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(54) **LIQUID CRYSTAL DISPLAY DEVICE**

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(30) **Foreign Application Priority Data**

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G02F 1/1343 (2006.01)
G09G 3/36 (2006.01)

(52) **U.S. Cl.** **349/43**; 349/139

(57) **ABSTRACT**

To reduce the number of components such as IC chips so that decrease in size and thickness of a display module and an electronic device on which the display module is mounted is achieved. Further, to reduce the number of components such as IC chips so that an inexpensive display module and an electronic device on which the display module is mounted are provided. An electronic device or a display module includes two display panels. One of the display panels (i.e., a peripheral portion of a display region of the one of the display panels) is provided with circuits which are necessary for operating the display panels or circuits which are necessary for an electronic device in which the display panels are incorporated. Then, the display panels or the electronic device in which the display panels are incorporated are/is driven by the circuits incorporated in the display panels.

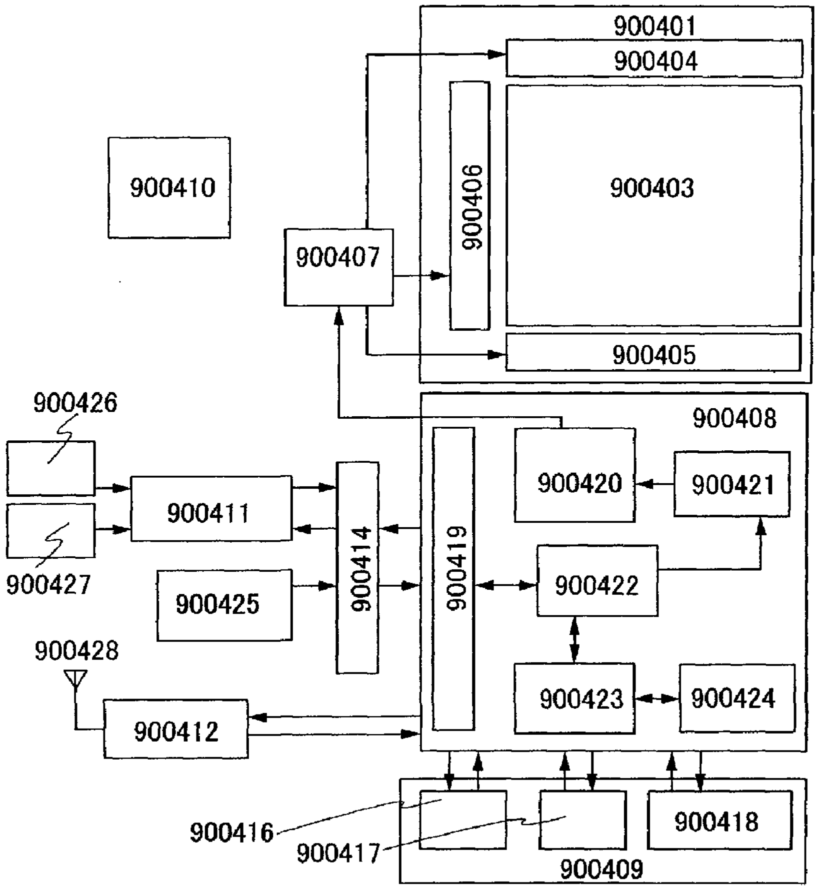

FIG. 1A

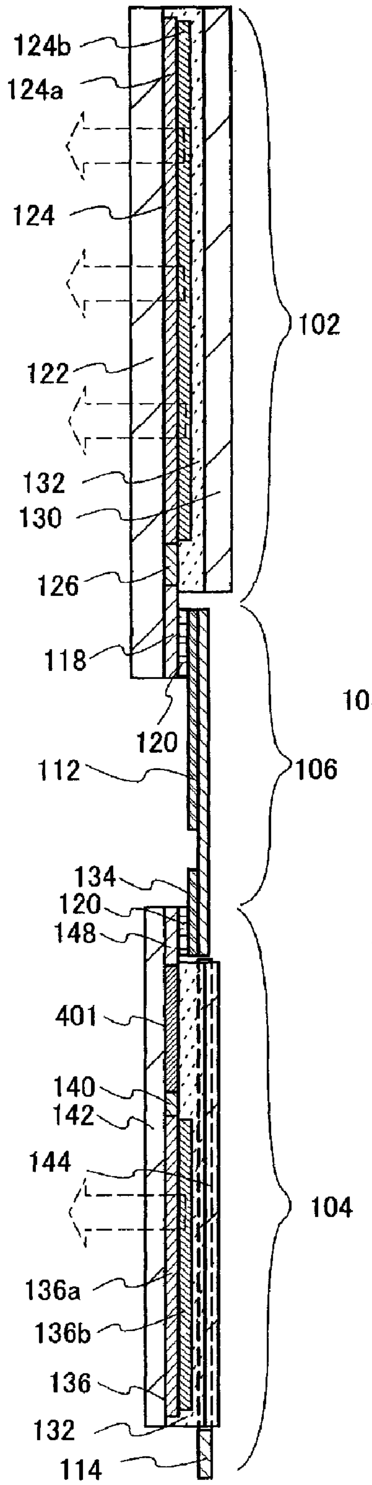
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FIG. 1B

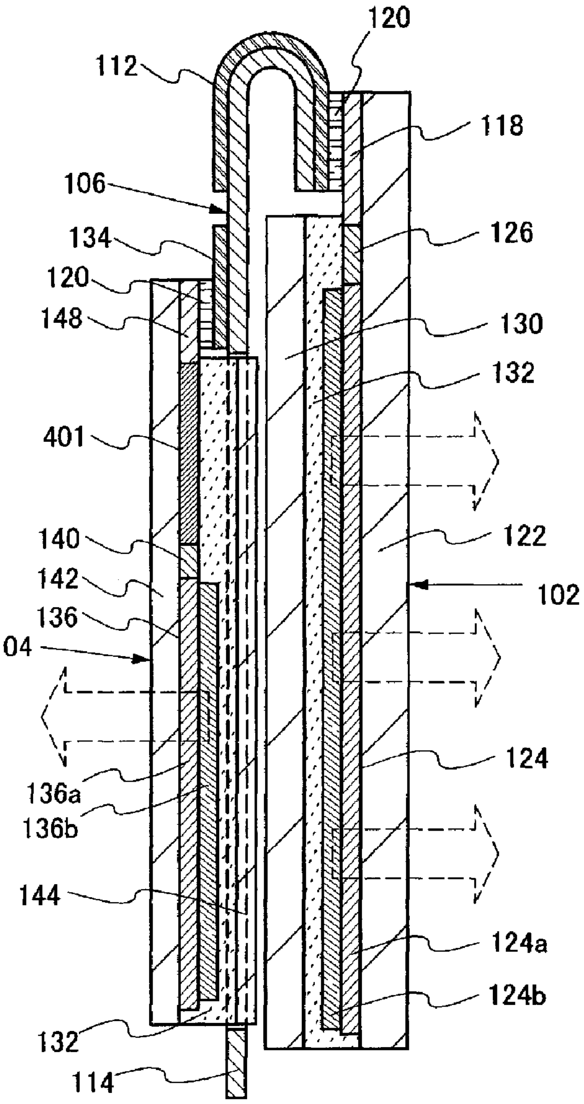
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FIG. 2

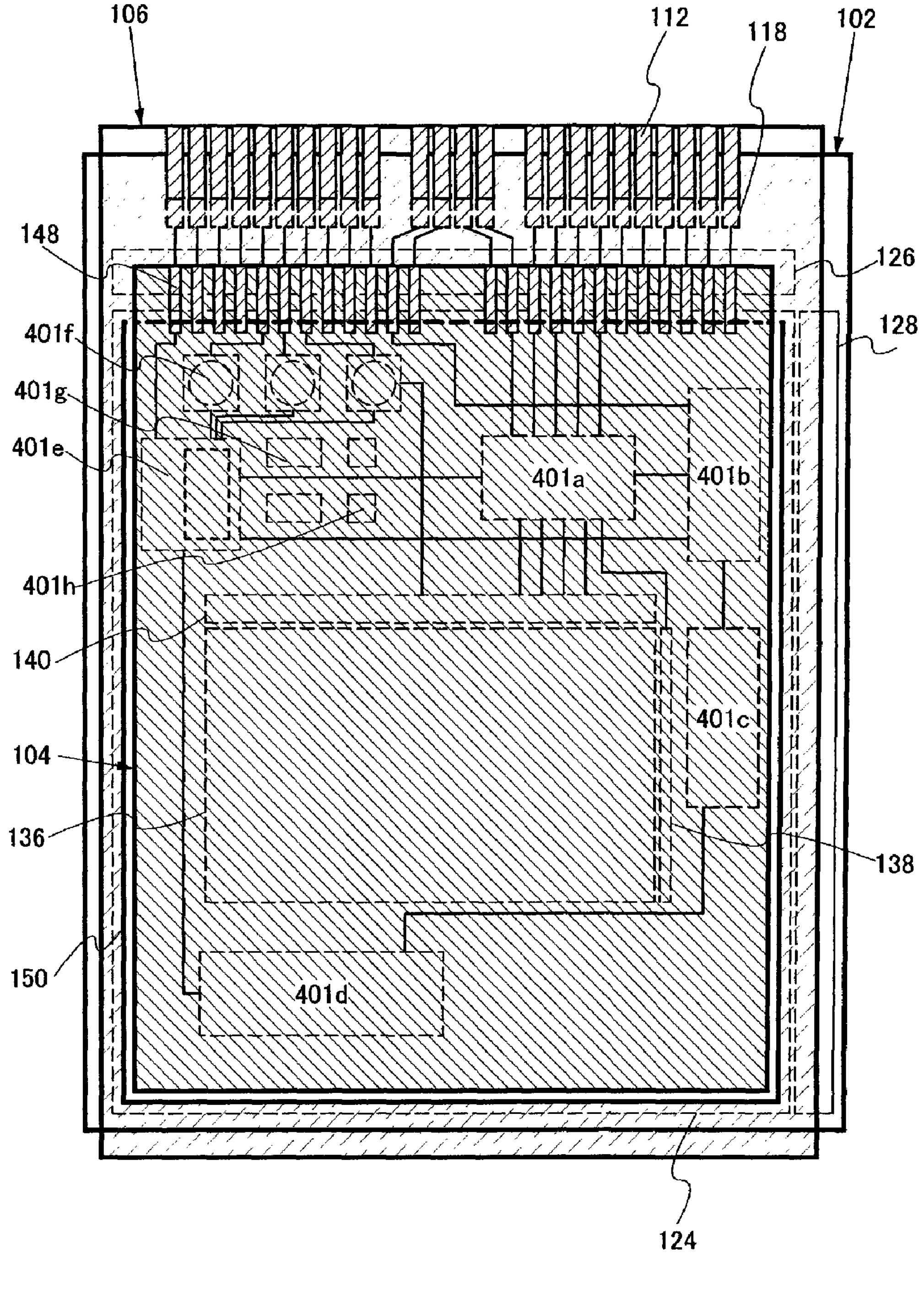
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FIG. 3A

