a film including a material obtained by stacking any of these films can be used as the insulating film **521** or the like.

[0247] Specifically, for the insulating film **521** or the like, polyester, polyolefin, polyamide, polyimide, polycarbonate, polysiloxane, an acrylic resin, or the like, or a laminated or composite material of a plurality of kinds of resins selected from these can be used. Alternatively, a photosensitive material may be used.

[0248] Thus, steps due to various components overlapping with the insulating film **521** can be reduced, for example.

[0249] Furthermore, polyimide having lower moisture permeability than an acrylic resin can be used for the insulating film **521** or the like. In that case, diffusion of impurities into the functional layer **520**, the first display element **750**(*i*,*j*), the second display element **550**(*i*,*j*), or the like can be inhibited, increasing the reliability of the display panel **700**.

<<Optical Element **560**>>

[0250] The optical element **560** has an optical axis Z (see FIG. **1**C). The optical axis Z passes through the center of the region of the first region **560**A to which light is supplied and the center of the third region **560**C. The second region **560**B includes an inclined portion with an inclination θ of 45° or more, preferably 75° or more and 85° or less, with respect to a plane orthogonal to the optical axis Z. For example, the second region **560**B illustrated in FIG. **1**C entirely has an inclination of approximately 60° with respect to the plane orthogonal to the optical axis Z.

[0251] The region of the first region **560**A to which light is supplied has an area larger than 10% of the area of the pixel **702**(*i*,*j*) (see FIG. **1**D).

[0252] The third region **560**C has an area smaller than or equal to 10% of the area of the pixel **702**(*i*,*j*).

[0253] The reflective film **751**B has an area larger than or equal to 70% of the area of the pixel **702**(*i*,*j*).

[0254] The sum of the area of the region of the first region **560**A to which light is supplied and the area of the reflective film **751**B is larger than the area of the pixel **702**(*i*,*j*).

[0255] For example, a rectangular pixel 27 μm wide and 81 μm long has an area of 2187 μm^2. In the case of such a pixel, the region of the first region **560**A to which light is supplied has an area of 324 μm^2. The third region **560**C has an area of 81 μm^2, and the reflective film **751**B has an area of 1894 μm^2.

[0256] In this structure, the area of a region of the first region **560**A to which light is supplied is approximately 14.8% of the area of the pixel.

[0257] The area of the reflective film **751**B is approximately 86.6% of the area of the pixel.

[0258] The sum of the area of the region of the first region **560**A to which light is supplied and the area of the reflective film **751**B is 2218 μm^2.

[0259] Thus, in the second region, light incident through the first region at various angles can be gathered. Consequently, a novel display panel with high convenience or high reliability can be provided.

[0260] Note that a plurality of materials can be used for the optical element **560**. For example, a plurality of materials selected such that a difference between their refractive indices is 0.2 or less can be used for the optical element **560**. Thus, reflection or scattering of light in the optical element or loss of light can be inhibited.

[0261] The optical element **560** can have any of various shapes. For example, the shape of a section orthogonal to the optical axis of the optical element **560** can be a circle or a polygon. The second region **560**B of the optical element **560** can have a flat surface or a curved surface.

[0262] An example of a cross-sectional view along the optical axis of the optical element **560** having a quadrangle section orthogonal to the optical axis is illustrated in

[0263] FIG. **12**A**1**, FIG. **12**B**1**, or FIG. **12**C**1**. FIG. **12**A**2**, FIG. **12**B**2**, or FIG. **12**C**2** shows a perspective view of the optical element **560**.

[0264] An example of a cross-sectional view along the optical axis of the optical element **560** having a circular section orthogonal to the optical axis is illustrated in FIG. **12**D**1**, FIG. **12**E**1**, or FIG. **12**F**1**. FIG. **12**D**2**, FIG. **12**E**2**, or FIG. **12**F**2** shows a perspective view of the optical element **560**.

<<Covering Film **565**>>

[0265] A single-layer film or a laminated film can be used as the covering film **565**. For example, a stack of a light-transmitting film and a reflective film can be used for the covering film **565**.

[0266] For example, an inorganic material such as an oxide film, a fluoride film, or a sulfide film can be used for the light-transmitting film.

[0267] For example, metal can be used for the reflective film. Specifically, a material containing silver can be used for the covering film **565**. For example, a material containing silver, palladium, and the like or a material containing silver, copper, and the like can be used for the reflective film. Alternatively, a multilayer film of dielectrics can be used for the reflective film.

<<Insulating Film **528**>>

[0268] For example, any of the materials that can be used for the insulating film **521** can be used for the insulating film **528** or the like. Specifically, a 1-μm-thick polyimide-containing film can be used as the insulating film **528**.

<<Insulating Film **501**B>>

[0269] For example, a material that can be used for the insulating film **521** can be used for the insulating film **501**B. For example, a material having a function of supplying hydrogen can be used for the insulating film **501**B.

[0270] Specifically, a material obtained by stacking a material containing silicon and oxygen and a material containing silicon and nitrogen can be used for the insulating film **501**B. For example, a material having a function of releasing hydrogen by heating or the like to supply the hydrogen to another component can be used for the insulating film **501**B. Specifically, a material having a function of releasing hydrogen taken in the manufacturing process, by heating or the like, to supply the hydrogen to another component can be used for the insulating film **501**B.

[0271] For example, a film containing silicon and oxygen that is formed by a chemical vapor deposition method using silane or the like as a source gas can be used as the insulating film **501**B.

[0272] Specifically, a material obtained by stacking a material containing silicon and oxygen and having a thickness greater than or equal to 200 nm and less than or equal

to 600 nm and a material containing silicon and nitrogen and having a thickness of approximately 200 nm can be used for the insulating film **501**B.

<<Insulating Film **501**C>>

[0273] For example, any of the materials that can be used for the insulating film **521** can be used for the insulating film **501**C. Specifically, a material containing silicon and oxygen can be used for the insulating film **501**C. Thus, diffusion of impurities into the pixel circuit, the second display element, or the like can be inhibited.

[0274] For example, a 200-nm-thick film containing silicon, oxygen, and nitrogen can be used as the insulating film **501**C.

<<Wiring, Terminal, and Conductive Film>>

[0275] A conductive material can be used for the wiring or the like. Specifically, the conductive material can be used for the signal line S**1**(*j*), the signal line S**2**(*j*), the scan line G**1**(*i*), the scan line G**2**(*i*), the wiring CSCOM, the conductive film ANO, the terminal **519**B, the terminal **519**C, the conductive film **511**B, the conductive film **511**C, or the like.

[0276] For example, an inorganic conductive material, an organic conductive material, a metal, conductive ceramics, or the like can be used for the wiring or the like.

[0277] Specifically, a metal element selected from aluminum, gold, platinum, silver, copper, chromium, tantalum, titanium, molybdenum, tungsten, nickel, iron, cobalt, palladium, and manganese can be used for the wiring or the like. Alternatively, an alloy containing any of the above-described metal elements, or the like can be used for the wiring or the like. In particular, an alloy of copper and manganese is suitably used in microfabrication using a wet etching method.

[0278] Specifically, any of the following structures can be used for the wiring or the like: a two-layer structure in which a titanium film is stacked over an aluminum film, a two-layer structure in which a titanium film is stacked over a titanium nitride film, a two-layer structure in which a tungsten film is stacked over a titanium nitride film, a two-layer structure in which a tungsten film is stacked over a tantalum nitride film or a tungsten nitride film, a three-layer structure in which a titanium film, an aluminum film, and a titanium film are stacked in this order, and the like.

[0279] Specifically, a conductive oxide, such as indium oxide, indium tin oxide, indium zinc oxide, zinc oxide, or zinc oxide to which gallium is added, can be used for the wiring or the like.

[0280] Specifically, a film containing graphene or graphite can be used for the wiring or the like.

[0281] For example, a film containing graphene oxide is formed and subjected to reduction, whereby a film containing graphene can be formed. As a reducing method, a method with application of heat, a method using a reducing agent, or the like can be employed.

[0282] A film containing a metal nanowire can be used for the wiring or the like, for example. Specifically, a nanowire containing silver can be used.

[0283] Specifically, a conductive high molecular compound can be used for the wiring or the like.

[0284] Note that the terminal **519**B can be electrically connected to a flexible printed circuit FPC**1** with the use of a conductive material ACF**1**, for example.

<<First Conductive Film and Second Conductive Film>>

[0285] For example, any of the materials that can be used for the wiring or the like can be used for the first conductive film or the second conductive film.

[0286] The electrode **751**(*i*,*j*), the wiring, or the like can be used for the first conductive film.

[0287] The conductive film **512**B functioning as the source electrode or the drain electrode of the transistor that can be used for the switch SW**1**, the wiring, or the like can be used for the second conductive film.

<<First Display Element **750**(*i*,*j*)>>

[0288] For example, a display element having a function of controlling transmission or reflection of light can be used as the first display element **750**(*i*,*j*). For example, a combined structure of a liquid crystal element and a polarizing plate, a MEMS shutter display element, a MEMS optical coherence display element, or the like can be used. The use of a reflective display element can reduce the power consumption of the display panel. For example, a display element using a microcapsule method, an electrophoretic method, an electrowetting method, or the like can be used as the first display element **750**(*i*,*j*). Specifically, a reflective liquid crystal display element can be used as the first display element **750**(*i*,*j*).

[0289] For example, a liquid crystal element driven in any of the following driving modes can be used: an in-plane switching (IPS) mode, a twisted nematic (TN) mode, a fringe field switching (FFS) mode, an axially symmetric aligned micro-cell (ASM) mode, an optically compensated birefringence (OCB) mode, a ferroelectric liquid crystal (FLC) mode, an antiferroelectric liquid crystal (AFLC) mode, and the like.

[0290] Alternatively, a liquid crystal element that can be driven by, for example, a vertical alignment (VA) mode such as a multi-domain vertical alignment (MVA) mode, a patterned vertical alignment (PVA) mode, an electrically controlled birefringence (ECB) mode, a continuous pinwheel alignment (CPA) mode, or an advanced super view (ASV) mode can be used.

[0291] The first display element **750**(*i*,*j*) includes a first electrode, a second electrode, and a layer containing a liquid crystal material. The layer containing a liquid crystal material contains a liquid crystal material whose orientation can be controlled by voltage applied between the first electrode and the second electrode. For example, the orientation of the liquid crystal material can be controlled by an electric field in the thickness direction (also referred to as the vertical direction) or an electric field in the direction that intersects the vertical direction (also referred to as the horizontal direction or the diagonal direction) of the layer containing a liquid crystal material.

<<Layer **753** Containing Liquid Crystal Material>>

[0292] For example, thermotropic liquid crystal, low-molecular liquid crystal, high-molecular liquid crystal, polymer dispersed liquid crystal, ferroelectric liquid crystal, antiferroelectric liquid crystal, or the like can be used for the layer containing a liquid crystal material. Alternatively, a liquid crystal material which exhibits a cholesteric phase, a smectic phase, a cubic phase, a chiral nematic phase, an isotropic phase, or the like can be used. Alternatively, a liquid crystal material which exhibits a blue phase can be used.

[0293] For example, a negative liquid crystal material can be used for the layer containing a liquid crystal material.

[0294] For example, a liquid crystal material having a resistivity of greater than or equal to 1.0×10^{13} Ω·cm, preferably greater than or equal to 1.0×10^{14} Ω·cm, more preferably greater than or equal to 1.0×10^{15} Ω·cm, is used for the layer **753** containing a liquid crystal material. This can suppress a variation in the transmittance of the first display element **750**(*i*,*j*). Alternatively, flickering of the first display element **750**(*i*,*j*) can be suppressed. Alternatively, the rewriting frequency of the first display element **750**(*i*,*j*) can be reduced.

<<Electrode **751**(*i*,*j*)>>

[0295] For example, the material that is used for the wiring or the like can be used for the electrode **751**(*i*,*j*). Specifically, a reflective film can be used for the electrode **751**(*i*,*j*). For example, a material in which a light-transmitting conductive film and a reflective film having an opening are stacked can be used for the electrode **751**(*i*,*j*).

<<Reflective Film>>

[0296] For example, a material that reflects visible light can be used for the reflective film. Specifically, a material containing silver can be used for the reflective film. For example, a material containing silver, palladium, and the like or a material containing silver, copper, and the like can be used for the reflective film.

[0297] The reflective film reflects light that passes through the layer **753** containing a liquid crystal material, for example. This allows the first display element **750** to serve as a reflective liquid crystal element. Alternatively, for example, a material with unevenness on its surface can be used for the reflective film. In that case, incident light can be reflected in various directions so that a white image can be displayed.

[0298] For example, the first conductive film, the electrode **751**(*i*,*j*), or the like can be used as the reflective film.

[0299] For example, a film including a region positioned such that a light-transmitting conductive film **751**A is sandwiched between the region and the layer **753** containing a liquid crystal material can be used as the reflective film **751**B (see FIG. **9**A).

[0300] For example, a film including a region positioned between the layer **753** containing a liquid crystal material and a light-transmitting conductive film **751**C can be used as the reflective film **751**B (see FIG. **9**B).

[0301] For example, a film including a region positioned between the light-transmitting conductive film **751**A and the light-transmitting conductive film **751**C can be used as the reflective film **751**B (see FIG. **9**C).

[0302] For example, a film reflecting visible light may be used for the electrode **751**(*i*,*j*) (see FIG. **9**D).

[0303] The reflective film has a shape including the region **751**H where light emitted from the second display element **550**(*i*,*j*) is not blocked (see FIGS. **10**A to **10**C).

[0304] For example, the reflective film can have one or more openings. Specifically, the region **751**H may have a polygonal shape, a quadrangular shape, an elliptical shape, a circular shape, a cross-like shape, or the like. The region **751**H may alternatively have a stripe shape, a slit-like shape, or a checkered pattern.

[0305] If the ratio of the total area of the region **751**H to the total area of the reflective film is too large, an image displayed using the first display element **750**(*i*,*j*) is dark.

[0306] If the ratio of the total area of the region **751**H to the total area of the reflective film is too small, an image displayed using the second display element **550**(*i*,*j*) is dark. The reliability of the second display element **550**(*i*,*j*) may be degraded.

[0307] For example, the region **751**H provided in the pixel **702**(*i*,*j*+1) is not provided on a line that extends in the row direction (the direction indicated by the arrow R**1** in the drawing) through the region **751**H provided in the pixel **702**(*i*,*j*) (see FIG. **10**A). Alternatively, for example, the region **751**H provided in the pixel **702**(*i*+1,j) is not provided on a line that extends in the column direction (the direction indicated by the arrow C**1** in the drawing) through the region **751**H provided in the pixel **702**(*i*,*j*) (see FIG. **10**B).

[0308] For example, the region **751**H provided in the pixel **702**(*i*,*j*+2) is provided on a line that extends in the row direction through the region **751**H provided in the pixel **702**(*i*,*j*) (see FIG. **10**A). In addition, the region **751**H provided in the pixel **702**(*i*,*j*+1) is provided on a line that is perpendicular to the above line between the region **751**H provided in the pixel **702**(*i*,*j*) and the region **751**H provided in the pixel **702**(*i*,*j*+2).

[0309] Alternatively, for example, the region **751**H provided in the pixel **702**(*i*+2,j) is provided on a line that extends in the column direction through the region **751**H provided in the pixel **702**(*i*,*j*) (see FIG. **10**B). In addition, for example, the region **751**H provided in the pixel **702**(*i*+1,j) is provided on a line that is perpendicular to the above line between the region **751**H provided in the pixel **702**(*i*,*j*) and the region **751**H provided in the pixel **702**(*i*+2,j).

[0310] When the second display elements are provided in the above manner to overlap with the regions where light is not blocked, the second display element of one pixel adjacent to another pixel can be apart from a second display element of the another pixel. A display element that displays color different from that displayed from the second display element of one pixel can be provided as the second display element of another pixel adjacent to the one pixel. The difficulty in arranging a plurality of display elements that represent different colors adjacent to each other can be lowered. Thus, a novel display panel with high convenience or high reliability can be provided.

[0311] The reflective film can have a shape in which an end portion is cut off so as to form the region **751**H, for example (see FIG. **10**C). Specifically, the electrode **751**(*i*,*j*) whose end portion is cut off so as to be shorter in the column direction (the direction indicated by an arrow C**1** in the drawing) can be used.

<<Electrode **752**>>

[0312] For example, a material that can be used for the wiring or the like can be used for the electrode **752**. For example, a material that has a light-transmitting property selected from materials that can be used for the wiring or the like can be used for the electrode **752**.

[0313] For example, a conductive oxide, a metal film thin enough to transmit light, a metal nanowire, or the like can be used for the electrode **752**.

[0314] Specifically, a conductive oxide containing indium can be used for the electrode **752**. Alternatively, a metal thin film with a thickness greater than or equal to 1 nm and less than or equal to 10 mn can be used for the electrode **752**. Alternatively, a metal nanowire containing silver can be used for the electrode **752**.

[0315] Specifically, indium oxide, indium tin oxide, indium zinc oxide, zinc oxide, zinc oxide to which gallium is added, zinc oxide to which aluminum is added, or the like can be used for the electrode **752**.

<<Alignment Films AF**1** and AF**2**>>

[0316] The alignment films AF**1** and AF**2** can be formed using a material containing polyimide or the like, for example. Specifically, a material formed by rubbing treatment or an optical alignment technique such that a liquid crystal material has predetermined alignment can be used.

[0317] For example, a film containing soluble polyimide can be used for the alignment film AF**1** or AF**2**. In that case, the temperature required in forming the alignment film AF**1** or AF**2** can be low. As a result, damage to other components caused when the alignment film AF**1** or the alignment film AF**2** is formed can be reduced.

<<Coloring Film CF**1**>>

[0318] The coloring film CF**1** can be formed using a material transmitting light of a certain color and can thus be used for a color filter or the like.

[0319] For example, a material that transmits blue light, green light, or red light can be used for the coloring film CF**1**. In that case, the spectral width of light that is transmitted through the coloring film CF**1** can be narrowed, so that clear display can be provided.

[0320] Furthermore, for example, a material that absorbs blue light, green light, or red light can be used for the coloring film CF**1**. Specifically, a material transmitting yellow light, magenta light, or cyan light can be used for the coloring film CF**1**. In that case, the spectral width of light that is absorbed by the coloring film CF**1** can be narrowed, so that bright display can be provided.

<<Light-Blocking Film BM>>

[0321] The light-blocking film BM can be formed with a material that prevents light transmission and can thus be used as a black matrix, for example.

[0322] Specifically, a resin containing a pigment or dye can be used for the light-blocking film BM. For example, a resin in which carbon black is dispersed can be used for the blocking film.

[0323] Alternatively, an inorganic compound, an inorganic oxide, a composite oxide containing a solid solution of a plurality of inorganic compounds, or the like can be used for the light-blocking film BM. Specifically, a black chromium film, a film containing cupric oxide, or a film containing copper chloride or tellurium chloride can be used for the light-blocking film BM.

<<Insulating Film **771**>>

[0324] The insulating film **771** can be formed of polyimide, an epoxy resin, an acrylic resin, or the like.

<<Functional Films **770**P and **770**D>>

[0325] An antireflective film, a polarizing film, a retardation film, a light diffusion film, a condensing film, or the like can be used for the functional film **770**P or the functional film **770**D, for example.

[0326] Specifically, a film containing a dichromatic pigment can be used for the functional film **770**P or the functional film **770**D. Alternatively, a material with a columnar structure having an axis along the direction intersecting a surface of a base can be used for the functional film **770**P or the functional film **770**D. In that case, light can be easily transmitted in the direction along the axis and easily scattered in other directions.

[0327] Alternatively, an antistatic film preventing the attachment of a foreign substance, a water repellent film suppressing the attachment of stain, a hard coat film suppressing a scratch in use, or the like can be used as the functional film **770**P.

[0328] Specifically, a circularly polarizing film can be used for the functional film **770**P. Furthermore, a light diffusion film can be used for the functional film **770**D.

<<Second Display Element **550**(*i*,*j*)>>

[0329] For example, a display element having a function of emitting light can be used as the second display element **550**(*i*,*j*). Specifically, a light-emitting diode or the like can be used as the second display element **550**(*i*,*j*). For example, a micro LED can be used as the second display element **550**(*i*,*j*). Specifically, a micro LED whose light-emitting region has an area of 1 mm^2 or less, preferably 10000 μm^2 or less, more preferably 3000 μm^2 or less, still more preferably 700 μm^2 or less can be used as the second display element **550**(*i*,*j*).

[0330] The second display element **550**(*i*,*j*) includes the electrode **551**(*i*,*j*), the electrode **552**, and the multilayer film **553**. The multilayer film **553** includes a semiconductor film. The multilayer film **553** includes, for example, a p-type clad layer, an n-type clad layer, and a light-emitting layer that includes a region positioned between the p-type clad layer and the n-type clad layer. For example, the electrode **551**(*i*,*j*) and the electrode **552** are electrically connected to the p-type clad layer and the n-type clad layer, respectively. This allows recombination of carriers in the light-emitting layer, resulting in light emission.

[0331] For example, a laminated material for emitting blue light, green light, or red light can be used for the multilayer film **553**. Specifically, a compound of gallium and phosphorus, a compound of gallium and arsenic, a compound of gallium, aluminum, and arsenic, a compound of aluminum, gallium, indium, and phosphorus, a compound of indium and gallium nitride, or the like can be used for the multilayer film **553**.

[0332] For example, any of the materials that can be used for the wiring or the like can be used for the electrode **551**(*i*,*j*) or the electrode **552**. Alternatively, a material that transmits light emitted from the multilayer film **553** and is selected from the materials that can be used for the wiring or the like can be used for the electrode **551**(*i*,*j*).

[0333] For example, conductive oxide, indium-containing conductive oxide, indium oxide, indium tin oxide, indium zinc oxide, zinc oxide, zinc oxide to which gallium is added, or the like can be used for the electrode **551**(*i*,*j*). Alternatively, a metal film that is thin enough to transmit light can be used for the electrode **551**(*i*,*j*).

<<Color Conversion Layer CC>>

[0334] A color conversion layer CC can be used. The color conversion layer CC has a function of absorbing light of a color that is emitted from the second display element **550**(*i*,*j*) and emitting light of a different color.

[0335] The color conversion layer CC has a function of absorbing blue light emitted from the second display ele-

ment **550**(*i,j*) and emitting yellow light, for example. Thus, yellow light emitted from the color conversion layer CC and blue light transmitted through the color conversion layer CC can be mixed, so that white light can be obtained.

[0336] The color conversion layer CC has a function of absorbing near-ultraviolet light emitted from the second display element **550**(*i,j*) and emitting red light, green light, and blue light, for example. Thus, a light-emitting element that emits near-ultraviolet light can be used as the second display element **550**(*i,j*). Accordingly, near-ultraviolet light can be converted to white light or light having an excellent color rendering property.

[0337] For example, a phosphor can be used for the color conversion layer. Alternatively, a quantum dot can be used for the color conversion layer. The use of a quantum dot for the color conversion layer allows emission of vivid-color light with a narrow half width.

<<Conductive Materials **31** and **32**>>

[0338] For example, a conductive paste, indium-containing solder, or an anisotropic conductive film can be used for the conductive material **31** or the conductive material **32**.

<<Driver Circuit GD>>

[0339] Any of a variety of sequential circuits, such as a shift register, can be used as the driver circuit GD. For example, a transistor MD, a capacitor, and the like can be used in the driver circuit GD. Specifically, a transistor including a semiconductor film that can be formed in the same process as the semiconductor film of the transistor M or the transistor that can be used as the switch SW**1** can be used.

[0340] As the transistor MD, a transistor having a structure different from that of the transistor that can be used as the switch SW**1** can be used, for example. Specifically, a transistor including the conductive film **524** can be used as the transistor MD (see FIG. **5**B).

[0341] Note that the transistor MD can have the same structure as the transistor M.

<<Transistor>>

[0342] For example, semiconductor films formed in the same process can be used for transistors in the driver circuit and the pixel circuit.

[0343] As the transistor in the driver circuit or the pixel circuit, a bottom-gate transistor or a top-gate transistor can be used, for example.

[0344] A manufacturing line for a bottom-gate transistor including amorphous silicon as a semiconductor can be easily remodeled into a manufacturing line for a bottom-gate transistor including an oxide semiconductor as a semiconductor, for example. Furthermore, for example, a manufacturing line for a top-gate transistor including polysilicon as a semiconductor can be easily remodeled into a manufacturing line for a top-gate transistor including an oxide semiconductor as a semiconductor. In either reconstruction, a conventional manufacturing line can be effectively used.

[0345] For example, a transistor including a semiconductor containing an element belonging to Group 14 for a semiconductor film can be used. Specifically, a semiconductor containing silicon can be used for a semiconductor film. For example, single crystal silicon, polysilicon, microcrystalline silicon, or amorphous silicon can be used for the semiconductor film of the transistor.

[0346] Note that the temperature for forming a transistor using polysilicon as a semiconductor is lower than the temperature for forming a transistor using single crystal silicon as a semiconductor.

[0347] In addition, the transistor using polysilicon as a semiconductor has higher field-effect mobility than the transistor using amorphous silicon as a semiconductor, and therefore a pixel including the transistor using polysilicon can have a high aperture ratio. Moreover, pixels arranged at high resolution, a gate driver circuit, and a source driver circuit can be formed over the same substrate. As a result, the number of components included in an electronic device can be reduced.

[0348] In addition, the transistor using polysilicon as a semiconductor has higher reliability than the transistor using amorphous silicon as a semiconductor.

[0349] Alternatively, a transistor including a compound semiconductor can be used. Specifically, a semiconductor containing gallium arsenide can be used for a semiconductor film.