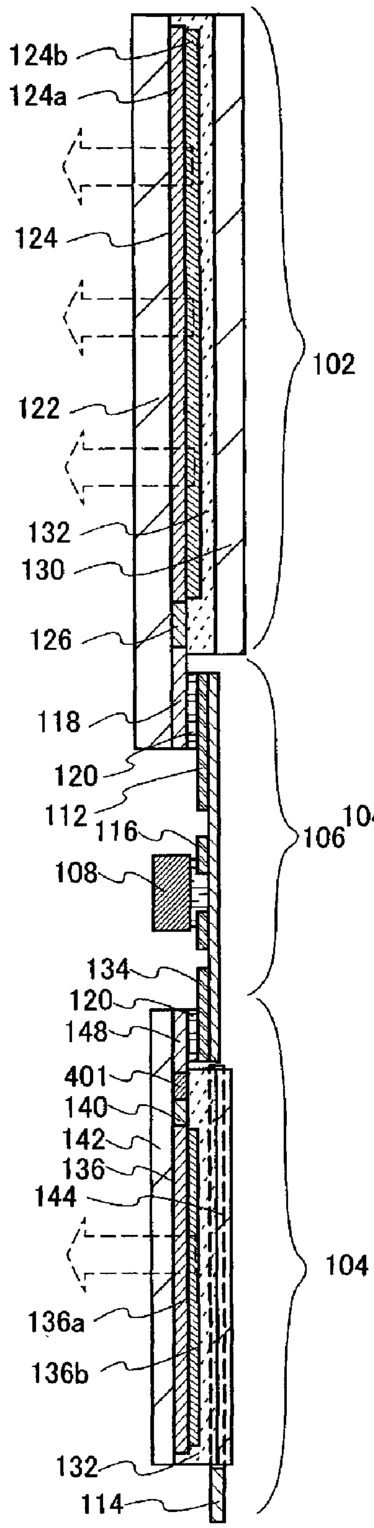

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FIG. 3B

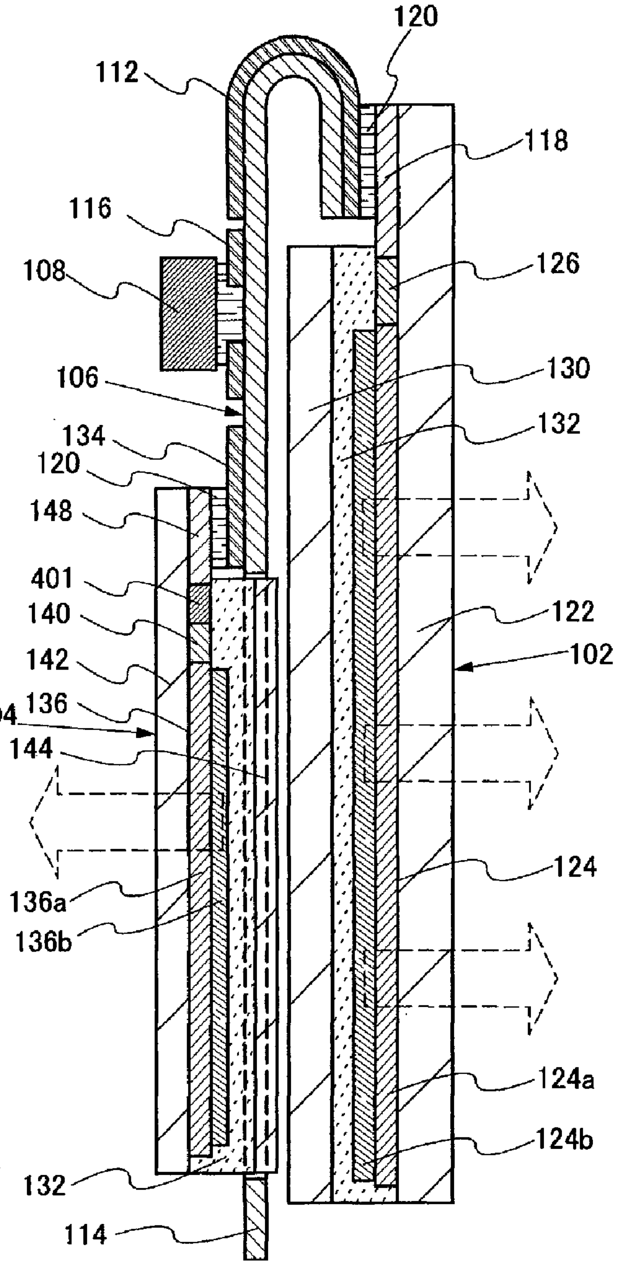

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FIG. 4

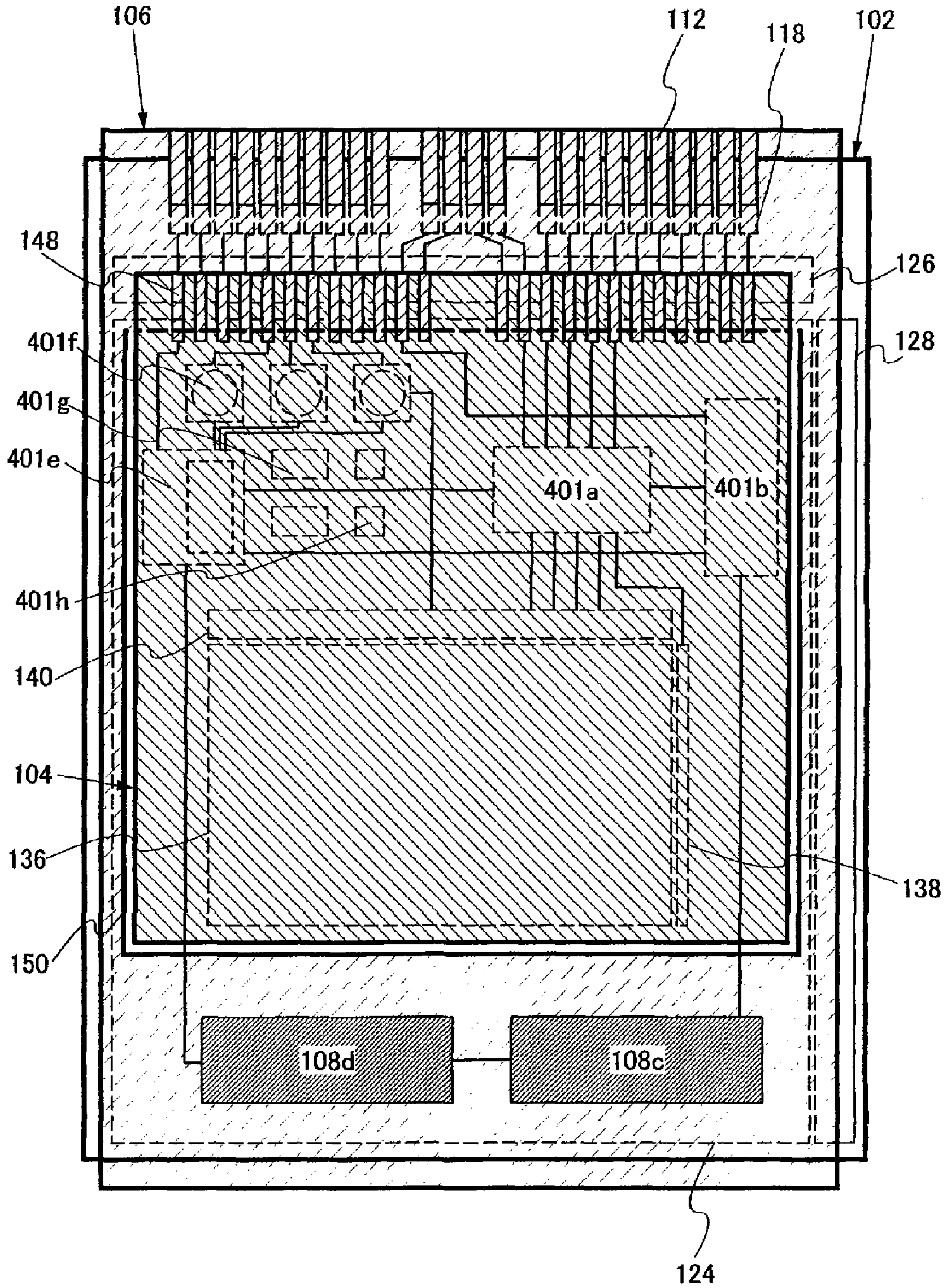
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FIG. 5

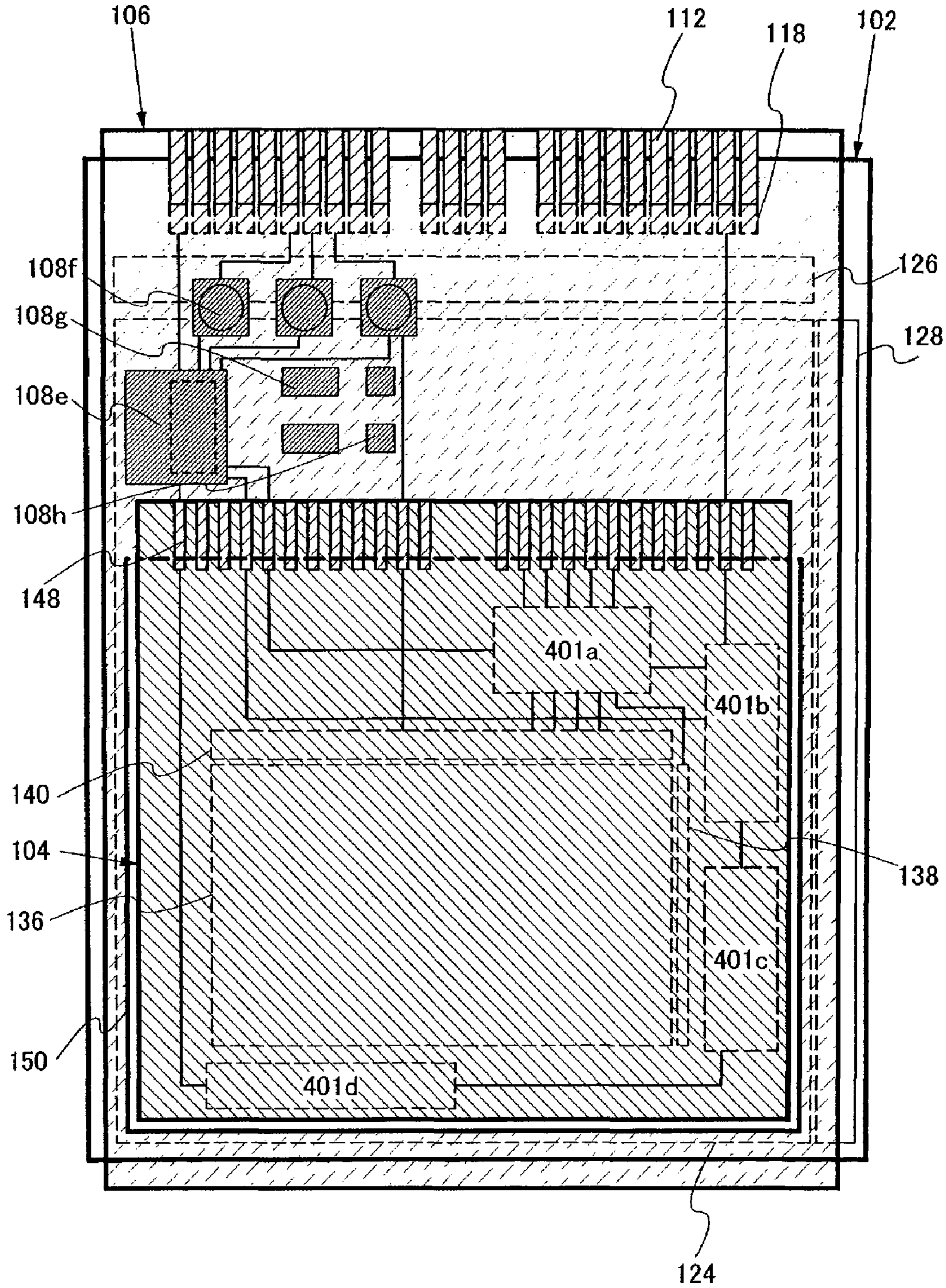
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FIG. 6A

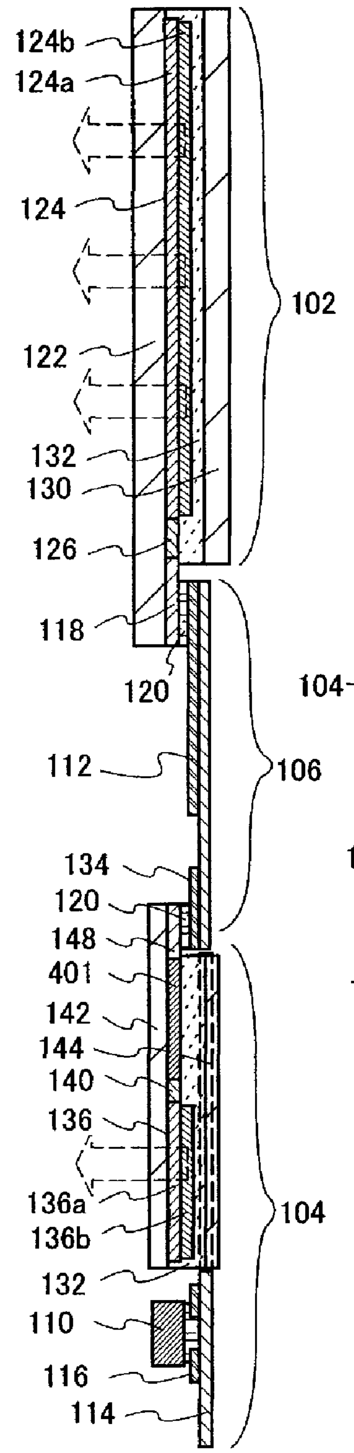
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FIG. 6B

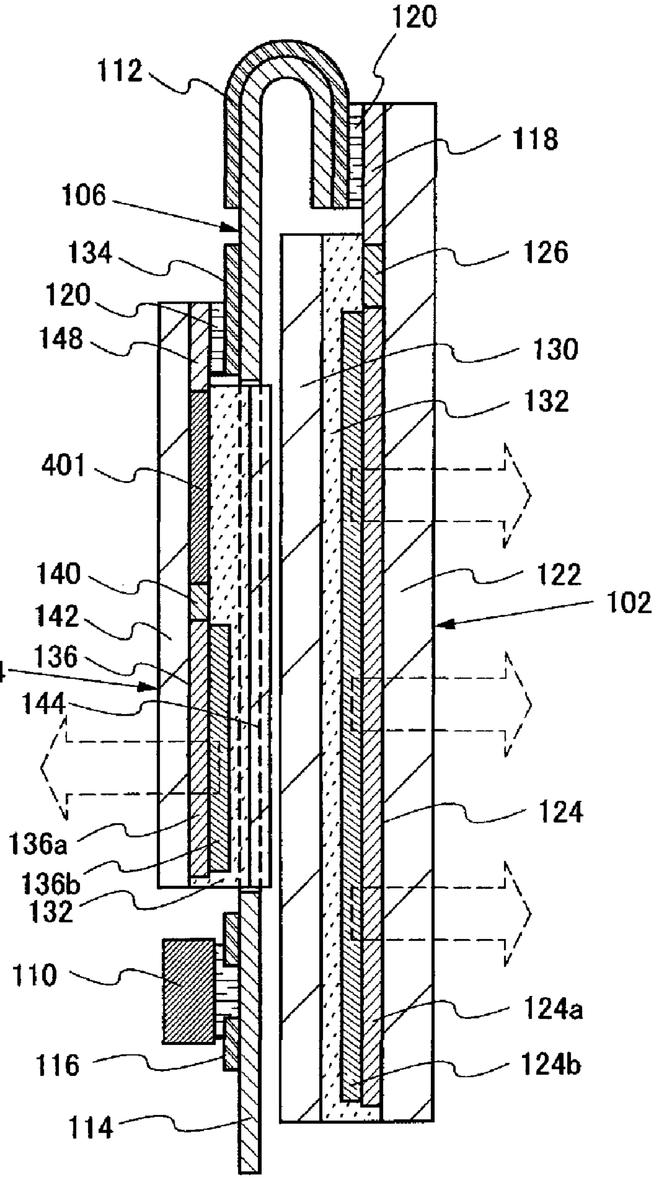
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FIG. 7

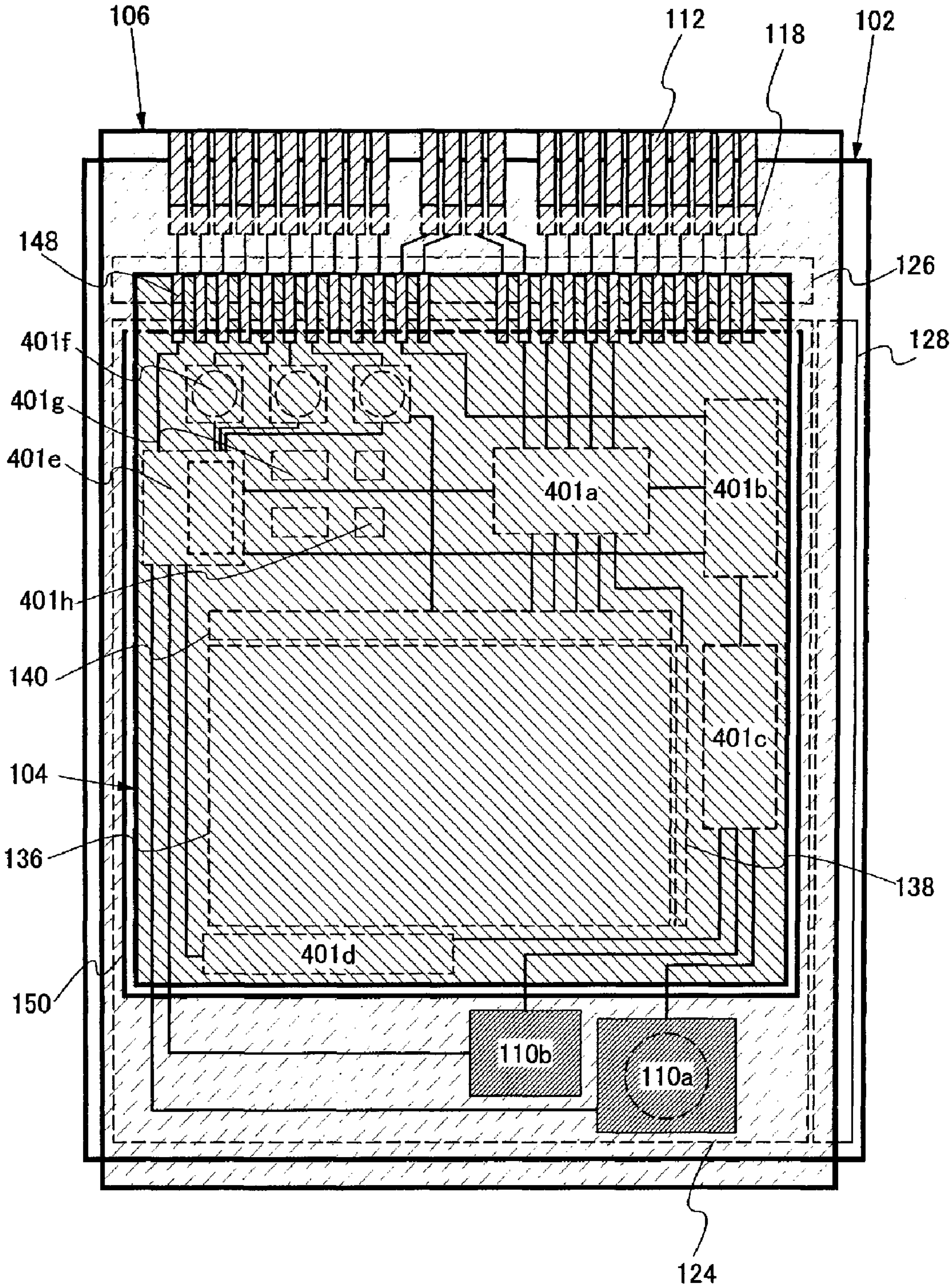
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FIG. 8A