[0350] Alternatively, a transistor including an organic semiconductor can be used. Specifically, an organic semiconductor containing any of polyacenes and graphene can be used for a semiconductor film.

[0351] For example, a transistor using an oxide semiconductor for a semiconductor film can be used. Specifically, an oxide semiconductor containing indium or an oxide semiconductor containing indium, gallium, and zinc can be used for a semiconductor film.

[0352] For example, a transistor having a lower leakage current in an off state than a transistor using amorphous silicon for a semiconductor film can be used. Specifically, a transistor using an oxide semiconductor for a semiconductor film can be used.

[0353] Thus, a pixel circuit can hold an image signal for a longer time than a pixel circuit including a transistor that uses amorphous silicon for a semiconductor film. Specifically, the selection signal can be supplied at a frequency of lower than 30 Hz, preferably lower than 1 Hz, more preferably less than once per minute while flickering is suppressed. Consequently, eyestrain on a user of the data processing device can be reduced, and power consumption for driving can be reduced.

[0354] For example, a transistor including a semiconductor film **508**, a conductive film **504**, the conductive film **512**A, and the conductive film **512**B can be used as the switch SW**1** (see FIG. **6**B). The insulating film **506** includes a region positioned between the semiconductor film **508** and the conductive film **504**.

[0355] The conductive film **504** includes a region overlapping with the semiconductor film **508**. The conductive film **504** functions as a gate electrode. The insulating film **506** functions as a gate insulating film.

[0356] The conductive films **512**A and **512**B are electrically connected to the semiconductor film **508**. The conductive film **512**A has one of a function of a source electrode and a function of a drain electrode, and the conductive film **512**B has the other.

[0357] Furthermore, a transistor including the conductive film **524** can be used as the transistor included in the driver circuit or the pixel circuit (see FIG. **5**B). The conductive film **524** includes a region provided such that the semiconductor

film **508** is positioned between the conductive film **504** and the conductive film **524**. The insulating film **516** includes a region positioned between the conductive film **524** and the semiconductor film **508**. For example, the conductive film **524** can be electrically connected to a wiring that supplies the same potential as that supplied to the conductive film **504**.

[0358] A conductive film in which a 10-nm-thick film containing tantalum and nitrogen and a 300-nm-thick film containing copper are stacked can be used as the conductive film **504**, for example. A film containing copper includes a region provided such that a film containing tantalum and nitrogen is positioned between the film containing copper and the insulating film **506**.

[0359] A material in which a 400-nm-thick film containing silicon and nitrogen and a 200-nm-thick film containing silicon, oxygen, and nitrogen are stacked can be used for the insulating film **506**, for example. Note that the film containing silicon and nitrogen includes a region provided such that the film containing silicon, oxygen, and nitrogen is positioned between the film containing silicon and nitrogen and the semiconductor film **508**.

[0360] For example, a 25-nm-thick film containing indium, gallium, and zinc can be used as the semiconductor film **508**.

[0361] For example, a conductive film in which a 50-nm-thick film containing tungsten, a 400-nm-thick film containing aluminum, and a 100-nm-thick film containing titanium are stacked in this order can be used as the conductive film **512**A or **512**B. Note that the film containing tungsten includes a region in contact with the semiconductor film **508**.

<Structural Example 6 of Display Panel>

[0362] The structure of a display panel of one embodiment of the present invention will be described with reference to FIGS. **3**A and **3**B.

[0363] FIGS. **3**A and **3**B illustrate the structure of the display panel of one embodiment of the present invention. FIG. **3**A is a cross-sectional view of a pixel, which corresponds to the cross-sectional view taken along line Y**1**-Y**2** in FIG. **1**A. FIG. **3**B is a cross-sectional view illustrating part of FIG. **3**A.

[0364] The structure of the display panel described in this structural example is the same as that of the display panel **700** described with reference to FIGS. **2**A and **2**B except that a lens **580** is provided. Different portions will be described in detail below, and the above description is referred to for the similar portions.

[0365] The display panel described in this embodiment includes the lens **580**. The lens **580** includes a region positioned between the optical element **560** and the second display element **550**(*i*,*j*) (see FIGS. **3**A and **3**B).

[0366] The lens **580** is a convex lens that includes a material with a refractive index of 1.5 or more and 2.5 or less.

[0367] With such a structure, light emitted from the second display element can be gathered toward the optical axis of the optical element, for example. Alternatively, light emitted from the second display element can be used efficiently. Alternatively, the density of a current supplied to the light-emitting diode can be decreased. Alternatively, the area of the second display element can be increased. Alternatively, the reliability of the light-emitting diode can be increased. Consequently, a novel display panel with high convenience or high reliability can be provided.

[0368] For example, a plano-convex lens can be used as the lens **580**.

<<Lens **580**>>

[0369] A plano-convex lens or a double-convex lens can be used as the lens **580**.

[0370] A material that transmits visible light can be used for the lens **580**. Alternatively, a material whose refractive index is greater than or equal to 1.3 and less than or equal to 2.5 can be used for the lens **580**. For example, an inorganic material or an organic material can be used for the lens **580**.

[0371] For example, a material including an oxide or a sulfide can be used for the lens **580**.

[0372] Specifically, cerium oxide, hafnium oxide, lanthanum oxide, magnesium oxide, niobium oxide, tantalum oxide, titanium oxide, yttrium oxide, zinc oxide, an oxide containing indium and tin, an oxide containing indium, gallium, and zinc, or the like can be used for the lens **580**. Alternatively, zinc sulfide or the like can be used for the lens **580**.

[0373] For example, the lens **580** can be formed using a material containing a resin. Specifically, the lens **580** can be formed using a resin to which chlorine, bromine, or iodine is introduced, a resin to which a heavy metal atom is introduced, a resin to which an aromatic ring is introduced, a resin to which sulfur is introduced, or the like. Alternatively, the lens **580** can be formed using a material containing a resin and nanoparticles of a material whose refractive index is higher than that of the resin. Titanium oxide, zirconium oxide, or the like can be used for the nanoparticles.

[0374] Note that this embodiment can be combined with any of the other embodiments in this specification as appropriate.

Embodiment 2

[0375] In this embodiment, the structures of display devices of embodiments of the present invention will be described with reference to FIGS. **13**A and **13**B and FIGS. **14**A to **14**B**3**.

[0376] FIG. **13**A is a block diagram illustrating the structure of the display device of one embodiment of the present invention. FIG. **13**B is a block diagram illustrating the structure of a pixel illustrated in FIG. **13**A.

[0377] FIG. **14**A is a block diagram illustrating a structure different from the structure of the display panel illustrated in FIG. **13**A. FIGS. **14**B**1** to **14**B**3** are external views of display devices of embodiments of the present invention.

<Structural Example of Display Device>

[0378] The display device described in this embodiment includes a control portion **238** and the display panel **700** (see FIG. **13**A).

<<Control Portion **238**>>

[0379] The control portion **238** has a function of receiving image data V**1** and control data SS.

[0380] The control portion **238** has a function of generating the data V**11** and the data V**12** on the basis of the image data V**1** and a function of supplying the data V**11** and the data V**12**.

[0381] For example, the control portion **238** includes a decompression circuit **234** and an image processing circuit **235**M.

<<Display Panel **700**>>

[0382] The display panel **700** has a function of receiving the data V**11** and the data V**12**. The display panel **700** includes the pixel **702**(*i*,*j*).

[0383] The pixel **702**(*i*,*j*) includes the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*) (see FIG. **13**B).

[0384] The first display element **750**(*i*,*j*) has a function of performing display on the basis of the data V**11**. The first display element **750**(*i*,*j*) is a reflective display element.

[0385] The second display element **550**(*i*,*j*) has a function of performing display on the basis of the data V**12**. The second display element **550**(*i*,*j*) is a light-emitting element.

[0386] For example, any of the display panels described in Embodiment 1 can be used as the display panel **700**. Alternatively, the display panel **700**B can be used. For example, a television receiver system (see FIG. **14**B**1**), a video monitor (see FIG. **14**B**2**), a laptop computer (see FIG. **14**B**3**), or the like can be provided.

[0387] Thus, image data can be displayed by controlling the intensity of light reflected by the reflective film with the use of the first display element. Alternatively, the first display element can use external light to display an image. Alternatively, glare of external light can be hardly perceived. Furthermore, image data can be displayed using the second display element. Furthermore, image data can be displayed using the second display element such that the image data overlaps with the image data displayed using the first display element. Furthermore, the image data displayed using the first display element can be complemented using the second display element. Consequently, a novel display device with high convenience or high reliability can be provided.

[0388] Hybrid display is a method for displaying text or an image with the use of reflected light and self-emitted light together in one panel that complement the color tone or light intensity of each other. Alternatively, hybrid display is a method for displaying text and/or an image with the use of light from a plurality of display elements in one pixel or one subpixel. Note that when a hybrid display that performs hybrid display is locally observed, a pixel or a subpixel that performs display using any one of the plurality of display elements and a pixel or a subpixel that performs display using two or more of the plurality of display elements are included in some cases.

[0389] Note that in the present specification and the like, hybrid display satisfies any one or a plurality of the above descriptions.

[0390] Furthermore, a hybrid display includes a plurality of display elements in one pixel or one subpixel. Note that as an example of the plurality of display elements, a reflective element that reflects light and a self-luminous element that emits light can be given. Note that the reflective element and the self-luminous element can be controlled independently. A hybrid display has a function of displaying text and/or an image with the use of one or both of reflected light and self-emitted light in a display portion.

<<Decompression Circuit **234**>>

[0391] The decompression circuit **234** has a function of decompressing the image data V**1** supplied in a compressed state. The decompression circuit **234** includes a memory portion. The memory portion has a function of storing decompressed image data, for example (see FIG. **13**A).

<<Image processing Circuit **235**M>>

[0392] The image processing circuit **235**M includes a region **235**M(**1**) and a region **235**M(**2**), for example.

[0393] The region **235**M(**1**) or the region **235**M(**2**) has a function of storing data contained in the image data V**1**, for example.

[0394] The image processing circuit **235**M has a function of generating the data V**11** by correcting the image data V**1** on the basis of a predetermined characteristic curve and a function of supplying the data V**11**, for example. Specifically, the image processing circuit **235**M has a function of generating the data V**11** so that the first display element displays a favorable image.

[0395] The image processing circuit **235**M has a function of generating the data V**12** by correcting the image data V**1** on the basis of a predetermined characteristic curve and a function of supplying the data V**12**, for example. Specifically, the image processing circuit **235**M has a function of generating the data V**12** so that the second display element displays a favorable image.

[0396] Note that this embodiment can be combined with any of the other embodiments in this specification as appropriate.

Embodiment 3

[0397] In this embodiment, the structure of an input/output device of one embodiment of the present invention will be described with reference to FIG. **15**.

[0398] FIG. **15** is a block diagram illustrating the structure of the input/output device of one embodiment of the present invention.

<Structural Example of Input/Output Device>

[0399] The input/output device described in this embodiment includes a display portion **230** and an input portion **240** (see FIG. **15**). For example, the display panel **700** described in Embodiment 1 can be used for the display portion **230**.

[0400] The input portion **240** includes a sensing region **241** and has a function of sensing an object that approaches the sensing region **241**.

[0401] The sensing region **241** includes a region overlapping with the pixel **702**(*i*,*j*).

<<Input Portion **240**>>

[0402] The input portion **240** includes a sensing region **241** and can include an oscillator circuit OSC and a detection circuit DC (see FIG. **15**).

[0403] The sensing region **241** can include a sensor element, for example.

<<Sensor Element>>

[0404] A sensor element has a function of sensing an approaching pointer. For example, a finger, a stylus pen, or the like can be used as the pointer. Specifically, a piece of metal, a coil, or the like can be used for the stylus pen.

[0405] For example, a capacitive proximity sensor, an electromagnetic inductive proximity sensor, an optical proximity sensor, a resistive proximity sensor, or the like can be used as the sensor element.

[0406] Alternatively, a plurality of kinds of proximity sensors can be used in combination. For example, a proximity sensor that senses a finger and a proximity sensor that senses a stylus pen can be used in combination. This allows determination of the kind of a pointer. Alternatively, an instruction can be associated with sensing data depending on the kind of a pointer. Specifically, in the case where it is determined that a finger is used as a pointer, sensing data can be associated with a gesture. In the case where it is determined that a stylus pen is used as a pointer, sensing data can be associated with drawing processing.

[0407] Specifically, a capacitive proximity sensor or an optical proximity sensor can be used to sense a finger. Alternatively, an electromagnetic inductive proximity sensor or an optical proximity sensor can be used to sense a stylus pen.

[0408] Note that this embodiment can be combined with any of the other embodiments in this specification as appropriate.

Embodiment 4

[0409] In this embodiment, the structure of an input/output panel of one embodiment of the present invention will be described with reference to FIGS. **16**A to **16**C to FIG. **18**.

[0410] FIGS. **16**A to **16**C illustrate the structure of the input/output panel that can be used for the input/output device of one embodiment of the present invention. FIG. **16**A is a top view of the input/output panel. FIG. **16**B is a schematic view illustrating part of an input portion of the input/output panel, and FIG. **16**C is a schematic view illustrating part of FIG. **16**B.

[0411] FIGS. **17**A and **17**B and FIG. **18** illustrate the structure of the input/output panel which can be used for the input/output device of one embodiment of the present invention. FIG. **17**A is a cross-sectional view taken along lines X**1**-X**2** and X**3**-X**4** in FIG. **16**A and line X**5**-X**6** in FIG. **16**C. FIG. **17**B is a cross-sectional view illustrating part of the structure illustrated in FIG. **17**A.

[0412] FIG. **18** is a cross-sectional view taken along line X**7**-X**8** in FIG. **16**C and lines X**9**-X**10** and X**11**-X**12** in FIG. **16**A.

<Structural Example 1 of Input/Output Panel>

[0413] The input/output panel **700**TP**2** described in this embodiment is different from the display panel **700** described in Embodiment 1, for example, in that the functional layer **720** has a different structure and a top-gate transistor is provided. Different portions will be described in detail below, and the above description is referred to for the similar portions.

<<Functional Layer **720**>>

[0414] The functional layer **720** includes a region positioned between the substrate **770** and the insulating film **501**C. The functional layer **720** includes the light-blocking film BM, the insulating film **771**, the coloring film CF**1**, a control line CL(g), a sensor signal line ML(h), and a sensor element **775**(*g*,*h*) (see FIG. **17**A).

[0415] Note that a gap between the control line CL(g) and the electrode **752** or between the sensor signal line ML(h) and the electrode **752** is greater than or equal to 0.2 μm and less than or equal to 16 μm, preferably greater than or equal to 1 μm and less than or equal to 8 μm, more preferably greater than or equal to 2.5 μm and less than or equal to 4 μm. This can reduce an influence of a control signal or a sensor signal on the display state of the first display element. Furthermore, the input/output panel can be made thin.

<<Sensing Region **241**>>

[0416] The sensing region **241** includes part of the functional layer **720**. For example, the sensing region **241** includes the control line CL(g), the sensor signal line ML(h), and the sensor element **775**(*g*,*h*).

[0417] The sensor element **775**(*g*,*h*) is electrically connected to the control line CL(g) and the sensor signal line ML(h).

[0418] The control line CL(g) has a function of supplying a control signal. The sensor signal line ML(h) has a function of receiving a sensor signal.

<<Sensor Element **775**(*g*,*h*)>>

[0419] The sensor element **775**(*g*,*h*) has a function of supplying a sensor signal that varies in accordance with a control signal and a distance between a region overlapping with the pixel **702**(*i*,*j*) and an object approaching the region. The sensor element **775**(*g*,*h*) includes a first electrode C(g) and a second electrode M(h).

[0420] The first electrode C(g) includes a light-transmitting region in the region overlapping with the pixel **702**(*i*,*j*) and is electrically connected to the control line CL(g).

[0421] The second electrode M(h) includes a light-transmitting region in the region overlapping with the pixel **702**(*i*,*j*) and is electrically connected to the sensor signal line ML(h). The second electrode M(h) is located such that an electric field part of which is blocked by an object approaching the region overlapping with the pixel **702**(*i*,*j*) is generated between the second electrode M(h) and the first electrode C(g).

[0422] With such a structure, an object approaching the region overlapping with the display portion can be sensed while image data is displayed by the display portion. Alternatively, a finger or the like that approaches the display portion can be used as a pointer to input positional data. Alternatively, positional data can be associated with image data displayed on the display portion. Consequently, a novel input/output device with high convenience or high reliability can be provided.

<<Oscillation Circuit OSC>>

[0423] The oscillator circuit OSC is electrically connected to the control line CL(g) and has a function of supplying a control signal. For example, a rectangular wave, a sawtooth wave, a triangular wave, or the like can be used as the control signal.

<<Detection Circuit DC>>

[0424] The detection circuit DC is electrically connected to the sensor signal line ML(h) and has a function of supplying a sensor signal in response to a change in the potential of the sensor signal line ML(h). Note that the sensor signal includes positional data P**1**, for example.

<<Display Portion **230**>>

[0425] Any of the display panels described in Embodiment 1 can be used for the display portion **230**, for example. Alternatively, the display device described in Embodiment 2 can be used for the display portion **230**.

[0426] Note that part of light emitted from the second display element **550**(*i,j*) passes through the layer **753** containing a liquid crystal material and then is reflected by the control line CL(g), the electrode **752**, or the like in some cases. Reflection is repeated between the electrode **752** and the electrode **751**(*i,j*) in some cases, for example. Alternatively, reflection is repeated between the substrate **770** and the electrode **751**(*i,j*) in some cases. Thus, image data can be displayed like indirect lighting with light emitted from the second display element. Alternatively, the second display element can display an image which gives less stress on eyes.

<<Sensor Element **775**(*g,h*)>>

[0427] The sensor element **775**(*g,h*) includes the first electrode C(g) and the sensor signal line ML(h).

[0428] For example, a light-transmitting conductive film can be used for the first electrode C(g) and the sensor signal line ML(h). Alternatively, a conductive film having an opening at a region overlapping with the pixel **702**(*i,j*) can be used for the first electrode C(g) and the sensor signal line ML(h). Accordingly, an object that approaches the region overlapping with the display panel can be sensed without disturbing display of the display panel.

[0429] Alternatively, a metal film having higher conductivity than a transparent conductive film can be used for the first electrode C(g) and the sensor signal line ML(h). Thus, the thickness of the input/output device can be reduced.

[0430] Note that the light-blocking film BM can be used (see FIG. **16**B and FIG. **18**). The light-blocking film BM includes a region overlapping with the first electrode C(g) and the sensor signal line ML(h) and a region positioned between the substrate **770** and the first electrode C(g) or between the substrate **770** and the sensor signal line ML(h), for example. Thus, the intensity of external light reflected by the sensor element **775**(*g,h*) can be reduced. Consequently, a novel input/output device with high convenience or high reliability can be provided.

[0431] The sensing region **241** includes a group consisting of sensor elements **775**(*g*,**1**) to **775**(*g,q*) and another group consisting of sensor elements **775**(**1**,*h*) to **775**(*p,h*) (see FIG. **15**). Note that g is an integer greater than or equal to 1 and less than or equal top, h is an integer greater than or equal to 1 and less than or equal to q, and each of p and q is an integer greater than or equal to 1.

[0432] The one group of sensor elements **775**(*g*,**1**) to **775**(*g,q*) include the sensor element **775**(*g,h*) and are arranged in the row direction (indicated by the arrow R**2** in the drawing). Note that the direction indicated by the arrow R**2** in FIG. **15** may be the same as or different from the direction indicated by the arrow R**1** in FIG. **15**.

[0433] The another group of sensor elements **775**(**1**,*h*) to **775**(*p,h*) include the sensor element **775**(*g,h*) and are provided in the column direction (indicated by the arrow C**2** in FIG. **15**) that intersects the row direction.

[0434] The one group of sensor elements **775**(*g*,**1**) to **775**(*g,q*) provided in the row direction include the first electrode C(g) that is electrically connected to the control line CL(g) (see FIG. **16**B). For example, a conductive film that can be formed in the same step can be used for the control line CL(g) and the first electrode C(g).

[0435] The another group of sensor elements **775**(**1**,*h*) to **775**(*p,h*) provided in the column direction include the electrode M(h) electrically connected to the sensor signal line ML(h). For example, a conductive film that can be formed in the same step can be used for a control line ML(h) and the electrode M(h).

[0436] The control line CL(g) includes a conductive film BR(g,h) (see FIGS. **16**B and **16**C and FIG. **17**A). The conductive film BR(g,h) includes a region overlapping with the sensor signal line ML(h).

[0437] An insulating film **706** includes a region positioned between the sensor signal line ML(h) and the conductive film BR(g,h). Thus, a short circuit between the sensor signal line ML(h) and the conductive film BR(g,h) can be prevented.

<<Conductive Film **511**D>>

[0438] The input/output panel **700**TP**2** described in this embodiment includes a conductive film **511**D (see FIG. **18**).

[0439] Note that the conductive material CP or the like can be provided between the control line CL(g) and the conductive film **511**D to electrically connect the control line CL(g) and the conductive film **511**D. Alternatively, the conductive material CP or the like can be provided between the sensor signal line ML(h) and the conductive film **511**D to electrically connect the sensor signal line ML(h) and the conductive film **511**D. A material that can be used for the wiring or the like can be used for the conductive film **511**D, for example.

<<Terminal **519**D>>

[0440] The input/output panel **700**TP**2** described in this embodiment includes a terminal **519**D. The terminal **519**D is electrically connected to the conductive film **511**D.

[0441] For example, a material that can be used for the wiring or the like can be used for the terminal **519**D. Specifically, the terminal **519**D can have the same structure as that of the terminal **519**B or the terminal **519**C (see FIG. **18**).

[0442] Note that the terminal **519**D can be electrically connected to a flexible printed circuit FPC**2** using a conductive material ACF**2**, for example. Thus, a control signal can be supplied to the control line CL(g) with the use of the terminal **519**D, for example. Alternatively, a sensor signal can be supplied from the sensor signal line ML(h) with the use of the terminal **519**D.

<<Switch SW**1**, Transistor M, and Transistor MD>>

[0443] A transistor that can be used as the switch SW**1**, the transistor M, and the transistor MD include the conductive film **504** including a region overlapping with the insulating film **501**C and the semiconductor film **508** including a region located between the insulating film **501**C and the conductive film **504**. Note that the conductive film **504** serves as a gate electrode (see FIG. **17**B).

[0444] The semiconductor film **508** includes a first region **508**A, a second region **508**B, and a third region **508**C. The first region **508**A and the second region **508**B do not overlap with the conductive film **504**. The third region **508**C is positioned between the first region **508**A and the second region **508**B and overlaps with the conductive film **504**.

[0445] The transistor MD includes the insulating film **506** between the third region **508**C and the conductive film **504**. Note that the insulating film **506** functions as a gate insulating film.

[0446] The first region **508**A and the second region **508**B have a lower resistivity than the third region **508**C, and function as a source region and a drain region.

[0447] For example, plasma treatment using a gas containing a rare gas is performed on an oxide semiconductor film, whereby the first region **508**A and the second region **508**B can be formed in the semiconductor film **508**.

[0448] For example, the conductive film **504** can be used as a mask. The use of the conductive film **504** as a mask allows the shape of part of the third region **508**C to be self-aligned with the shape of an end of the conductive film **504**.

[0449] The transistor MD includes the conductive film **512**A and the conductive film **512**B that are in contact with the first region **508**A and the second region **508**B, respectively. The conductive film **512**A and the conductive film **512**B function as a source electrode and a drain electrode.

[0450] For example, a transistor that can be fabricated in the same process as the transistor MD can be used as the transistor M.

<Structural Example 2 of Input/Output Panel>

[0451] The structure of an input/output panel of one embodiment of the present invention will be described with reference to FIG. **19**.

[0452] FIG. **19** illustrates the structure of the input/output panel of one embodiment of the present invention. FIG. **19** is a cross-sectional view of a pixel included in the input/output panel.

[0453] An input/output panel **700**TP**3** described in this structural example includes the pixel **702**(*i*,*j*) (see FIG. **19**). The input/output panel **700**TP**3** includes a first unit **10**, a second unit **20**, an input unit **30**, and the functional film **770**P. The first unit **10** includes the functional layer **520**, and the second unit **20** includes the functional layer **720**.

<<Pixel **702**(*i*,*j*)>>

[0454] The pixel **702**(*i*,*j*) includes a portion of the functional layer **520**, the first display element **750**(*i*,*j*), and the second display element **550**(*i*,*j*) (see FIG. **19**).

[0455] The functional layer **520** includes the first conductive film, the second conductive film, the insulating film **501**C, and the pixel circuit **530**(*i*,*j*). The pixel circuit **530**(*i*,*j*) that is not illustrated includes the transistor M, for example. The functional layer **520** includes the optical element **560**, the covering film **565**, and the lens **580**. The functional layer **520** includes the insulating film **528** and the insulating film **521**. A stack of the insulating film **521**A and the insulating film **521**B can be used as the insulating film **521**.

[0456] For example, a material whose refractive index is around 1.55 can be used for the insulating film **521**A or the insulating film **521**B. Alternatively, a material whose refractive index is around 1.6 can be used for the insulating film **521**A or the insulating film **521**B. Alternatively, an acrylic resin or polyimide can be used for the insulating film **521**A or the insulating film **521**B.

[0457] The insulating film **501**C includes a region positioned between the first conductive film and the second conductive film and has an opening **591**A.

[0458] The first conductive film is electrically connected to the first display element **750**(*i*,*j*). Specifically, the first conductive film is electrically connected to an electrode **751**(*i*,*j*) of the first display element **750**(*i*,*j*). The electrode **751**(*i*,*j*) can be used as the first conductive film.