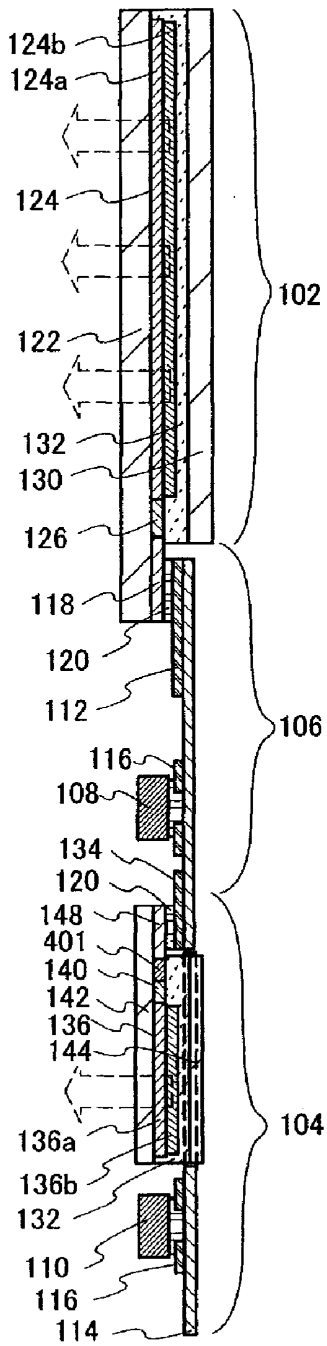
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FIG. 8B

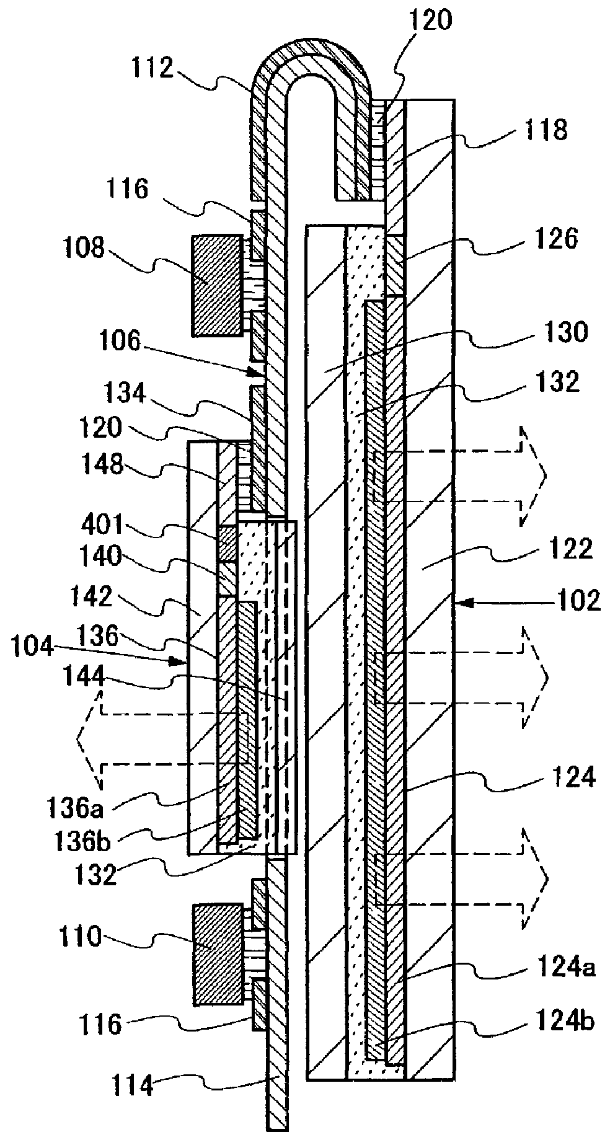
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FIG. 9

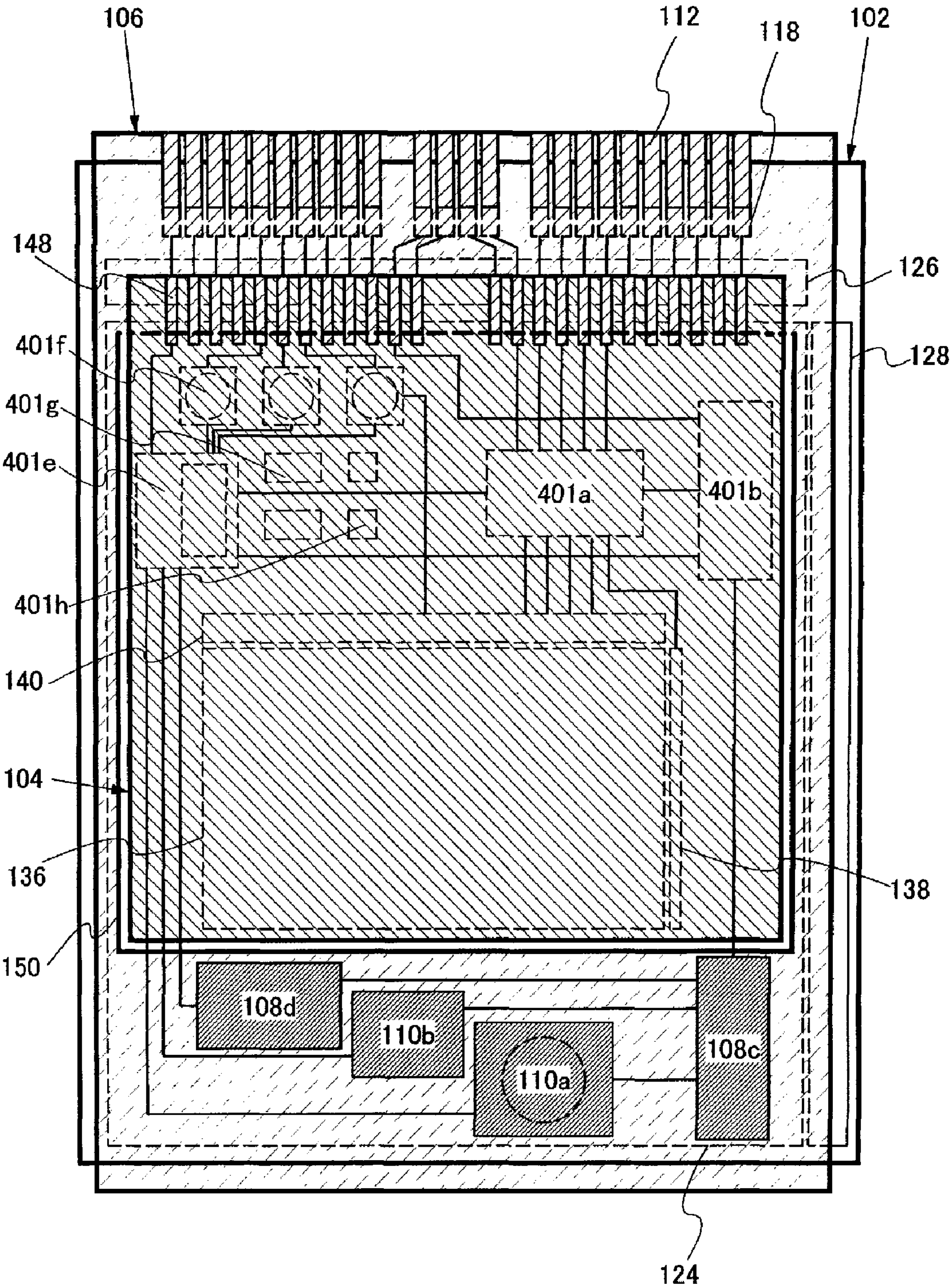
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FIG. 10A