[0459] The second conductive film includes a region overlapping with the first conductive film. The second conductive film is electrically connected to the first conductive film through the opening **591**A. For example, the conductive film **512**B can be used as the second conductive film. The second conductive film is electrically connected to the pixel circuit **530**(*i*,*j*). For example, a conductive film that functions as a source electrode or a drain electrode of a transistor used as the switch SW**1** of the pixel circuit **530**(*i*,*j*) can be used as the second conductive film. Note that the first conductive film electrically connected to the second conductive film in the opening **591**A formed in the insulating film **501**C can be referred to as a through electrode.

[0460] The second display element **550**(*i*,*j*) is electrically connected to the pixel circuit **530**(*i*,*j*). The second display element **550**(*i*,*j*) has a function of emitting light toward the functional layer **520**. The second display element **550**(*i*,*j*) has a function of emitting light toward the lens **580** or the optical element **560**, for example.

[0461] The second display element **550**(*i*,*j*) is provided such that display using the second display element **550**(*i*,*j*) can be seen from part of a region where display using the first display element **750**(*i*,*j*) can be seen. For example, the electrode **751**(*i*,*j*) of the first display element **750**(*i*,*j*) includes the region **751**H where light emitted from the second display element **550**(*i*,*j*) is not blocked. Note that dashed arrows shown in FIG. **19** denote the directions in which external light is incident on and reflected by the first display element **750**(*i*,*j*) that displays image data by controlling the intensity of external light reflection. In addition, a solid arrow shown in FIG. **19** denotes the direction in which the second display element **550**(*i*,*j*) emits light to the part of the region where display using the first display element **750**(*i*,*j*) can be seen.

[0462] Accordingly, display using the second display element can be seen from part of the region where display using the first display element can be seen. Alternatively, a user can see display without changing the attitude or the like of the input/output panel. Alternatively, an object color expressed by light reflected by the first display element and a light source color expressed by light emitted from the second display element can be mixed. Alternatively, an object color and a light source color can be used to display an image like a painting. Consequently, a novel input/output panel with high convenience or high reliability can be provided.

[0463] The first display element **750**(*i*,*j*) includes the electrode **751**(*i*,*j*), the electrode **752**, and the layer **753** containing a liquid crystal material, for example. The first display element **750**(*i*,*j*) further includes the alignment film AF**1** and the alignment film AF**2**. Specifically, a reflective liquid crystal element can be used as the first display element **750**(*i*,*j*).

[0464] For example, a transparent conductive film whose refractive index is around 2.0 can be used as the electrode **752** or the electrode **751**(*i*,*j*). Specifically, an oxide containing indium, tin, and silicon can be used for the electrode **752** or the electrode **751**(*i*,*j*). Alternatively, a material whose refractive index is around 1.6 can be used for the alignment film.

[0465] The second display element **550**(*i*,*j*) includes the electrode **551**(*i*,*j*), the electrode **552**, and a multilayer film **553**(*j*), for example. The electrode **551**(*i*,*j*) is electrically connected to the pixel circuit **530**(*i*,*j*) at the connection portion **522**. Specifically, a light-emitting diode can be used as the second display element **550**(*i*,*j*).

[0466] For example, a transparent conductive film having a refractive index of around 2.0 can be used for the electrode **551**(*i*,*j*). Specifically, an oxide containing indium, tin, and silicon can be used for the electrode **551**(*i*,*j*).

[0467] The optical element **560** has a light-transmitting property and includes a first region, a second region, and a third region.

[0468] The first region includes a region to which visible light is supplied from the second display element **550**(*i*,*j*), the second region includes a region in contact with the covering film **565**, and the third region has a function of emitting part of visible light. The third region has an area smaller than or equal to the area of the region of the first region to which visible light is supplied.

[0469] The covering film **565** has visible light reflectivity and has a function of reflecting part of visible light and supplying it to the third region.

[0470] For example, a metal can be used for the covering film **565**. Specifically, a material containing silver can be used for the covering film **565**. For example, a material containing silver, palladium, and the like or a material containing silver, copper, and the like can be used for the covering film **565**.

<<Functional Layer **720**>>

[0471] The functional layer **720** includes a region positioned between the substrate **770** and the insulating film **501**C. The functional layer **720** further includes the insulating film **771** and the coloring film CF**1**.

[0472] The coloring film CF**1** includes a region positioned between the substrate **770** and the first display element **750**(*i*,*j*).

[0473] The insulating film **771** includes a region positioned between the coloring film CF**1** and the layer **753** containing a liquid crystal material. The insulating film **771** can reduce unevenness due to the thickness of the coloring film CF**1**. Furthermore, the insulating film **771** can prevent impurities from diffusing from the coloring film CF**1** or the like to the layer **753** containing a liquid crystal material.

[0474] For example, an acrylic resin whose refractive index is around 1.55 can be used for the insulating film **771**.

<<Substrate **570** and Substrate **770**>>

[0475] The input/output panel described in this embodiment includes the substrate **570** and the substrate **770**.

[0476] The substrate **770** includes a region overlapping with the substrate **570**. The substrate **770** includes a region provided such that the functional layer **520** is positioned between the substrate **770** and the substrate **570**.

[0477] The substrate **770** includes a region overlapping with the first display element **750**(*i*,*j*). For example, a material with low birefringence can be used for the region.

[0478] For example, a resin material whose refractive index is around 1.5 can be used for the substrate **770**.

<<Bonding Layer **505**>>

[0479] The input/output panel described in this embodiment also includes the bonding layer **505**.

[0480] The bonding layer **505** includes a region positioned between the functional layer **520** and the substrate **570**, and has a function of bonding the functional layer **520** and the substrate **570** to each other.

<<Structure Bodies KB**1** and KB**2**>>

[0481] The input/output panel described in this embodiment includes the structure body KB**1** and a structure body KB**2**.

[0482] The structure body KB**1** has a function of providing a certain space between the functional layer **520** and the substrate **770**. The structure body KB**1** includes a region overlapping with the region **751**H and has a light-transmitting property. Thus, light emitted from the second display element **550**(*i*,*j*) can be supplied to one surface of the structure body KB**1** and extracted from the other surface.

[0483] Furthermore, the structure body KB**1** includes a region overlapping with the optical element **560** and is formed using a material whose refractive index is different from that of a material used for the optical element **560** by 0.2 or less, for example. Accordingly, light emitted from the second display element can be used efficiently. Alternatively, the area of the second display element can be increased. Alternatively, the density of a current supplied to a light-emitting diode can be decreased.

[0484] The structure body KB**2** has a function of controlling the thickness of a polarizing layer **770**PB to be a predetermined thickness. The structure body KB**2** includes a region overlapping with the second display element **550**(*i*,*j*) and has a light-transmitting property.

[0485] A material that transmits light of a predetermined color may be used for the structure body KB**1** or KB**2**. Thus, the structure body KB**1** or KB**2** can be used as a color filter, for example. For example, a material that transmits blue light, green light, or red light can be used for the structure body KB**1** or KB**2**. Alternatively, a material that transmits yellow light, white like, or the like can be used for the structure body KB**1** or KB**2**.

[0486] Specifically, polyester, polyolefin, polyamide, polyimide, polycarbonate, polysiloxane, an acrylic resin, or the like, or a composite material of a plurality of kinds of resins selected from these can be used for the structure bodies KB**1** and KB**2**. Alternatively, a photosensitive material may be used.

[0487] For example, an acrylic resin whose refractive index is around 1.5 can be used for the structure body KB**1**. An acrylic resin whose refractive index is around 1.55 can be used for the structure body KB**2**.

<<Input Unit **30**>>

[0488] The input unit **30** includes a sensor element. The sensor element has a function of sensing an object that approaches a region overlapping with the pixel **702**(*i*,*j*). Accordingly, a finger or the like that approaches the display portion can be used as a pointer to input positional data.

[0489] For example, a capacitive proximity sensor, an electromagnetic inductive proximity sensor, an optical proximity sensor, a resistive proximity sensor, or a surface acoustic wave proximity sensor can be used as the input unit

30. Specifically, a surface capacitive proximity sensor, a projected capacitive proximity sensor, or an infrared proximity sensor can be used.

[0490] For example, a touch sensor which includes a capacitive proximity sensor and whose refractive index is around 1.6 can be used as the input unit **30**.

<<Functional Films **770**D and **770**P and Other Components>>

[0491] The input/output panel **700**TP**3** described in this embodiment includes the functional film **770**D and the functional film **770**P.

[0492] The functional film **770**D includes a region overlapping with the first display element **750**(*i*,*j*). The functional film **770**D includes a region provided such that the first display element **750**(*i*,*j*) is positioned between the functional film **770**D and the functional layer **520**.

[0493] For example, a light diffusion film can be used as the functional film **770**D. Specifically, a material with a columnar structure having an axis along the direction intersecting a surface of a base can be used for the functional film **770**D. In that case, light can be easily transmitted in the direction along the axis and easily scattered in other directions. For example, light reflected by the first display element **750**(*i*,*j*) can be diffused.

[0494] The functional film **770**P includes the polarizing layer **770**PB, a retardation film **770**PA, and the structure body KB**2**. The polarizing layer **770**PB includes an opening, and the retardation film **770**PA includes a region overlapping with the polarizing layer **770**PB. Note that the structure body KB**2** is provided in the opening.

[0495] For example, a dichromatic pigment, a liquid crystal material, and a resin can be used for the polarizing layer **770**PB. The polarizing layer **770**PB has a polarization property. In that case, the functional film **770**P can be used as a polarizing plate.

[0496] The polarizing layer **770**PB includes a region overlapping with the first display element **750**(*i*,*j*), and the structure body KB**2** includes a region overlapping with the second display element **550**(*i*,*j*). Thus, a liquid crystal element can be used as the first display element. For example, a reflective liquid crystal element can be used as the first display element. Alternatively, light emitted from the second display element can be extracted efficiently. Alternatively, the density of a current supplied to a light-emitting diode can be decreased. Alternatively, the reliability of a light-emitting diode can be increased.

[0497] For example, an anti-reflection film, a polarizing film, or a retardation film can be used as the functional film **770**P. Specifically, a film containing a dichromatic pigment and a retardation film can be used as the functional film **770**P.

[0498] Alternatively, an antistatic film preventing the attachment of a foreign substance, a water repellent film suppressing the attachment of stain, a hard coat film suppressing a scratch in use, or the like can be used as the functional film **770**P.

[0499] For example, a material whose refractive index is around 1.6 can be used for a diffusion film. A material whose refractive index is around 1.6 can be used for the retardation film **770**PA.

[0500] Note that this embodiment can be combined with any of the other embodiments in this specification as appropriate.

Embodiment 5

[0501] In this embodiment, the structure of a data processing device of one embodiment of the present invention will be described with reference to FIGS. **20**A to **20**C, FIGS. **21**A and **21**B, and FIG. **22**.

[0502] FIG. **20**A is a block diagram illustrating the structure of the data processing device of one embodiment of the present invention. FIGS. **20**B and **20**C are projection views each illustrating an example of an external view of the data processing device **200**.

[0503] FIGS. **21**A and **21**B are flow charts showing a program of one embodiment of the present invention. FIG. **21**A is a flow chart showing main processing of the program of one embodiment of the present invention. FIG. **21**B is a flow chart showing interrupt processing.

[0504] FIG. **22** is a flow chart showing interrupt processing of the program of one embodiment of the present invention.

<Structural Example 1 of Data Processing Device>

[0505] The data processing device **200** described in this embodiment includes an input/output device **220** and an arithmetic device **210** (see FIG. **20**A). The input/output device **220** is electrically connected to the arithmetic device **210**. Furthermore, the data processing device **200** can include a housing (see FIG. **20**B or **20**C).

[0506] The input/output device **220** includes the display portion **230** and the input portion **240** (see FIG. **20**A). The input/output device **220** includes a sensor portion **250**. The input/output device **220** can include a communication portion **290**.

[0507] The input/output device **220** has a function of receiving the image data V**1** or the control data SS and a function of supplying the positional data P**1** or sensing data S**1**.

[0508] The arithmetic device **210** has a function of receiving the positional data P**1** or the sensing data S**1**. The arithmetic device **210** has a function of supplying the image data V**1**. The arithmetic device **210** has a function of operating on the basis of the positional data P**1** or the sensing data S**1**.

[0509] Note that the housing has a function of housing the input/output device **220** or the arithmetic device **210**. Alternatively, the housing has a function of supporting the display portion **230** or the arithmetic device **210**.

[0510] The display portion **230** has a function of displaying an image on the basis of the image data V**1**. The display portion **230** has a function of displaying an image on the basis of the control data SS.

[0511] The input portion **240** has a function of supplying the positional data P**1**.

[0512] The sensor portion **250** has a function of supplying the sensing data S**1**. The sensor portion **250** has a function of sensing the illuminance of the environment where the data processing device **200** is used and a function of supplying illuminance data, for example.

[0513] Thus, the data processing device can determine the intensity of light received by the housing of the data processing device and operate in a usage environment. Alternatively, a user of the data processing device can select a display method. Specifically, when a display method using the first display element is selected, power consumption can be reduced, for example. Alternatively, when a display

method using the second display element is selected, display can be performed in a dark place, for example. Alternatively, when a display method using the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*) is selected, display that is based on the user's preference and comfortable for the user can be performed. Consequently, a novel data processing device with high convenience or high reliability can be provided.

[0514] Individual components included in the data processing device will be described below. Note that these components cannot be clearly distinguished from each other and one component may also serve as another component or include part of another component. For example, a touch panel in which a touch sensor is provided to overlap with a display panel serves as an input portion as well as a display portion.

<<Structural Example>>

[0515] The data processing device **200** of one embodiment of the present invention includes a housing or the arithmetic device **210**.

[0516] The arithmetic device **210** includes an arithmetic portion **211**, a memory portion **212**, a transmission path **214**, and an input/output interface **215**.

[0517] The data processing device of one embodiment of the present invention includes the input/output device **220**.

[0518] The input/output device **220** includes the display portion **230**, the input portion **240**, the sensor portion **250**, and the communication portion **290**.

<<Data Processing Device>>

[0519] The data processing device of one embodiment of the present invention includes the arithmetic device **210** and the input/output device **220**.

<<Arithmetic Device **210**>>

[0520] The arithmetic device **210** includes the arithmetic portion **211** and the memory portion **212**. The arithmetic device **210** also includes the transmission path **214** and the input/output interface **215**.

<<Arithmetic Portion **211**>>

[0521] The arithmetic portion **211** has a function of executing a program, for example.

<<Memory Portion **212**>>

[0522] The memory portion **212** has a function of, for example, storing a program executed by the arithmetic portion **211**, initial data, setting data, an image, or the like.

[0523] Specifically, a hard disk, a flash memory, a memory including a transistor including an oxide semiconductor, or the like can be used for the memory portion **212**.

<<Input/Output Interface **215** and Transmission Path **214**>>

[0524] The input/output interface **215** includes a terminal or a wiring and has a function of supplying and receiving data. The input/output interface **215** can be electrically connected to the transmission path **214** and the input/output device **220**.

[0525] The transmission path **214** includes a wiring and has a function of supplying and receiving data. For example, the transmission path **214** can be electrically connected to the input/output interface **215**. In addition, the transmission path **214** can be electrically connected to the arithmetic portion **211** and the memory portion **212**.

<<Input/Output Device **220**>>

[0526] The input/output device **220** includes the display portion **230**, the input portion **240**, the sensor portion **250**, and the communication portion **290**. For example, the input/output device described in Embodiment 3 can be used. In that case, power consumption can be reduced.

<<Display Portion **230**>>

[0527] The display portion **230** includes the control portion **238**, the driver circuit GD, the driver circuit SD, and the display panel **700** (see FIG. **13**A). For example, any of the display devices described in Embodiment 2 can be used for the display portion **230**.

<<Input Portion **240**>>

[0528] Any of a variety of human interfaces or the like can be used as the input portion **240** (see FIGS. **20**A to **20**C).

[0529] For example, a keyboard, a mouse, a touch sensor, a microphone, a camera, or the like can be used as the input portion **240**. Note that a touch sensor having a region overlapping with the display portion **230** can be used. An input/output device that includes the display portion **230** and a touch sensor having a region overlapping with the display portion **230** can be referred to as a touch panel or a touch screen.

[0530] For example, a user can make various gestures (e.g., tap, drag, swipe, and pinch in) using his/her finger as a pointer on the touch panel.

[0531] The arithmetic device **210**, for example, analyzes data on the position, track, or the like of the finger on the touch panel and determines that a specific gesture is supplied when the analysis results meet predetermined conditions. Therefore, the user can supply a certain operation instruction associated with a predetermined gesture by using the gesture.

[0532] For instance, the user can supply a "scrolling instruction" for changing a portion where image data is displayed by using a gesture of touching and moving his/her finger on the touch panel.

<<Sensor Portion **250**>>

[0533] The sensor portion **250** has a function of sensing the ambient conditions and supplying the sensing data. Specifically, the sensor portion **250** can supply illuminance data, attitude data, pressure data, positional data, and the like.

[0534] For example, a photosensor, an attitude sensor, an acceleration sensor, a direction sensor, a global positioning system (GPS) signal receiving circuit, a pressure sensor, a temperature sensor, a humidity sensor, a camera, or the like can be used as the sensor portion **250**.

<<Communication Portion **290**>>

[0535] The communication portion **290** has a function of supplying and acquiring data to/from a network.

<<Program>>

[0536] The program of one embodiment of the present invention has the following steps (see FIG. **21**A).

[First Step]

[0537] In a first step, setting is initialized (see S**1** in FIG. **21**A).

[0538] For example, predetermined image data which is to be displayed on start-up and data for determining a predetermined mode of displaying the image data and a predetermined method of displaying the image data are acquired from the memory portion **212**. Specifically, still image data or moving image data can be used as the predetermined image data. Furthermore, a first mode or a second mode can be used as the predetermined mode. Furthermore, a first display method, a second display method, or a third display method can be used as the predetermined display method.

[Second Step]

[0539] In a second step, interrupt processing is allowed (see S**2** in FIG. **21**A). Note that an arithmetic device allowed to execute the interrupt processing can perform the interrupt processing in parallel with the main processing. The arithmetic device which has returned from the interrupt processing to the main processing can reflect the results of the interrupt processing in the main processing.

[0540] The arithmetic device may execute the interrupt processing when a counter has an initial value, and the counter may be set at a value other than the initial value when the arithmetic device returns from the interrupt processing. Thus, the interrupt processing is ready to be executed after the program is started up.

[Third Step]

[0541] In a third step, image data is displayed in a predetermined mode or a predetermined display method selected in the first step or the interrupt processing (see S**3** in FIG. **21**A). Note that the predetermined mode identifies a mode for displaying the data, and the predetermined display method identifies a method for displaying image data. For example, the image data V**1**, the data V**11**, or the data V**12** can be used for data to be displayed.

[0542] For example, a method for displaying the image data V**1** can be associated with the first mode. Another method for displaying the image data V**1** can be associated with the second mode. Thus, a display method can be selected on the basis of the selected mode.

[0543] For example, three different methods for displaying the image data V**1** can be associated with the first display method to the third display method. Thus, display can be performed on the basis of the selected display method.

<<First Mode>>

[0544] Specifically, a method of supplying selection signals to a scan line at a frequency of 30 Hz or more, preferably 60 Hz or more, and performing display in accordance with the selection signals can be associated with the first mode.

[0545] For example, the supply of selection signals at a frequency of 30 Hz or more, preferably 60 Hz or more, can display a smooth moving image.

[0546] For example, an image is refreshed at a frequency of 30 Hz or more, preferably 60 Hz or more, so that an image smoothly following the user's operation can be displayed on the data processing device **200** the user operates.

<<Second Mode>>

[0547] Specifically, a method of supplying selection signals to a scan line at a frequency of less than 30 Hz, preferably less than 1 Hz, further preferably less than once a minute and performing display in accordance with the selection signals can be associated with the second mode.

[0548] The supply of selection signals at a frequency of less than 30 Hz, preferably less than 1 Hz, more preferably less than once a minute, can perform display with flickering reduced. Furthermore, power consumption can be reduced.

[0549] For example, when the data processing device **200** is used for a clock or watch, the display can be refreshed at a frequency of once a second, once a minute, or the like.

[0550] For example, when a light-emitting element is used as the second display element, the light-emitting element can be made to emit light in a pulsed manner so as to display image data. Specifically, a light-emitting diode can be made to emit light in a pulsed manner, and its afterglow can be used to display image data. A light-emitting diode has excellent frequency characteristics; therefore, time for driving the second display element can be shortened and thus power consumption can be reduced in some cases. Alternatively, heat generation can be inhibited, and thus the deterioration of the light-emitting diode can be suppressed in some cases.

<<First Display Method>>

[0551] Specifically, a method in which the first display element **750**(*i*,*j*) is used to display image data can be used as the first display method. Thus, for example, power consumption can be reduced. Furthermore, image data with high contrast can be favorably displayed in a bright environment.

<<Second Display Method>>

[0552] Specifically, a method in which the second display element **550**(*i*,*j*) is used to display image data can be used as the second display method. Thus, for example, an image can be favorably displayed in a dark environment. Furthermore, a photograph and the like can be displayed with favorable color reproducibility. Furthermore, a moving image that moves fast can be displayed smoothly.

[0553] In the case where the image data V**1** is displayed using the second display element **550**(*i*,*j*), brightness for displaying the image data V**1** can be determined on the basis of illuminance data. For example, when illuminance is higher than or equal to 5,000 lux and less than 100,000 lux, the image data V**1** is displayed using the second display element **550**(*i*,*j*) to be bright compared with the case where the illuminance is less than 5,000 lux.

<<Third Display Method>>

[0554] Specifically, a method in which the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*) are used to display image data can be used as the third display method. In that case, power consumption can be reduced. Furthermore, an image can be favorably displayed in a dark environment. Furthermore, a photograph and the like can be displayed with favorable color reproducibility. Furthermore,

a moving image which moves fast can be displayed smoothly. Furthermore, display comfortable for the user can be achieved.

[0555] Note that a function of adjusting the brightness of display by using the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*) to display image data can be referred to as a light adjusting function. For example, the brightness of a reflective display element can be complemented using the display element having a function of emitting light.

[0556] Note that a function of adjusting the color of display by using the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*) can be referred to as a color adjusting function. For example, the color of a reflective display element can be changed using the display element having a function of emitting light. Specifically, a yellowish color displayed by a reflective liquid crystal element can be made closer to a white color with the use of a blue light-emitting diode. Thus, text data can be displayed like text printed on plain paper, for example. Furthermore, eye-friendly display can be achieved.

[0557] When the first display element **750**(*i*,*j*) and the second display element **550**(*i*,*j*) are used to display image data, a color reflected by an object and a color emitted from an object are mixed. Thus, an image like a painting can be displayed.

[0558] Note that the brightness of the image data V**1** displayed using the second display element **550**(*i*,*j*) and overlapping with the image data V**1** displayed using the first display element **750**(*i*,*j*) can be determined on the basis of illuminance data and the user's preference. This allows display comfortable for the user.

[Fourth Step]

[0559] In a fourth step, the next step is determined as follows: a fifth step is selected when a termination instruction has been supplied, whereas the third step is selected when the termination instruction has not been supplied (see S**4** in FIG. **21**A).

[0560] For example, the termination instruction supplied in the interrupt processing can be used to determine the next step.

[Fifth Step]

[0561] In the fifth step, the program terminates (see S**5** in FIG. **21**A).

<<Interrupt Processing>>

[0562] The interrupt processing includes sixth to eighth steps described below (see FIG. **21**B).

[Sixth Step]

[0563] In the sixth step, the illuminance of the environment where the data processing device **200** is used can be sensed using the sensor portion **250**, for example (see S**6** in FIG. **21**B). Note that the color temperature or chromaticity of ambient light can be sensed instead of the illuminance of the environment.

[Seventh Step]

[0564] In the seventh step, a display method is determined on the basis of the sensed illuminance data. For example, the first display method is selected when the illuminance is greater than or equal to a predetermined value, whereas the second display method is selected when the illuminance is less than the predetermined value. Furthermore, the third display method may be selected when the illuminance is within a predetermined range (see S**7** in FIG. **21**B).

[0565] Specifically, in the case where the illuminance is greater than or equal to 100,000 lux, the first display method may be selected. In the case where the illuminance is less than 5,000 lux, the second display method may be selected. In the case where the illuminance is greater than or equal to 5,000 lux and less than 100,000 lux, the third display method may be selected.

[0566] In the case where the color temperature or chromaticity of the ambient light is sensed in the sixth step, the color of display may be adjusted using the second display element **550**(*i*,*j*) by the third display method.

[0567] For example, first-status control data SS is supplied when the first display method is used, second-status control data SS is supplied when the second display method is used, and third-status control data SS is supplied when the third display method is used.

[Eighth Step]

[0568] In the eighth step, the interrupt processing terminates (see S**8** in FIG. **21**B).

<Structural Example 2 of Data Processing Device>

[0569] Another structure of the data processing device of one embodiment of the present invention will be described with reference to FIG. **22**.

[0570] FIG. **22** is a flow chart showing a program of one embodiment of the present invention. The interrupt processing in the flow chart in FIG. **22** is different from that in FIG. **21**B.

[0571] Note that the structural example 2 of the data processing device is different from the interrupt processing in FIG. **21**B in that the interrupt processing includes a step in which a mode is changed on the basis of a supplied predetermined event. Different structures will be described in detail below, and the above description is referred to for the similar portions.

<<Interrupt Processing>>

[0572] The interrupt processing includes sixth to eighth steps described below (see FIG. **22**).