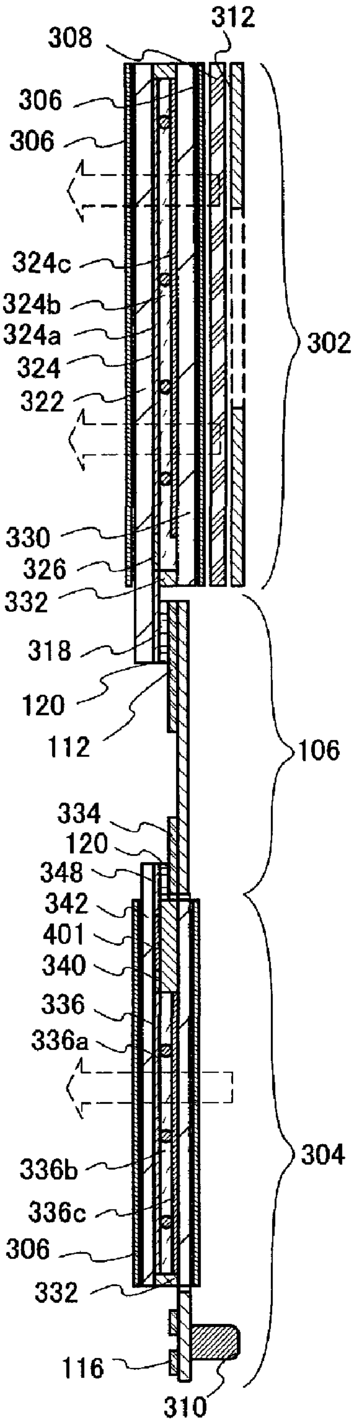

FIG. 10B

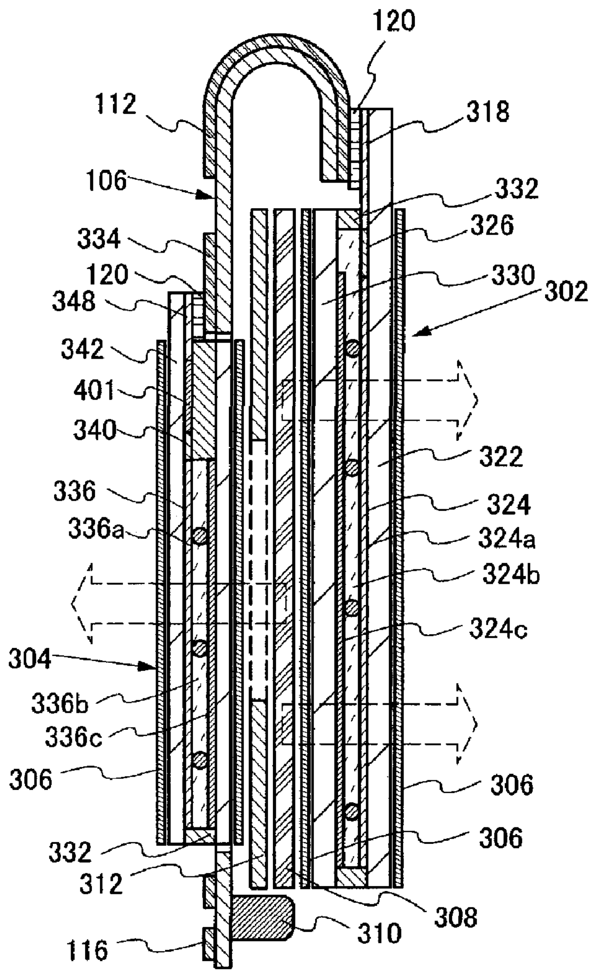

FIG. 11

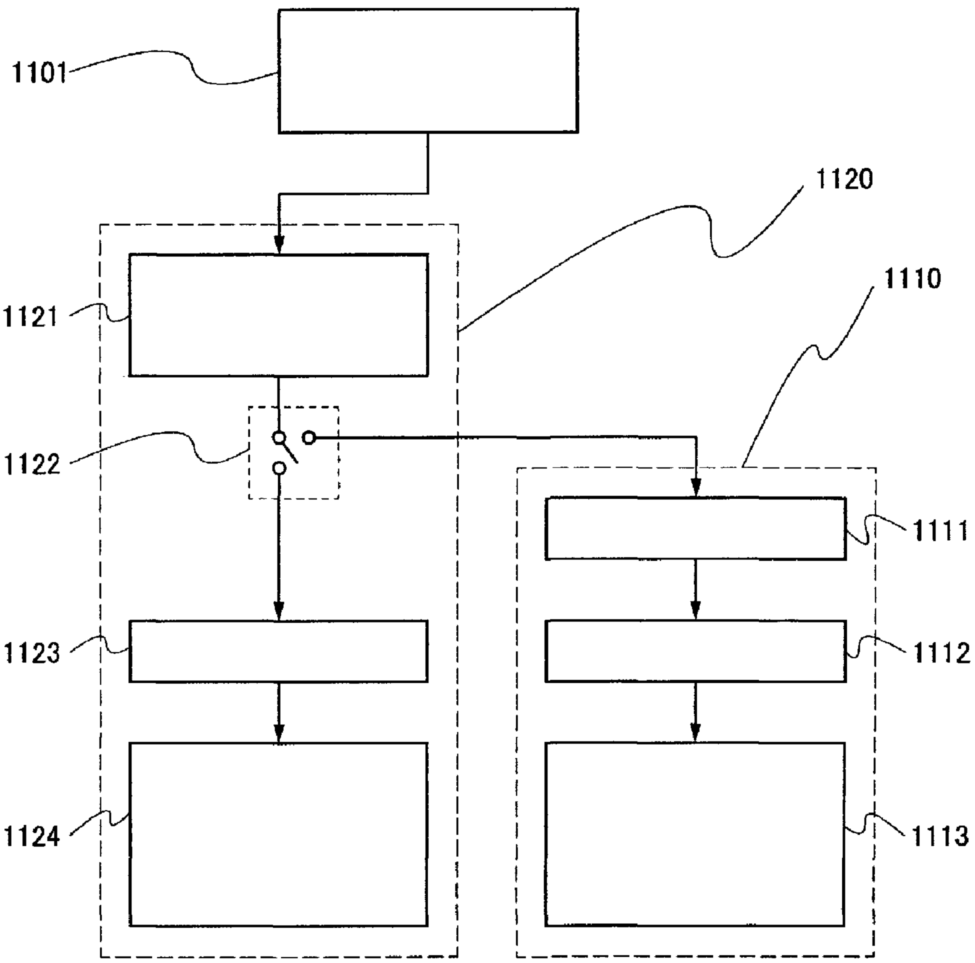

FIG. 12A

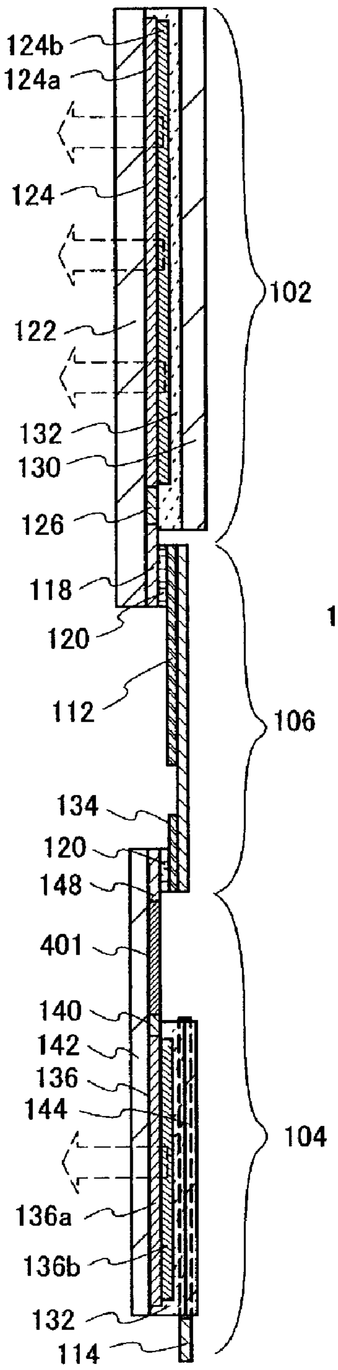

FIG. 12B

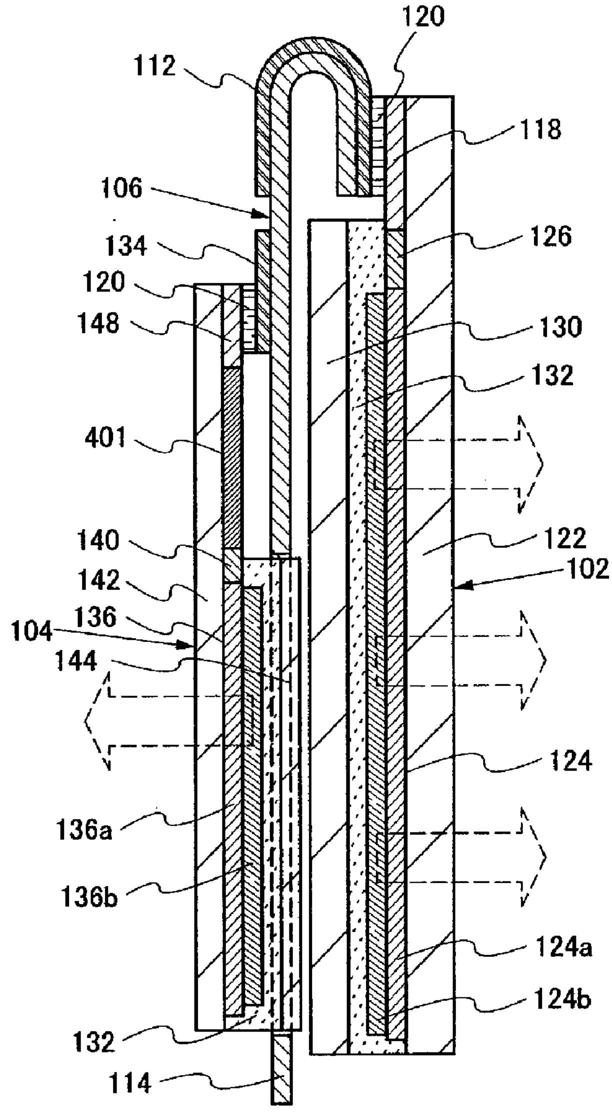

FIG. 13A

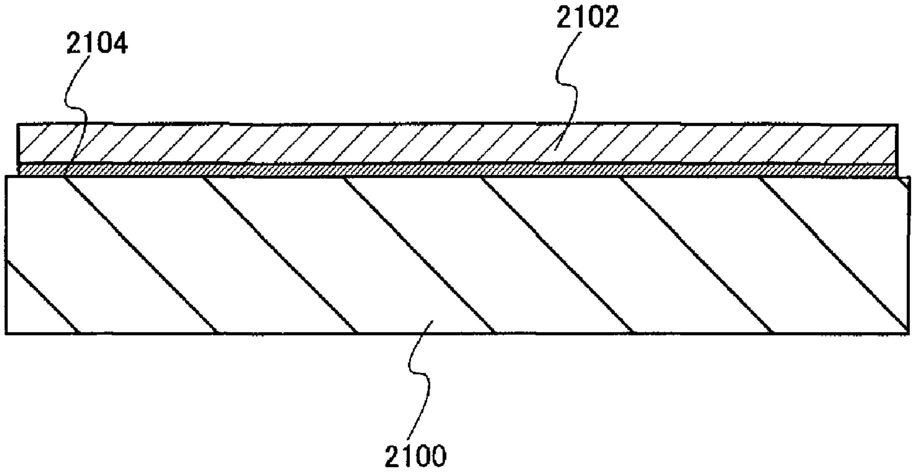

FIG. 13B

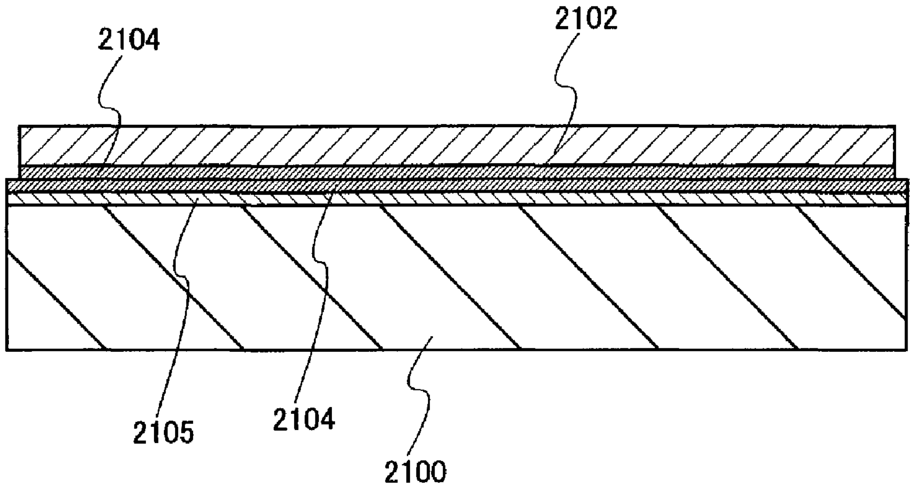

FIG. 14A

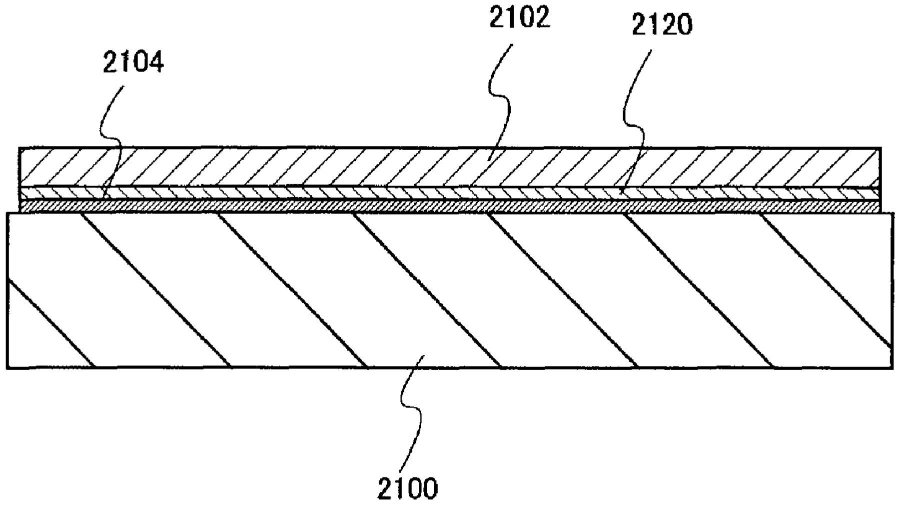

FIG. 14B

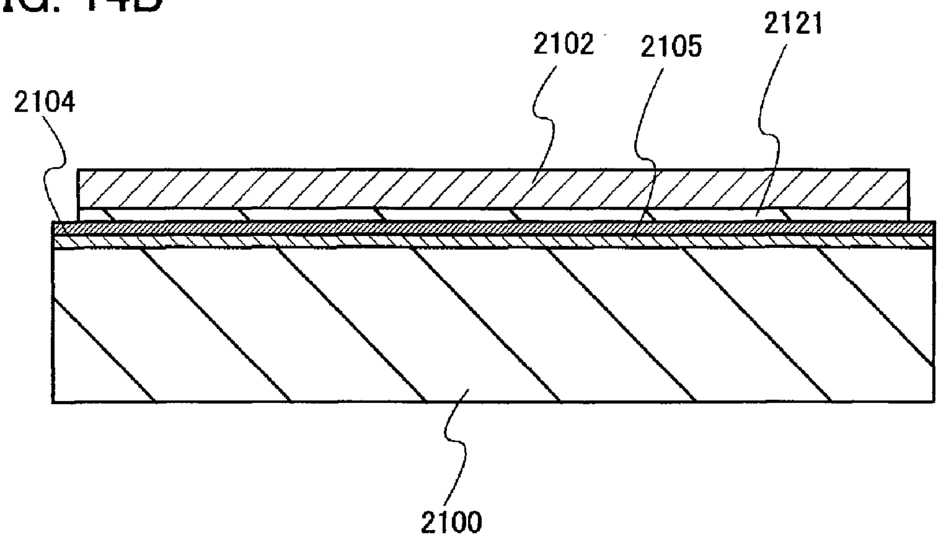

FIG. 15A

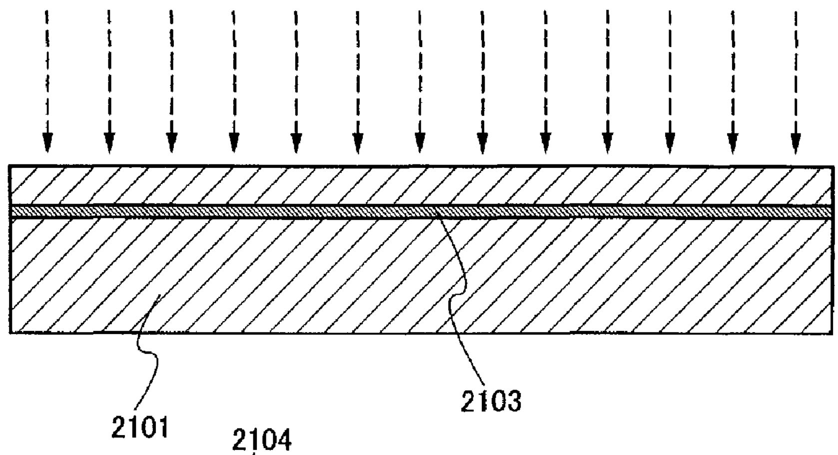

FIG. 15B

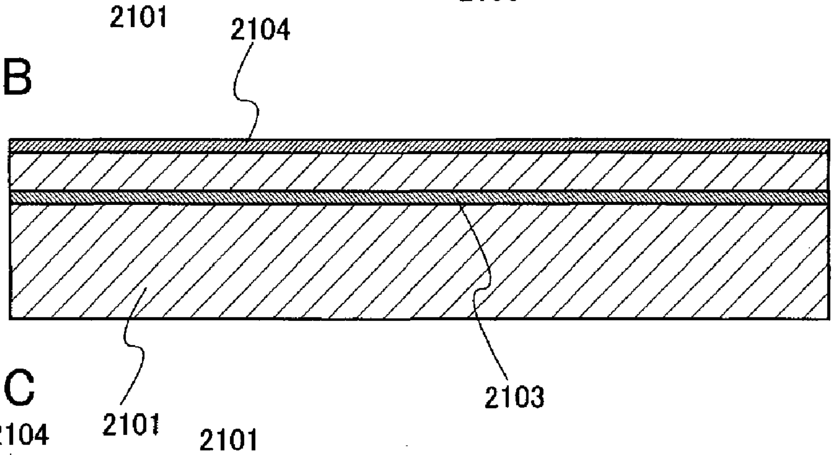