[Sixth Step]

[0573] In the sixth step, the processing proceeds to the seventh step when a predetermined event has been supplied, whereas the processing proceeds to the eighth step when the predetermined event has not been supplied (see U**6** in FIG. **22**). For example, whether the predetermined event is supplied in a predetermined period or not can be a branch condition. Specifically, the predetermined period can be longer than 0 seconds and shorter than or equal to 5 seconds, preferably shorter than or equal to 1 second, more preferably shorter than or equal to 0.5 seconds, still more preferably shorter than or equal to 0.1 seconds.

[Seventh Step]

[0574] In the seventh step, the mode is changed (see U7 in FIG. **22**). Specifically, the mode is changed to the second mode when the first mode has been selected, or the mode is changed to the first mode when the second mode has been selected.

[Eighth Step]

[0575] In the eighth step, the interrupt processing terminates (see U**8** in FIG. **22**). Note that in a period in which the main processing is executed, the interrupt processing may be repeatedly executed.

<<Predetermined Event>>

[0576] For example, the following events can be used: events supplied using a pointing device such as a mouse (e.g., "click" and "drag") and events supplied to a touch panel with a finger or the like used as a pointer (e.g., "tap", "drag", and "swipe").

[0577] For example, the position of a slide bar pointed by a pointer, the swipe speed, and the drag speed can be used as parameters assigned to various instructions. Furthermore, for example, the position of a slide bar pointed by a pointer, the swipe speed, and the drag speed can be used as parameters assigned to an instruction associated with a predetermined event.

[0578] For example, data sensed by the sensor portion **250** is compared to a predetermined threshold value, and the compared results can be used for the event.

[0579] Specifically, a pressure sensor or the like in contact with a button or the like that can be pushed in a housing can be used as the sensor portion **250**.

<<Instruction Associated with Predetermined Event>>

[0580] For example, the termination instruction can be associated with a predetermined event.

[0581] For example, "page-turning instruction" for switching displayed image data from one to another can be associated with a predetermined event. Note that a parameter for determining the page-turning speed or the like when the "page-turning instruction" is executed can be supplied using the predetermined event.

[0582] For example, "scroll instruction" for moving the display position of part of image data and displaying another part continuing from that part can be associated with a predetermined event. Note that a parameter for determining the moving speed of the display position, or the like, when the "scroll instruction" is executed can be supplied using the predetermined event.

[0583] For example, an instruction for setting the display method or an instruction for generating image data can be associated with a predetermined event. Note that a parameter for determining the brightness of a generated image can be associated with a predetermined event. Note that a parameter for determining the brightness of a generated image may be determined on the basis of ambient brightness sensed by the sensor portion **250**.

[0584] For example, an instruction for acquiring data distributed via a push service using the communication portion **290** can be associated with a predetermined event.

[0585] Note that positional data sensed by the sensor portion **250** may be used for the determination of the presence or absence of a qualification for acquiring data. Specifically, it may be determined that there is a qualification for acquiring data when a user is in a predetermined class room, school, conference room, office, building, or the like. For example, educational materials can be fed from a classroom of a school or a university, so that the data processing device **200** can be used as a schoolbook or the like (see FIG. **20**C). Alternatively, materials distributed from a conference room in, for example, a company can be received and used for a conference material.

[0586] Note that this embodiment can be combined with any of the other embodiments in this specification as appropriate.

Embodiment 6

[0587] In this embodiment, a display module that can be fabricated using one embodiment of the present invention will be described.

[0588] In a display module **6000** in FIG. **23**A, a display panel **6006** connected to an FPC **6005**, a frame **6009**, a printed board **6010**, and a battery **6011** are provided between an upper cover **6001** and a lower cover **6002**.

[0589] For example, the display device manufactured using one embodiment of the present invention can be used for the display panel **6006**. Thus, the display module can be manufactured with high yield.

[0590] The shapes and sizes of the upper cover **6001** and the lower cover **6002** can be changed as appropriate in accordance with the size of the display panel **6006**.

[0591] A touch panel may be provided to overlap with the display panel **6006**. The touch panel can be a resistive touch panel or a capacitive touch panel and may be formed to overlap with the display panel **6006**. Instead of providing a touch panel, the display panel **6006** can have a touch panel function.

[0592] The frame **6009** protects the display panel **6006** and functions as an electromagnetic shield for blocking electromagnetic waves generated by the operation of the printed board **6010**. The frame **6009** may function as a radiator plate.

[0593] The printed board **6010** is provided with a power supply circuit and a signal processing circuit for outputting a video signal and a clock signal. As a power source for supplying power to the power supply circuit, an external commercial power source or a power source using the battery **6011** provided separately may be used. The battery **6011** can be omitted in the case of using a commercial power source.

[0594] The display module **6000** may be additionally provided with a member such as a polarizing plate, a retardation plate, or a prism sheet.

[0595] FIG. **23**B is a schematic cross-sectional view of the display module **6000** with an optical touch sensor.

[0596] The display module **6000** includes a light-emitting portion **6015** and a light-receiving portion **6016** that are provided on the printed board **6010**. A pair of light guide portions (a light guide portion **6017***a* and a light guide portion **6017***b*) is provided in a region surrounded by the upper cover **6001** and the lower cover **6002**.

[0597] For example, a plastic or the like can be used for the upper cover **6001** and the lower cover **6002**. The upper cover **6001** and the lower cover **6002** can each be thin (e.g., more than or equal to 0.5 mm and less than or equal to 5 mm). Therefore, the display module **6000** can be significantly lightweight. In addition, the upper cover **6001** and the

lower cover **6002** can be manufactured with a small amount of material, and therefore, manufacturing cost can be reduced.

[0598] The display panel **6006** overlaps with the printed board **6010** and the battery **6011** with the frame **6009** therebetween. The display panel **6006** and the frame **6009** are fixed to the light guide portion **6017***a* and the light guide portion **6017***b*.

[0599] Light **6018** emitted from the light-emitting portion **6015** travels over the display panel **6006** through the light guide portion **6017***a* and reaches the light-receiving portion **6016** through the light guide portion **6017***b*. For example, blocking of the light **6018** by a sensing target such as a finger or a stylus can be detected as touch operation.

[0600] A plurality of light-emitting portions **6015** are provided along two adjacent sides of the display panel **6006**, for example. A plurality of light-receiving portions **6016** are provided to face the light-emitting portions **6015** with the display panel **6006** therebetween. Accordingly, data on the position of touch operation can be obtained.

[0601] As the light-emitting portion **6015**, a light source such as an LED element can be used. It is particularly preferable to use a light source that emits infrared light, which is not visually recognized by users and is harmless to users, as the light-emitting portion **6015**.

[0602] As the light-receiving portion **6016**, a photoelectric element that receives light emitted by the light-emitting portion **6015** and converts it into an electrical signal can be used. A photodiode that can receive infrared light can be favorably used.

[0603] For the light guide portions **6017***a* and **6017***b*, members that transmit at least the light **6018** can be used. The use of the light guide portions **6017***a* and **6017***b* allows the light-emitting portion **6015** and the light-receiving portion **6016** to be placed under the display panel **6006**, and a malfunction of the touch sensor due to external light reaching the light-receiving portion **6016** can be suppressed. It is particularly preferable to use a resin that absorbs visible light and transmits infrared light. This is more effective in suppressing the malfunction of the touch sensor.

[0604] Note that this embodiment can be combined with any of the other embodiments in this specification as appropriate.

Embodiment 7

[0605] In this embodiment, the structures of data processing devices of embodiments of the present invention will be described with reference to FIGS. **24**A to **24**E and FIGS. **25**A to **25**E.

[0606] FIGS. **24**A to **24**E and FIGS. **25**A to **25**E illustrate the structures of the data processing devices of embodiments of the present invention. FIG. **24**A is a block diagram of the data processing device, and FIGS. **24**B to **24**E are perspective views illustrating the structures of the data processing devices. FIGS. **25**A to **25**E are perspective views illustrating the structures of the data processing devices.

<Data Processing Device>

[0607] A data processing device **5200**B described in this embodiment includes an arithmetic device **5210** and an input/output device **5220** (see FIG. **24**A).

[0608] The arithmetic device **5210** has a function of receiving control data and a function of supplying image data on the basis of the control data.

[0609] The input/output device **5220** includes a display portion **5230**, an input portion **5240**, a sensor portion **5250**, and a communication portion **5290** and has a function of supplying control data and a function of receiving image data. The input/output device **5220** also has a function of supplying sensing data, a function of supplying communication data, and a function of receiving communication data.

[0610] The input portion **5240** has a function of supplying control data. For example, the input portion **5240** supplies control data on the basis of control by the user of the data processing device **5200**B.

[0611] Specifically, a keyboard, a hardware button, a pointing device, a touch sensor, an audio input device, a viewpoint input device, or the like can be used as the input portion **5240**.

[0612] The display portion **5230** includes a display panel and has a function of displaying image data. For example, the display panel described in Embodiment 1 can be used for the display portion **5230**.

[0613] The sensor portion **5250** has a function of supplying sensing data. For example, the sensor portion **5250** has a function of sensing a surrounding environment where the data processing device is used and supplying sensing data.

[0614] Specifically, an illuminance sensor, an imaging device, an attitude determination device, a pressure sensor, a human motion sensor, or the like can be used as the sensor portion **5250**.

[0615] The communication portion **5290** has a function of receiving and supplying communication data. For example, the communication portion **5290** has a function of being connected to another electronic device or a communication network by wireless communication or wired communication. Specifically, the communication portion **5290** has a function of local area wireless communication, telephone communication, or near field wireless communication, for example.

<<Structural Example 1 of Data Processing Device>>

[0616] For example, the display portion **5230** can have an outer shape along a cylindrical column (see FIG. **24**B). Furthermore, the display portion **5230** has a function of changing a displaying method in accordance with the illuminance of a usage environment and a function of changing display data when sensing the existence of a person.

[0617] Thus, the data processing device **5200**B can be mounted on a column of a building or can display advertisements.

<<Structural Example 2 of Data Processing Device>>

[0618] For example, the data processing device **5200**B has a function of generating image data on the basis of the path of a pointer used by a user (see FIG. **24**C). Thus, the data processing device **5200**B can be used as an electronic blackboard, for example.

<<Structural Example 3 of Data Processing Device>>

[0619] For example, the data processing device **5200**B has a function of changing a displaying method in accordance with the illuminance of a usage environment (see FIG. **24**D). Thus, the power consumption of a smartwatch can be

reduced. Furthermore, a smartwatch that allows users to favorably see display even outdoors on a sunny day can be provided.

<<Structural Example 4 of Data Processing Device>>

[0620] The display portion **5230** has a surface gently curved along a side surface of a housing (see FIG. **24**E). The display portion **5230** includes a display panel that has, for example, a function of performing display on the front surface, side surfaces, and the top surface. Thus, a portable phone that can display image data on the front surface, side surfaces, and the top surface can be provided.

<<Structural Example 5 of Data Processing Device>>

[0621] For example, the data processing device **5200**B has a function of changing a displaying method in accordance with the illuminance of a usage environment (see FIG. **25**A). Thus, the power consumption of a smartphone can be reduced.

<<Structural Example 6 of Data Processing Device>>

[0622] For example, the data processing device **5200**B has a function of changing a displaying method in accordance with the illuminance of a usage environment (see FIG. **25**B). Thus, a television system that allows users to favorably view an image even in an environment with high-intensity external light can be provided.

<<Structural Example 7 of Data Processing Device>>

[0623] For example, the data processing device **5200**B has a function of changing a displaying method in accordance with the illuminance of a usage environment (see FIG. **25**C). Thus, the data processing device **5200**B can be used for an eye-friendly tablet computer.

<<Structural Example 8 of Data Processing Device>>

[0624] For example, the data processing device **5200**B has a function of changing a displaying method in accordance with the illuminance of a usage environment (see FIG. **25**D). Thus, a digital camera that can favorably display a subject even in an environment with high-intensity external light can be provided.

<<Structural Example 9 of Data Processing Device>>

[0625] For example, the data processing device **5200**B has a function of changing a displaying method in accordance with the illuminance of a usage environment (see FIG. **25**E). Thus, a personal computer that can be favorably used even in an environment with high-intensity external light can be provided.

[0626] Note that this embodiment can be combined with any of the other embodiments in this specification as appropriate.

Embodiment 8

[0627] In this embodiment, the structures of electronic devices of embodiments of the present invention will be described with reference to FIGS. **26**A to **26**C.

<Electronic Device>

[0628] FIGS. **26**A to **26**C illustrate foldable electronic devices.

[0629] An electronic device **900** illustrated in FIG. **26**A includes a housing **901***a*, a housing **901***b*, a hinge **903**, a display portion **902**, and the like. The display portion **902** is incorporated in the housing **901***a* and the housing **901***b*.

[0630] The housing **901***a* and the housing **901***b* are rotatably joined to each other by the hinge **903**. The electronic device **900** can be changed in shape between a state where the housing **901***a* and the housing **901***b* are closed and a state where the housing **901***a* and the housing **901***b* are opened as illustrated in FIG. **26**A. Thus, the electronic device **900** has high portability when carried and excellent visibility when used because of its large display region.

[0631] The hinge **903** preferably includes a locking mechanism so that an angle formed between the housing **901***a* and the housing **901***b* does not become larger than a predetermined angle when the housing **901***a* and the housing **901***b* are opened. For example, an angle at which they become locked (they are not opened any further) can be preferably greater than or equal to 90° and less than 180° and is typically 90°, 120°, 135°, 150°, 175°, or the like. In that case, the convenience, the safety, and the reliability can be improved.

[0632] The display portion **902** can function as a touch panel and be controlled with a finger, a stylus, or the like.

[0633] Either of the housing **901***a* and the housing **901***b* is provided with a wireless communication module, and data can be transmitted and received through a computer network such as the Internet, a local area network (LAN), or Wi-Fi®.

[0634] One flexible display is preferably incorporated in the display portion **902**. In that case, an image can be displayed continuously between the housing **901***a* and the housing **901***b*. Note that each of the housing **901***a* and the housing **901***b* may be provided with a display.

[0635] FIG. **26**B illustrates an electronic device **910** that functions as a portable game console. The electronic device **910** includes a housing **911***a*, a housing **911***b*, a display portion **912**, a hinge **913**, an operation button **914***a*, an operation button **914***b*, and the like.

[0636] A cartridge **915** can be inserted into the housing **911***b*. The cartridge **915** stores application software such as a game, for example, and a variety of applications can be executed on the electronic device **910** by replacing the cartridge **915**.

[0637] FIG. **26**B illustrates an example where a part of the display portion **912** that overlaps with the housing **911***a* and the other part of the display portion **912** that overlaps with the housing **911***b* have different sizes. Specifically, a portion of the display portion **912** that is provided on the housing **911***a* is larger than a portion of the display portion **912** that overlaps with the housing **911***b* where the operation buttons **914***a* and **914***b* are provided. For example, the portions of the display portion can be used for different purposes by performing display using the part of the display portion **912** on the housing **911***a* side as a main screen and the part of the display portion **912** on the housing **911***b* side as an operation screen.

[0638] In an electronic device **920** illustrated in FIG. **26**C, a flexible display portion **922** is provided across a housing **921***a* and a housing **921***b* which are joined to each other by a hinge **923**.

[0639] In FIG. **26**C, the display portion **922** is greatly curved with the housing **921***a* and the housing **921***b* open. For example, the display portion **922** is held with a curvature radius of 1 mm or greater and 50 mm or less, preferably 5 mm or greater and 30 mm or less. Part of the display portion **922** can display an image while being bent since pixels are arranged continuously from the housing **921***a* to the housing **921***b*.

[0640] Since the hinge **923** includes the above locking mechanism, excessive force is not applied to the display portion **922**; thus, breakage of the display portion **922** can be prevented. Consequently, a highly reliable electronic device can be obtained.

[0641] At least part of this embodiment can be implemented in combination with any of the other embodiments described in this specification as appropriate.

[0642] For example, in this specification and the like, an explicit description "X and Y are connected" means that X and Y are electrically connected, X and Y are functionally connected, and X and Y are directly connected. Accordingly, without limitation to a predetermined connection relation, for example, a connection relation shown in drawings or text, another connection relation is included in the drawings or the text.

[0643] Here, X and Y each denote an object (e.g., a device, an element, a circuit, a wiring, an electrode, a terminal, a conductive film, or a layer).

[0644] Examples of the case where X and Y are directly connected include the case where an element that allows an electrical connection between X and Y (e.g., a switch, a transistor, a capacitor, an inductor, a resistor, a diode, a display element, a light-emitting element, and a load) is not connected between X and Y, that is, the case where X and are connected without the element that allows the electrical connection between X and Y provided therebetween.

[0645] For example, in the case where X and Y are electrically connected, one or more elements that enable electrical connection between X and Y (e.g., a switch, a transistor, a capacitor, an inductor, a resistor, a diode, a display element, a light-emitting element, and a load) can be connected between X and Y. A switch is controlled to be on or off. That is, a switch is conducting or not conducting (is turned on or off) to determine whether a current flows therethrough or not. Alternatively, the switch has a function of selecting and changing a current path. Note that the case where X and Y are electrically connected includes the case where X and Y are directly connected.

[0646] For example, in the case where X and Y are functionally connected, one or more circuits that enable functional connection between X and Y (e.g., a logic circuit such as an inverter, a NAND circuit, or a NOR circuit; a signal converter circuit such as a DA converter circuit, an AD converter circuit, or a gamma correction circuit; a potential level converter circuit such as a power supply circuit (e.g., a step-up circuit and a step-down circuit) or a level shifter circuit for changing the potential level of a signal; a voltage source; a current source; a switching circuit; an amplifier circuit such as a circuit that can increase signal amplitude, the amount of current, or the like, an operational amplifier, a differential amplifier circuit, a source follower circuit, or a buffer circuit; a signal generation circuit; a memory circuit; and/or a control circuit) can be connected between X and Y. Note that for example, in the case where a signal output from X is transmitted to Y even when another circuit is interposed between X and Y, X and Y are functionally connected. Note that the case where X and Y are functionally connected includes the case where X and Y are directly connected and X and Y are electrically connected.

[0647] Note that in this specification and the like, an explicit description "X and Y are electrically connected" means that X and Y are electrically connected (i.e., the case where X and Y are connected with another element or another circuit provided therebetween), X and Y are functionally connected (i.e., the case where X and Y are functionally connected with another circuit provided therebetween), and X and Y are directly connected (i.e., the case where X and Y are connected without another element or another circuit provided therebetween). That is, in this specification and the like, the explicit description "X and Y are electrically connected" is the same as the description "X and Y are connected".

[0648] Note that, for example, the case where a source (or a first terminal or the like) of a transistor is electrically connected to X through (or not through) Z1 and a drain (or a second terminal or the like) of the transistor is electrically connected to Y through (or not through) Z2, or the case where a source (or a first terminal or the like) of a transistor is directly connected to a part of Z1 and another part of Z1 is directly connected to X while a drain (or a second terminal or the like) of the transistor is directly connected to a part of Z2 and another part of Z2 is directly connected to Y, can be expressed by using any of the following expressions.

[0649] The expressions include, for example, "X, Y, a source (or a first terminal or the like) of a transistor, and a drain (or a second terminal or the like) of the transistor are electrically connected to each other, and X, the source (or the first terminal or the like) of the transistor, the drain (or the second terminal or the like) of the transistor, and Y are electrically connected to each other in this order", "a source (or a first terminal or the like) of a transistor is electrically connected to X, a drain (or a second terminal or the like) of the transistor is electrically connected to Y, and X, the source (or the first terminal or the like) of the transistor, the drain (or the second terminal or the like) of the transistor, and Y are electrically connected to each other in this order", and "X is electrically connected to Y through a source (or a first terminal or the like) and a drain (or a second terminal or the like) of a transistor, and X, the source (or the first terminal or the like) of the transistor, the drain (or the second terminal or the like) of the transistor, and Y are provided to be connected in this order". When the connection order in a circuit configuration is defined by an expression similar to the above examples, a source (or a first terminal or the like) and a drain (or a second terminal or the like) of a transistor can be distinguished from each other to specify the technical scope.

[0650] Other examples of the expressions include, "a source (or a first terminal or the like) of a transistor is electrically connected to X through at least a first connection path, the first connection path does not include a second connection path, the second connection path is a path between the source (or the first terminal or the like) of the transistor and a drain (or a second terminal or the like) of the transistor, Z1 is on the first connection path, the drain (or the second terminal or the like) of the transistor is electrically connected to Y through at least a third connection path, the third connection path does not include the second connec-

tion path, and Z2 is on the third connection path". Other examples of the expressions also include "a source (or a first terminal or the like) of a transistor is electrically connected to X through at least Z1 on a first connection path, the first connection path does not include a second connection path, the second connection path includes a connection path through the transistor, a drain (or a second terminal or the like) of the transistor is electrically connected to Y through at least Z2 on a third connection path, and the third connection path does not include the second connection path", and "a source (or a first terminal or the like) of a transistor is electrically connected to X through at least Z1 on a first electrical path, the first electrical path does not include a second electrical path, the second electrical path is an electrical path from the source (or the first terminal or the like) of the transistor to a drain (or a second terminal or the like) of the transistor, the drain (or the second terminal or the like) of the transistor is electrically connected to Y through at least Z2 on a third electrical path, the third electrical path does not include a fourth electrical path, and the fourth electrical path is an electrical path from the drain (or the second terminal or the like) of the transistor to the source (or the first terminal or the like) of the transistor". When the connection path in a circuit configuration is defined by an expression similar to the above examples, a source (or a first terminal or the like) and a drain (or a second terminal or the like) of a transistor can be distinguished from each other to specify the technical scope.

[0651] Note that these expressions are only examples and one embodiment of the present invention is not limited to the expressions. Here, X, Y, Z1, and Z2 each denote an object (e.g., a device, an element, a circuit, a wiring, an electrode, a terminal, a conductive film, and a layer).

[0652] Even when independent components are electrically connected to each other in a circuit diagram, one component has functions of a plurality of components in some cases. For example, when part of a wiring also functions as an electrode, one conductive film functions as the wiring and the electrode. Thus, "electrical connection" in this specification includes in its category such a case where one conductive film has functions of a plurality of components.

[0653] This application is based on Japanese Patent Application Serial No. 2016-193458 filed with Japan Patent Office on Sep. 30, 2016, the entire contents of which are hereby incorporated by reference.

What is claimed is:

1. A display panel comprising:

a pixel comprising:

a first display element comprising a reflective film;

a second display element comprising a light-emitting element; and

a functional layer including a region between the first and second display elements,

wherein:

the functional layer comprises a pixel circuit electrically connected to the first and second display elements,

the first display element is configured to control intensity of light reflected by the reflective film having a shape not blocking light emitted from the second display element, and

the second display element is provided such that display using the second display element can be seen from part of a region where display using the first display element can be seen.

2. The display panel according to claim **1**, wherein:

the pixel further comprises an optical element having a light-transmitting property and a covering film having light reflectivity,

the optical element includes a first region to which light is supplied, a second region partly in contact with the covering film, and a third region configured to emit part of the light,

the third region has an area smaller than or equal to the first region,

the covering film is configured to reflect the part of the light and supply the part of the light to the third region,

the reflective film having a shape not blocking light emitted from the third region, and

the second display element is configured to supply the light.

3. The display panel according to claim **2**, wherein:

the optical element has an optical axis,

the optical axis passes through a center of each of the first and third regions, and

the second region includes an inclined portion with an inclination of 45° or more with respect to a plane orthogonal to the optical axis.

4. The display panel according to claim **2**, further comprising a lens between the optical element and the second display element,

wherein:

the lens includes a material with a refractive index of 1.5 or more and 2.5 or less, and

the lens is a convex lens.

5. The display panel according to claim **1**, wherein:

the pixel comprises:

a first conductive film electrically connected to the first display element;

a second conductive film partly overlapping with the first conductive film; and

an insulating film between the first and second conductive films, the insulating film has an opening,

the second conductive film is electrically connected to the first conductive film in the opening, and to the pixel circuit,

the second display element is electrically connected to the pixel circuit, and

the second display element is configured to emit light toward the insulating film.

6. The display panel according to claim **1**, further comprising:

a display region comprising:

one group of pixels comprising the pixel;

another group of pixels comprising the pixel;

a scan line electrically connected to the one group of pixels; and

a signal line electrically connected to the another group of pixels,

wherein:

the pixels of the one group are arranged in a row direction,

the pixels of the another group are arranged in a column direction intersecting the row direction.

7. A display device comprising:
the display panel according to claim **1**; and
a control portion,
wherein:
the control portion is configured to receive image data and control data, to generate first data and/or second data on the basis of the image data, and to supply the first data and the second data, and
the display panel is configured to receive the first data and the second data, to display a first image on the basis of the first data, and to display a second image on the basis of the second data.

8. An input/output device comprising:
an input portion comprising a sensing region; and
a display portion comprising the display panel according to claim **1**,
wherein:
the input portion is configured to sense an object approaching the sensing region, and
the sensing region partly overlaps with the pixel.

9. The input/output device according to claim **8**, wherein:
the sensing region comprises:
a control line configured to supply a control signal;
a sensor signal line configured to receive a sensor signal; and
a sensor element electrically connected to the control line and the sensor signal line,
the sensor element is configured to supply the sensor signal that varies in accordance with the control signal and a distance between a region overlapping with the pixel and an object approaching the region,
the sensor element comprises a first electrode including a first light-transmitting region overlapping with the pixel, and a second electrode including a second light-transmitting region overlapping with the pixel,
the first electrode is electrically connected to the control line,
the second electrode is electrically connected to the sensor signal line, and
the second electrode is located such that an electric field part of which is blocked by an object approaching the region overlapping with the pixel is generated between the first and second electrodes.

10. A data processing device comprising:
at least one of a keyboard, a hardware button, a pointing device, a touch sensor, an illuminance sensor, an imaging device, an audio input device, a viewpoint input device, and an attitude determination device; and
the display panel according to claim **1**.

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