FIG. 15C

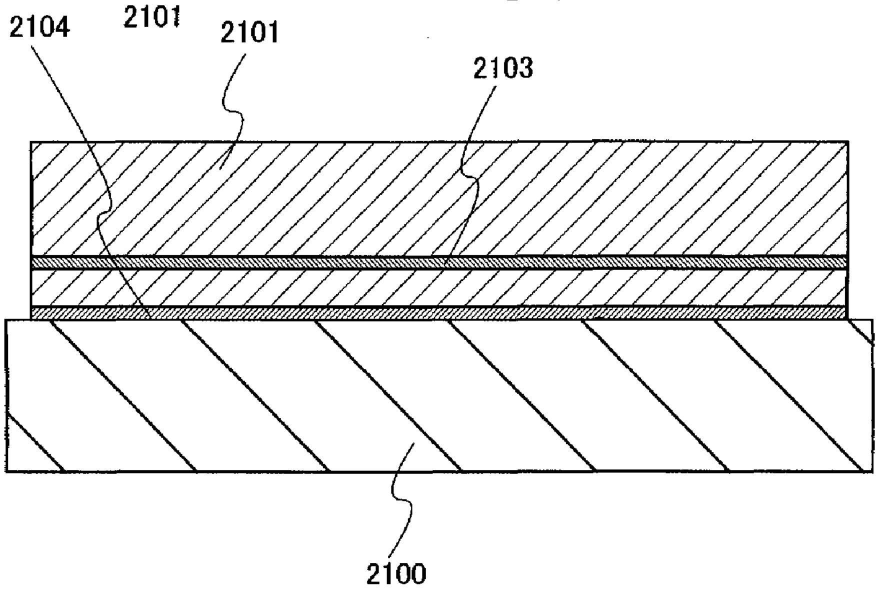

FIG. 16

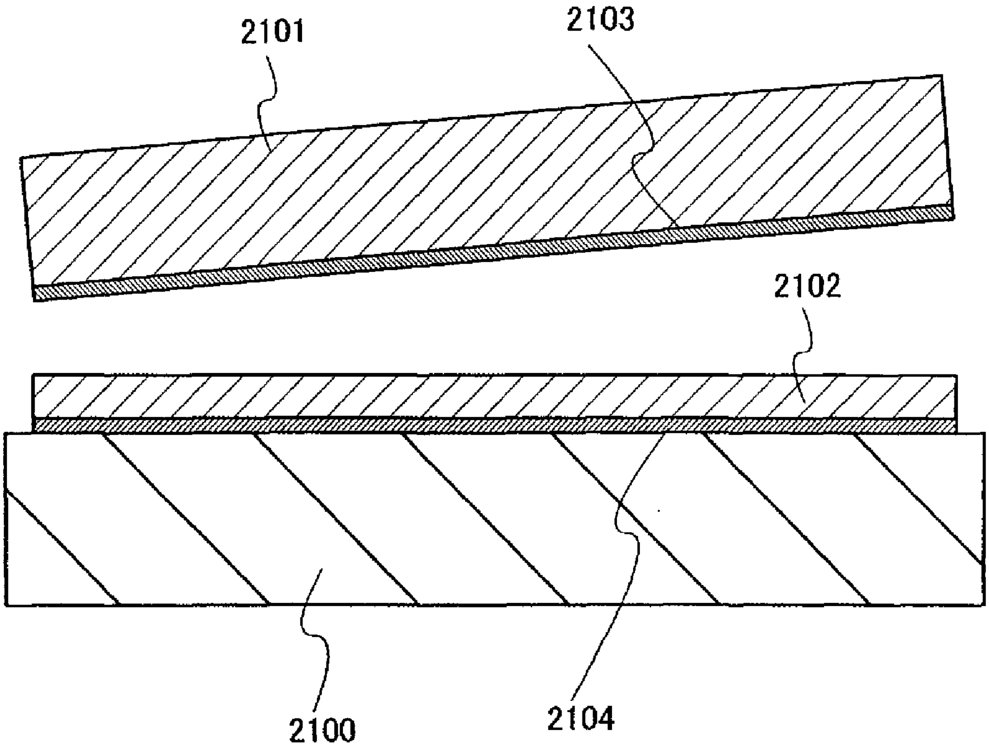

FIG. 17A

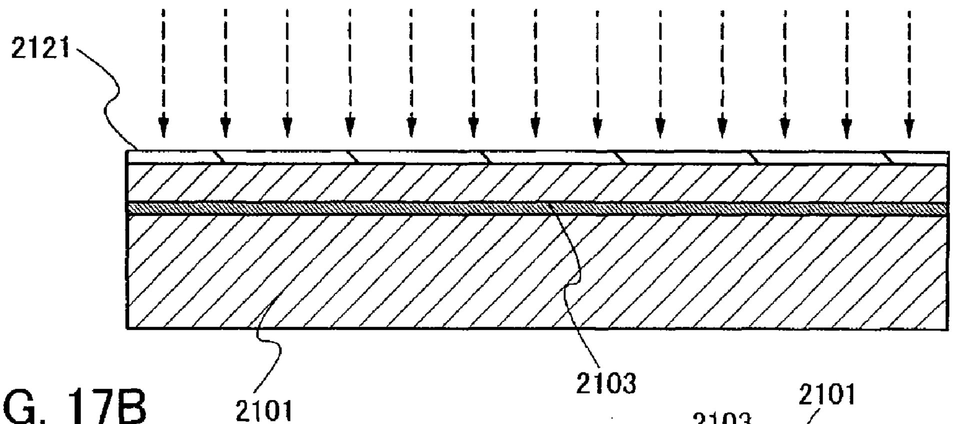

FIG. 17B

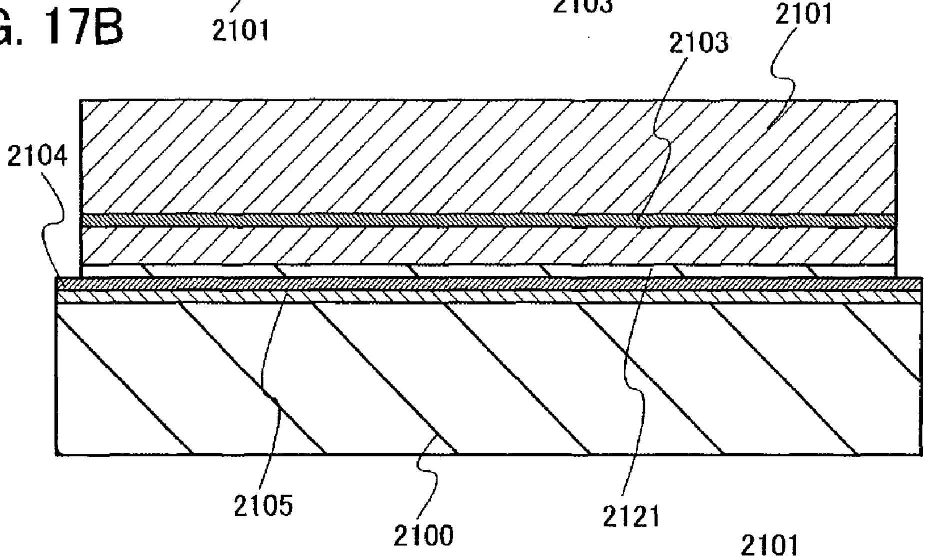

FIG. 17C

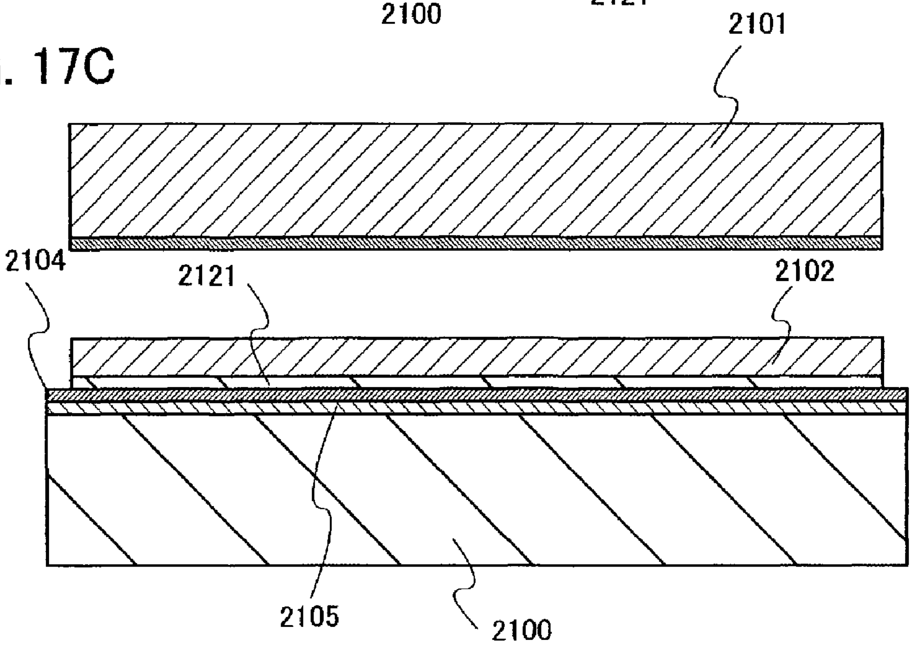

FIG. 18A

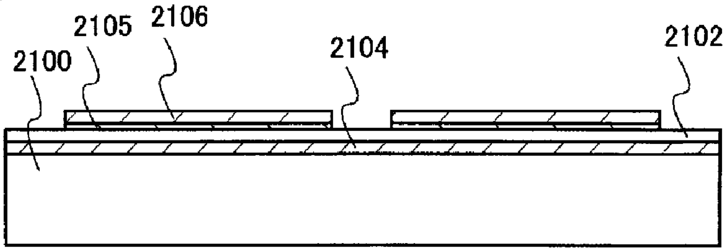

FIG. 18B

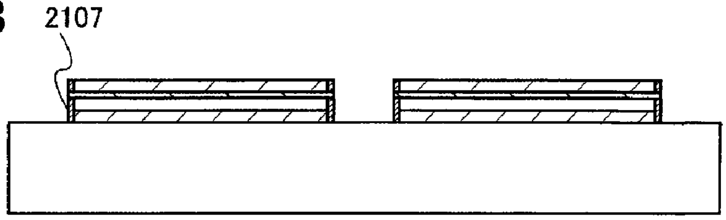

FIG. 18C

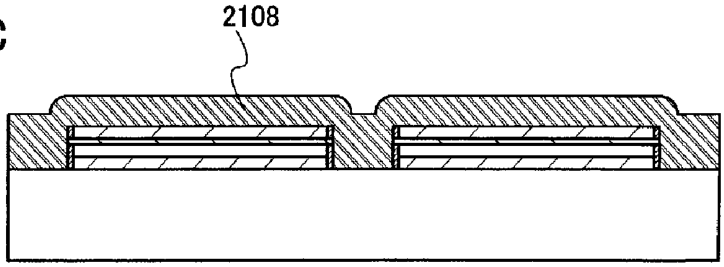

FIG. 18D

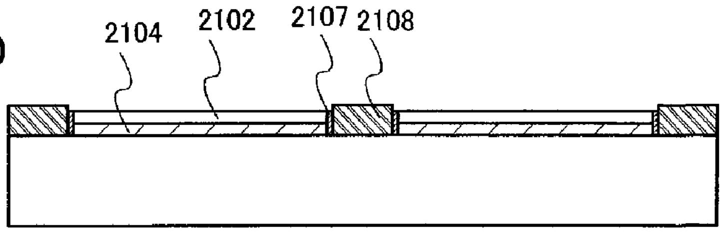

FIG. 18E

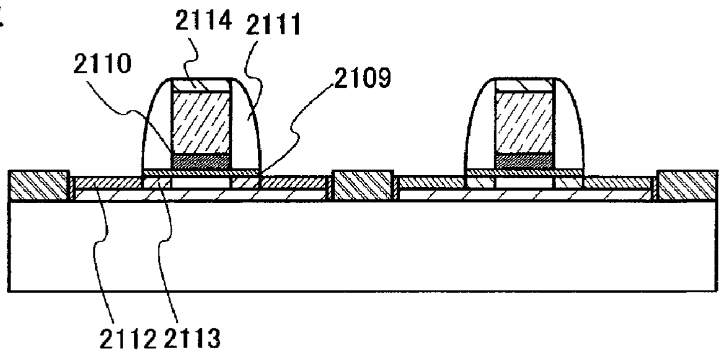

FIG. 19A

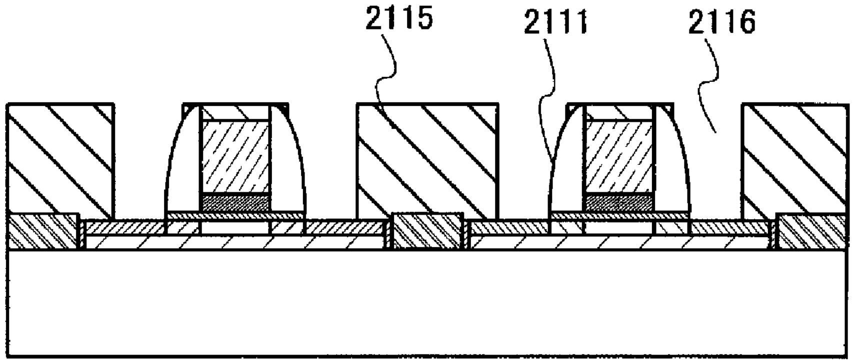

FIG. 19B

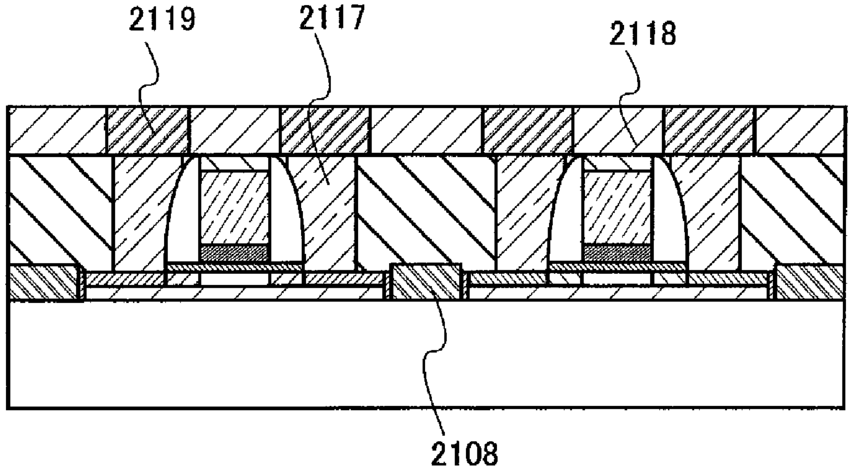

FIG. 20A

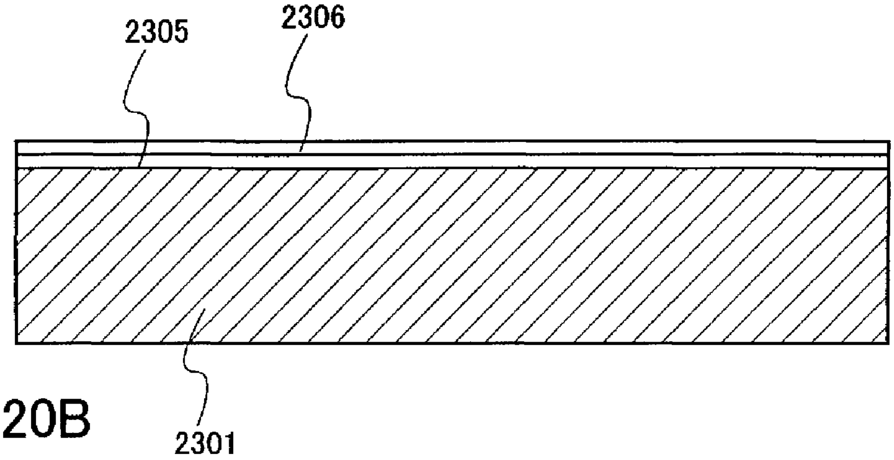

FIG. 20B

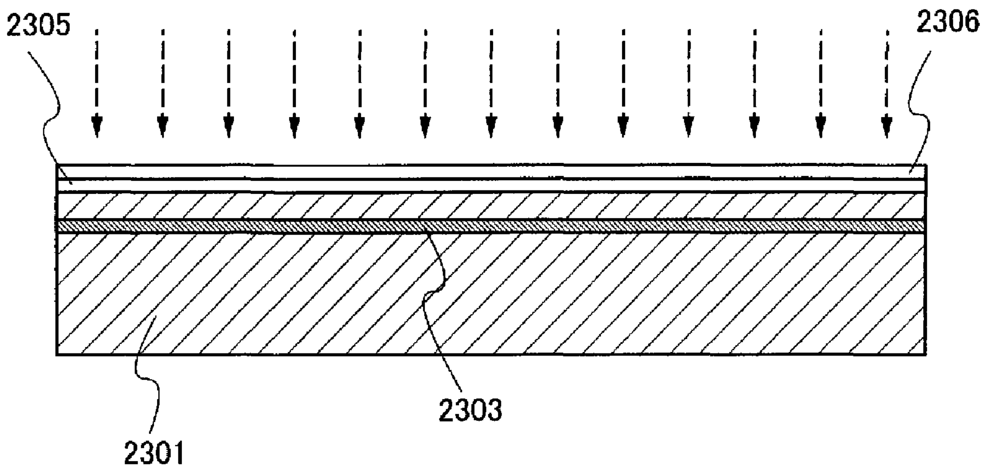

FIG. 20C

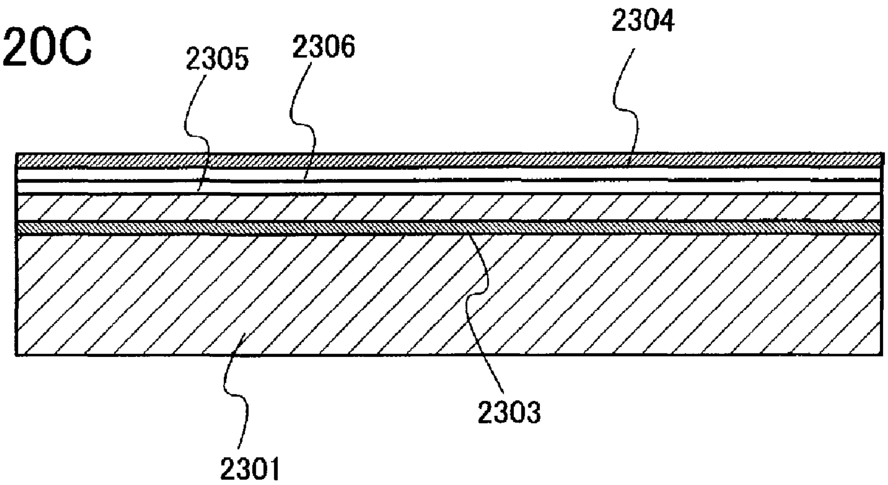

FIG. 21A

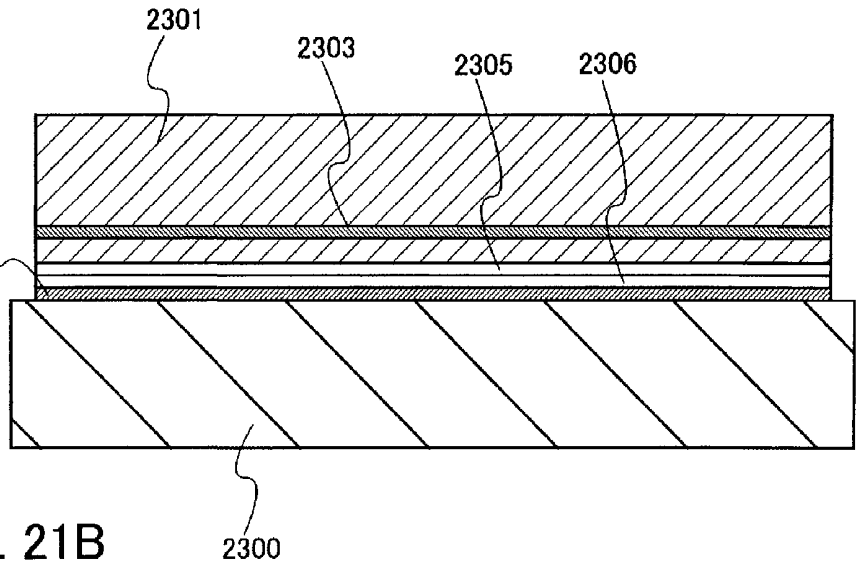

FIG. 21B

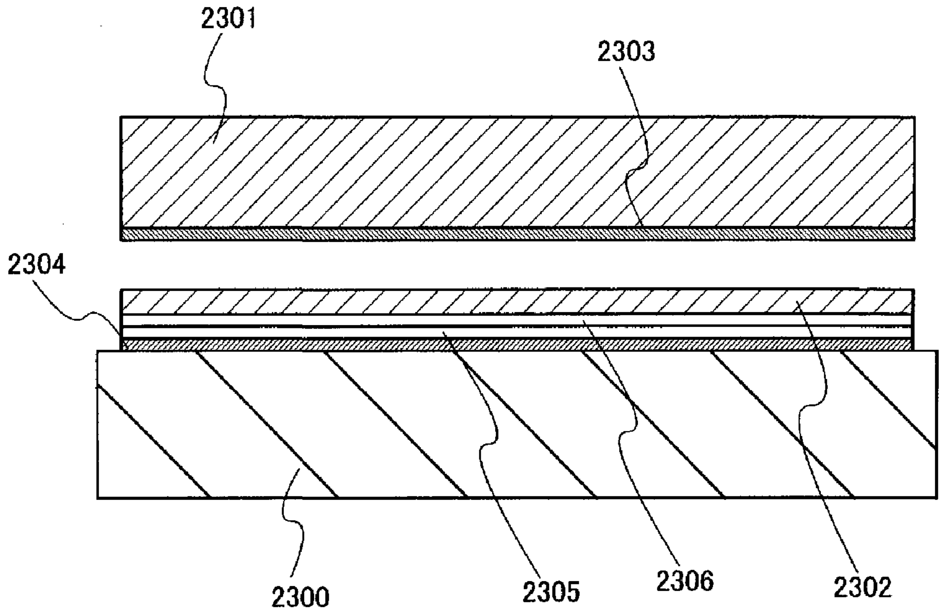

FIG. 22A

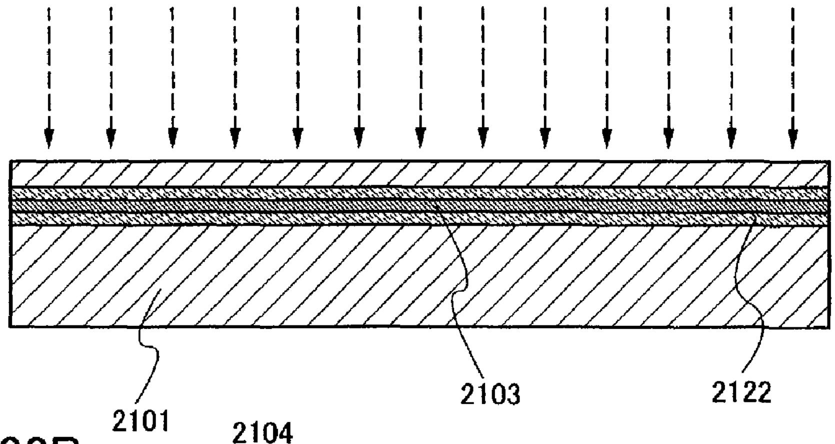

FIG. 22B

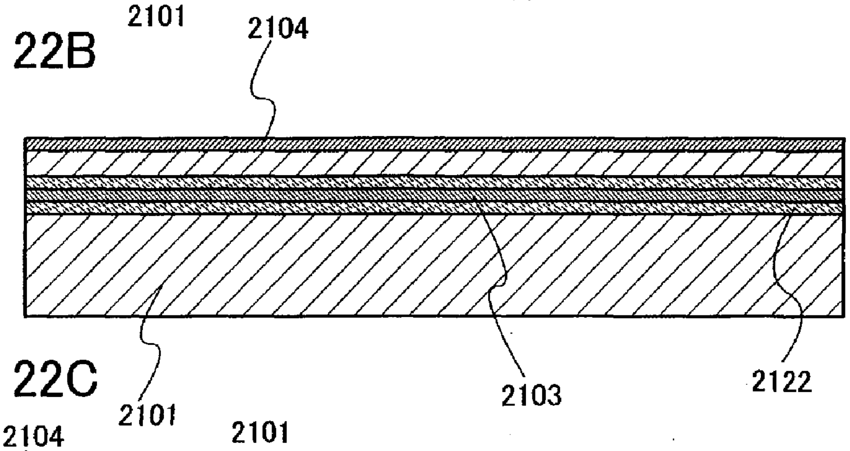

FIG. 22C

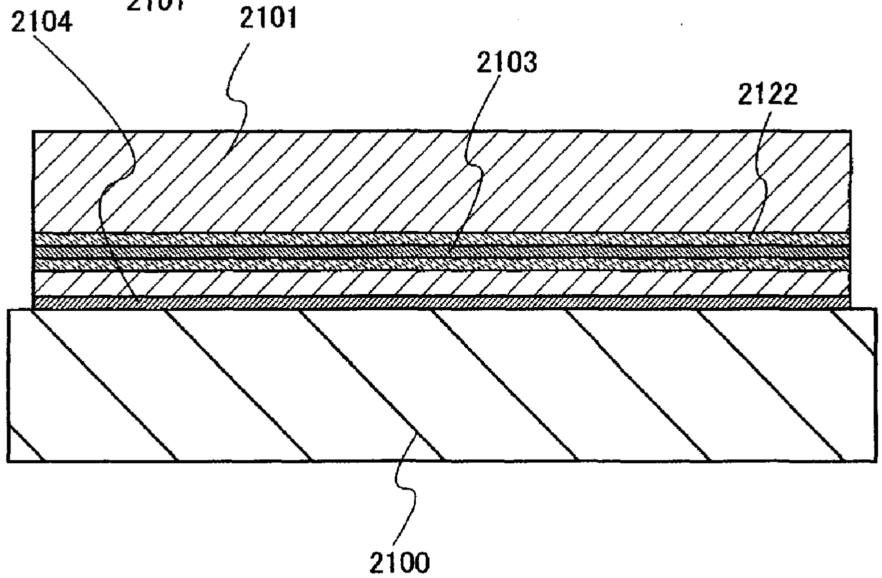

FIG. 23A

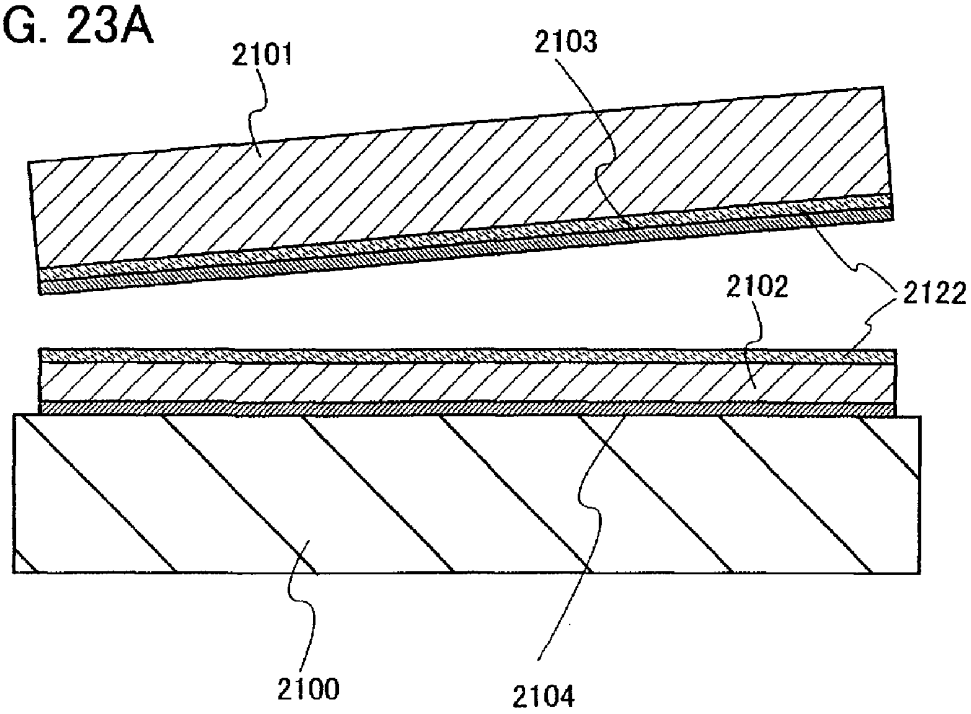

FIG. 23B

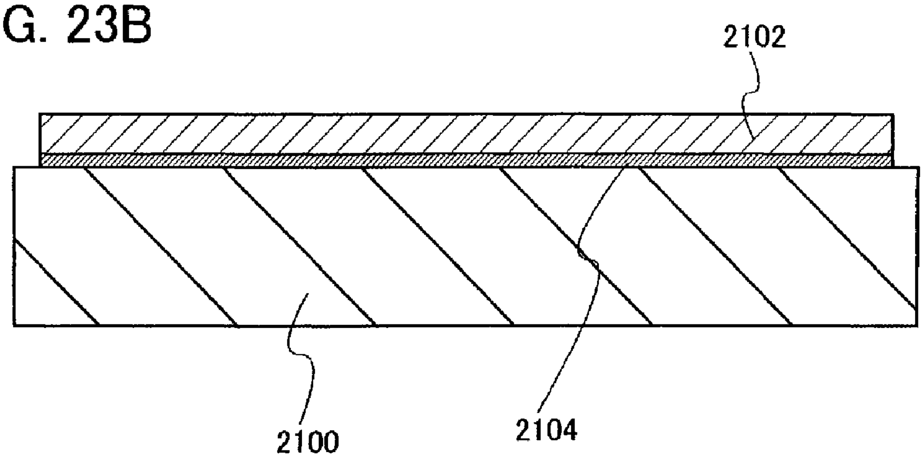

FIG. 24

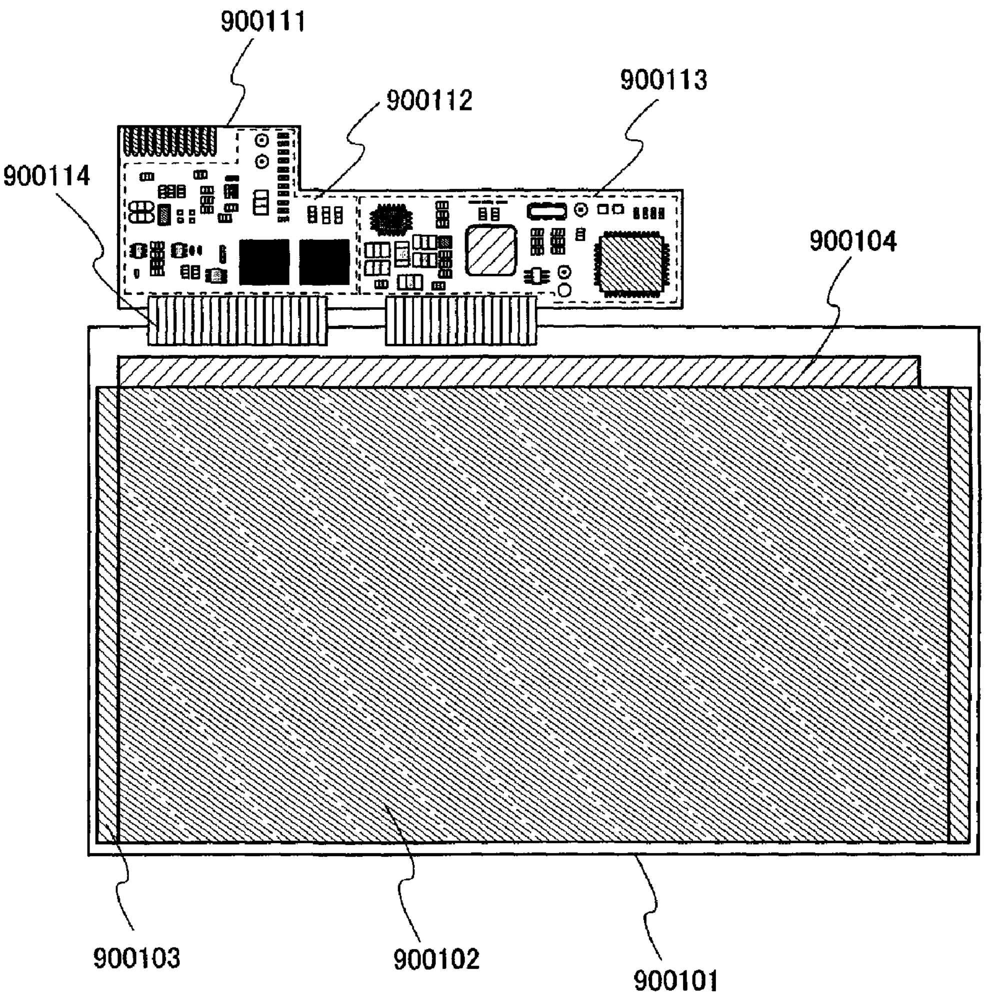

FIG. 25

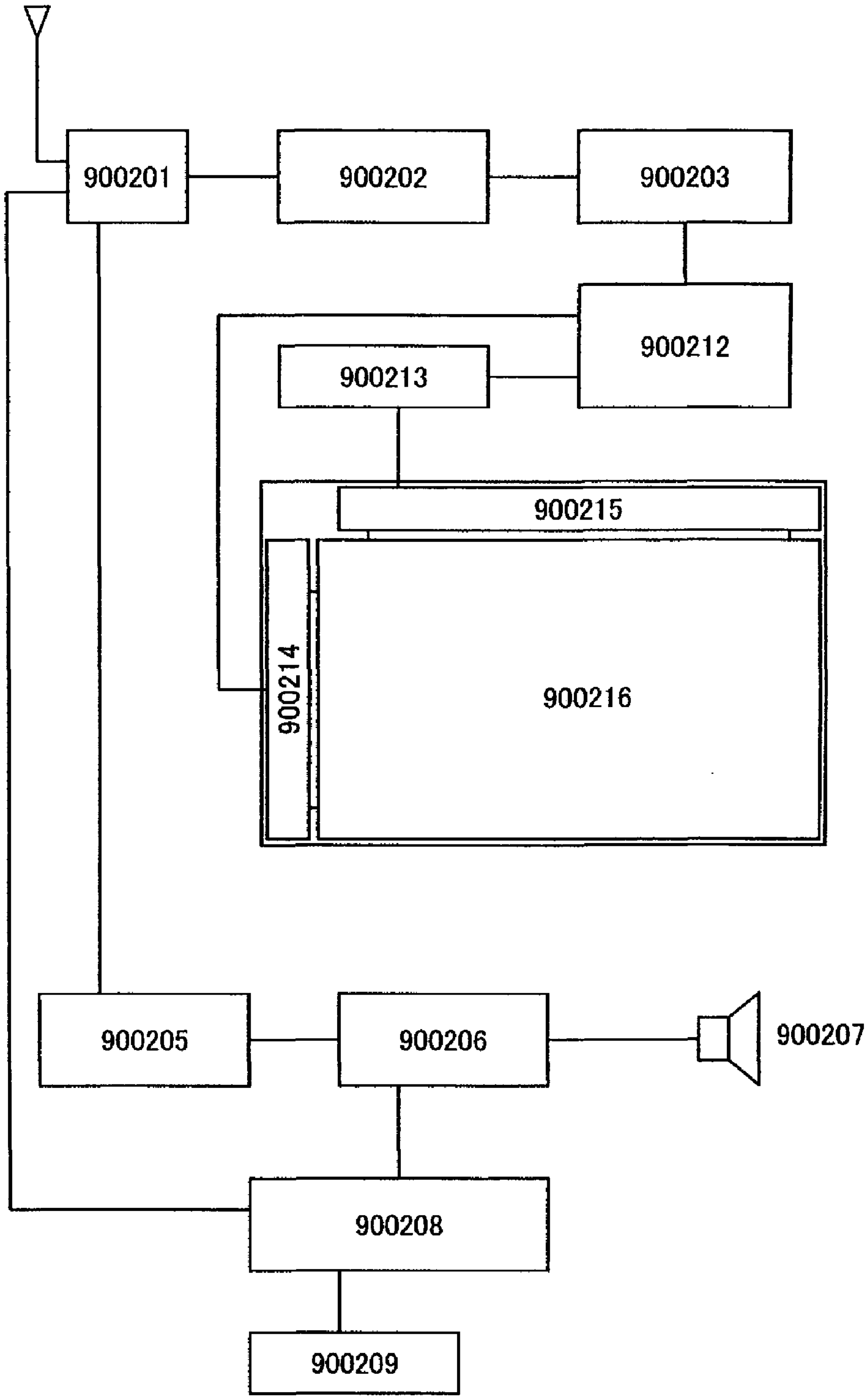
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FIG. 26A

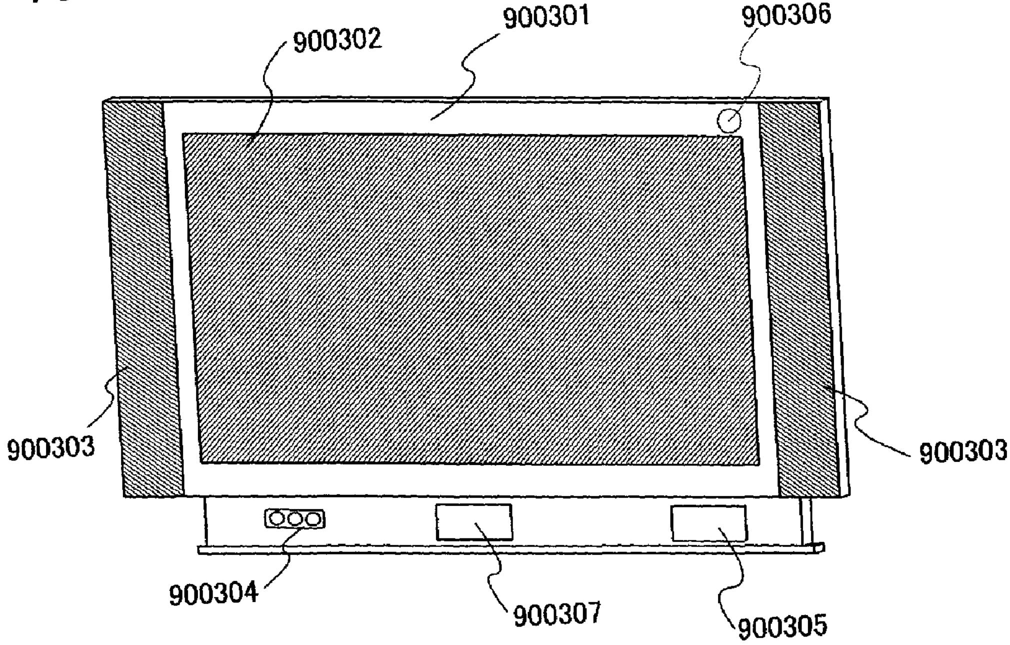

FIG. 26B

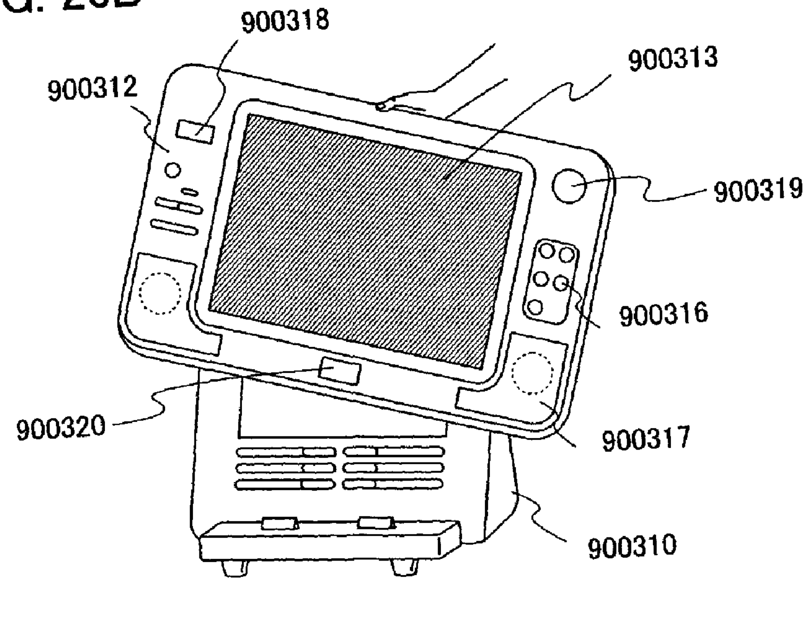

FIG. 27A

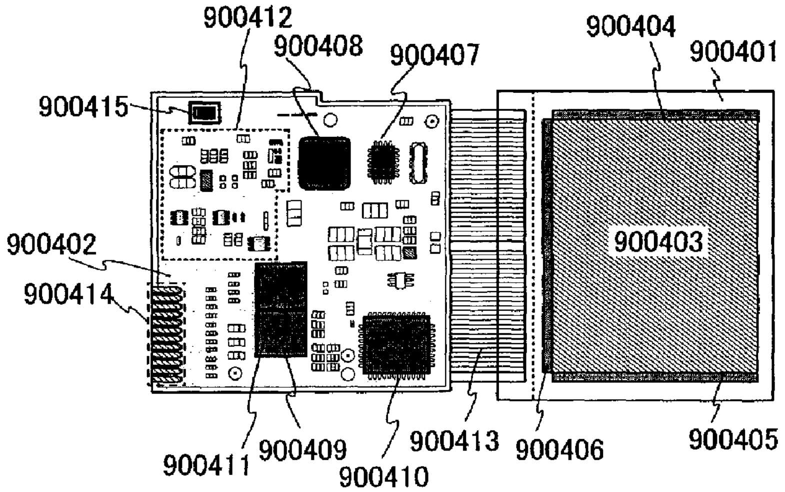

FIG. 27B

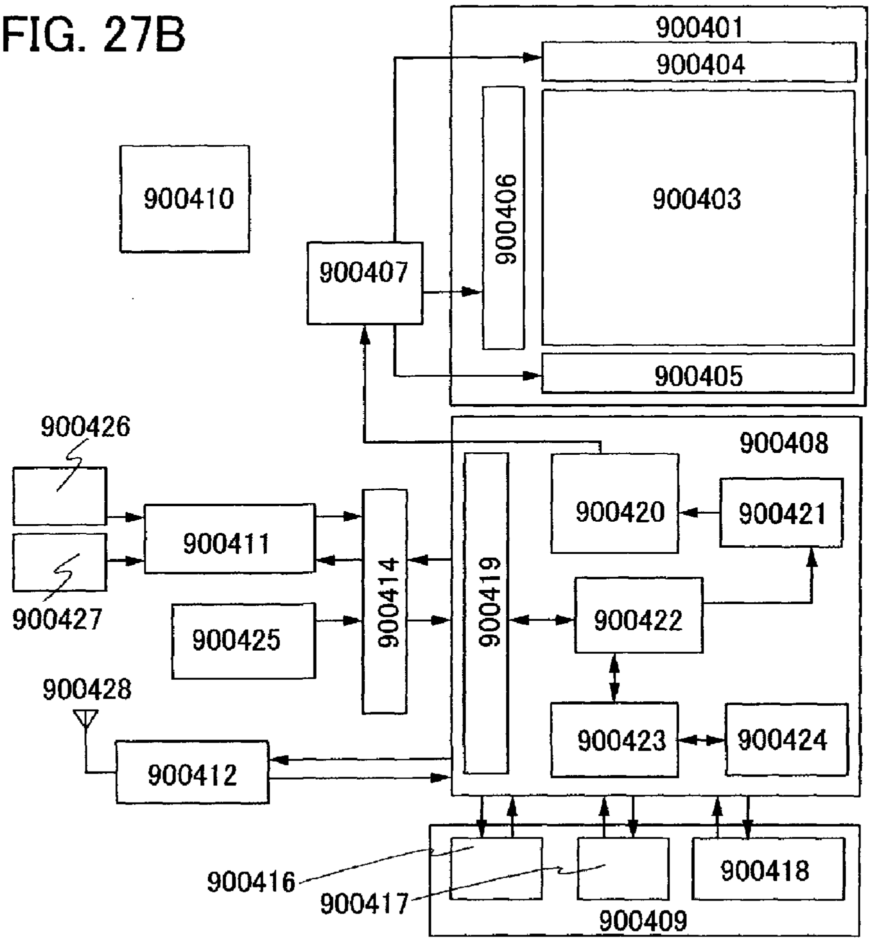

FIG. 28

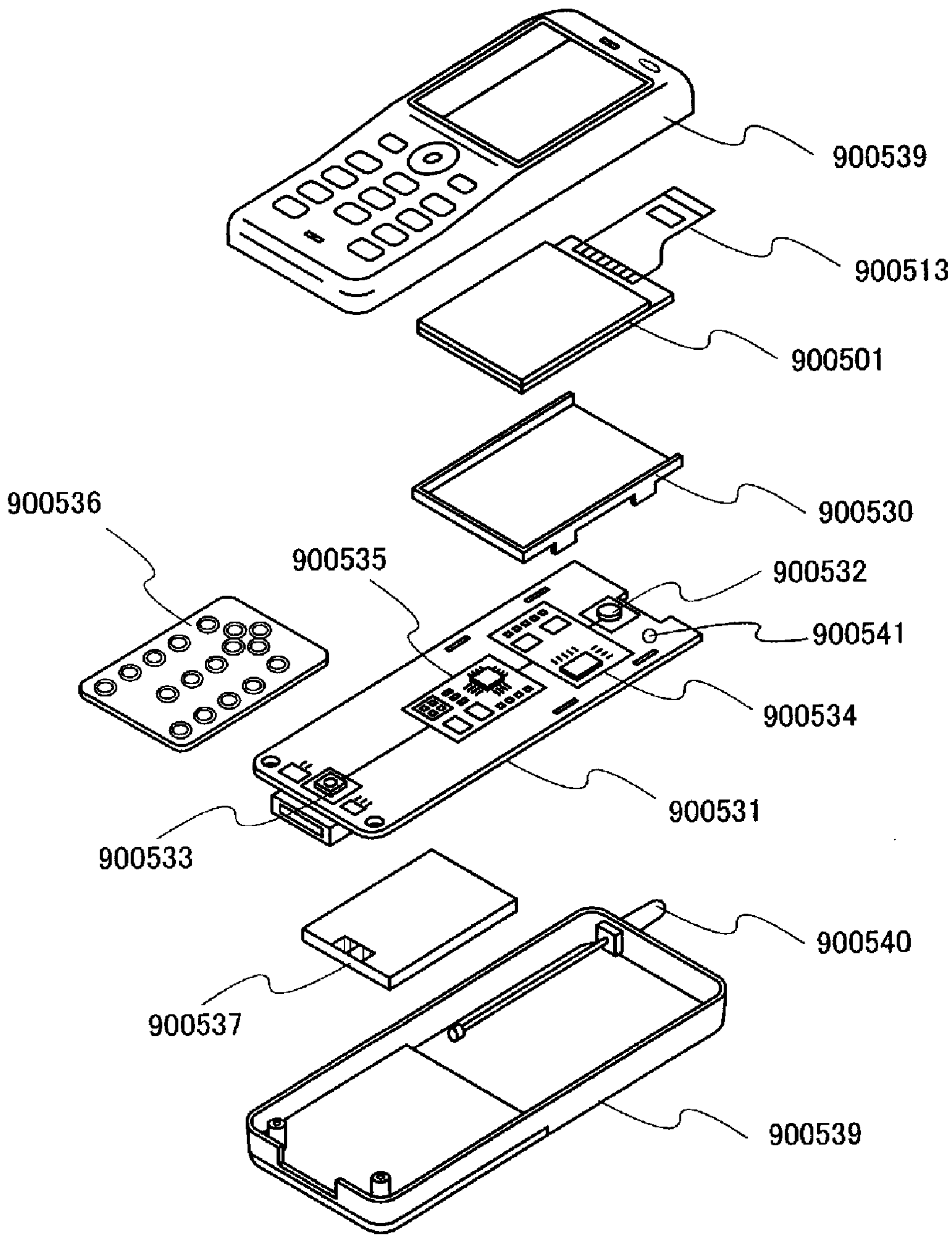
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FIG. 29

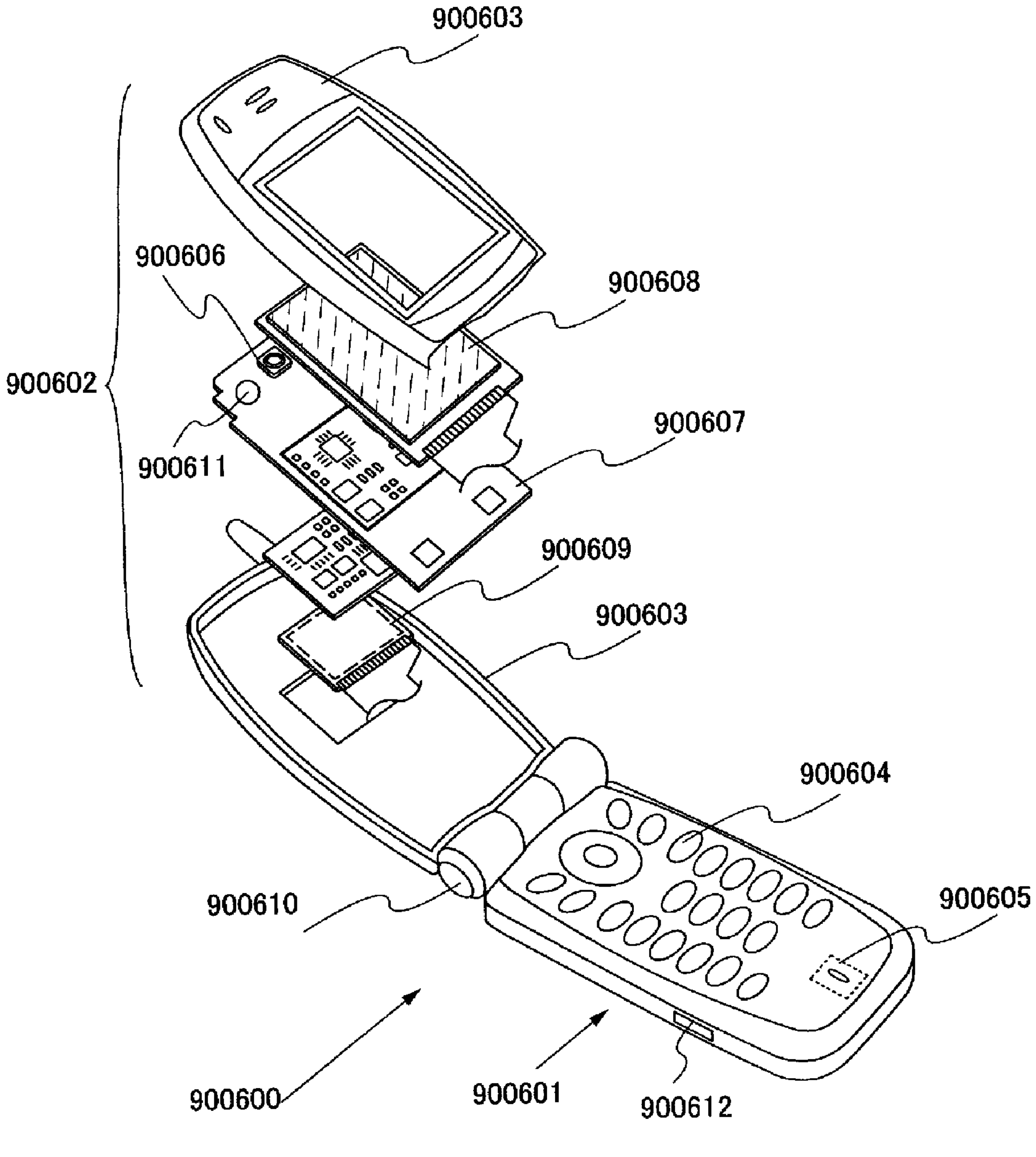
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FIG. 30A

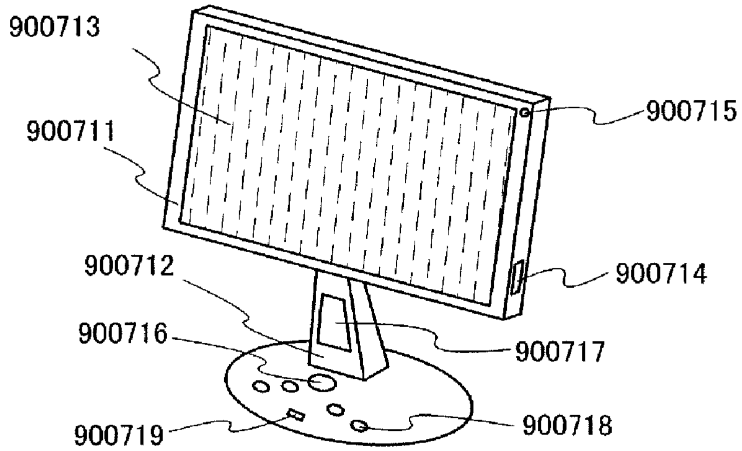


FIG. 30B

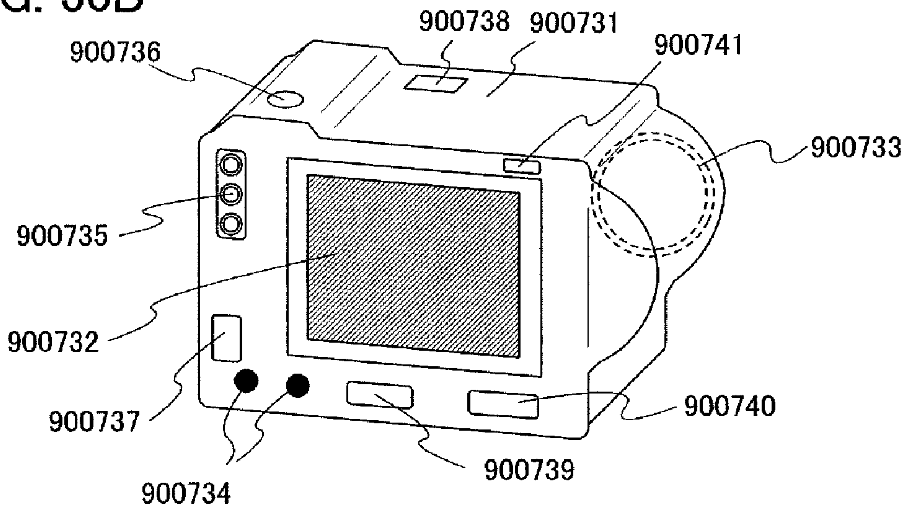


FIG. 30C

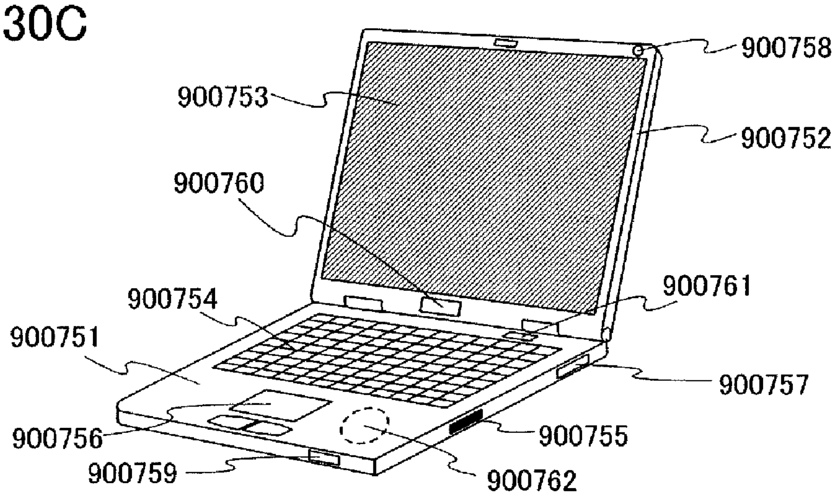


FIG. 31

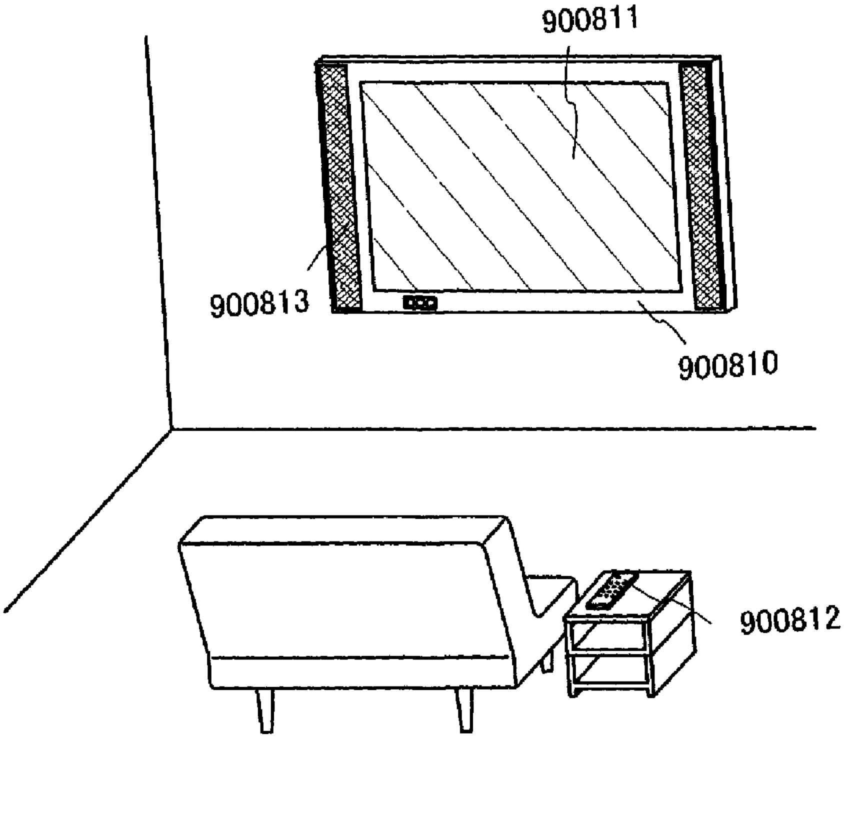


FIG. 32

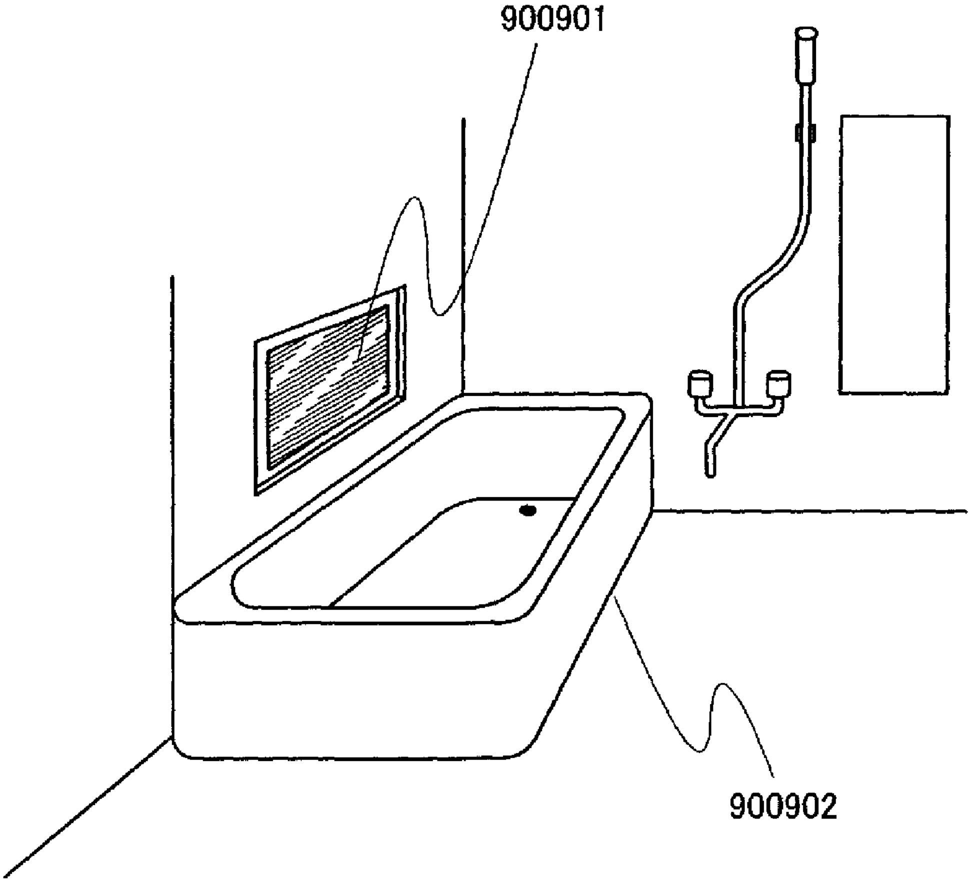


FIG. 33

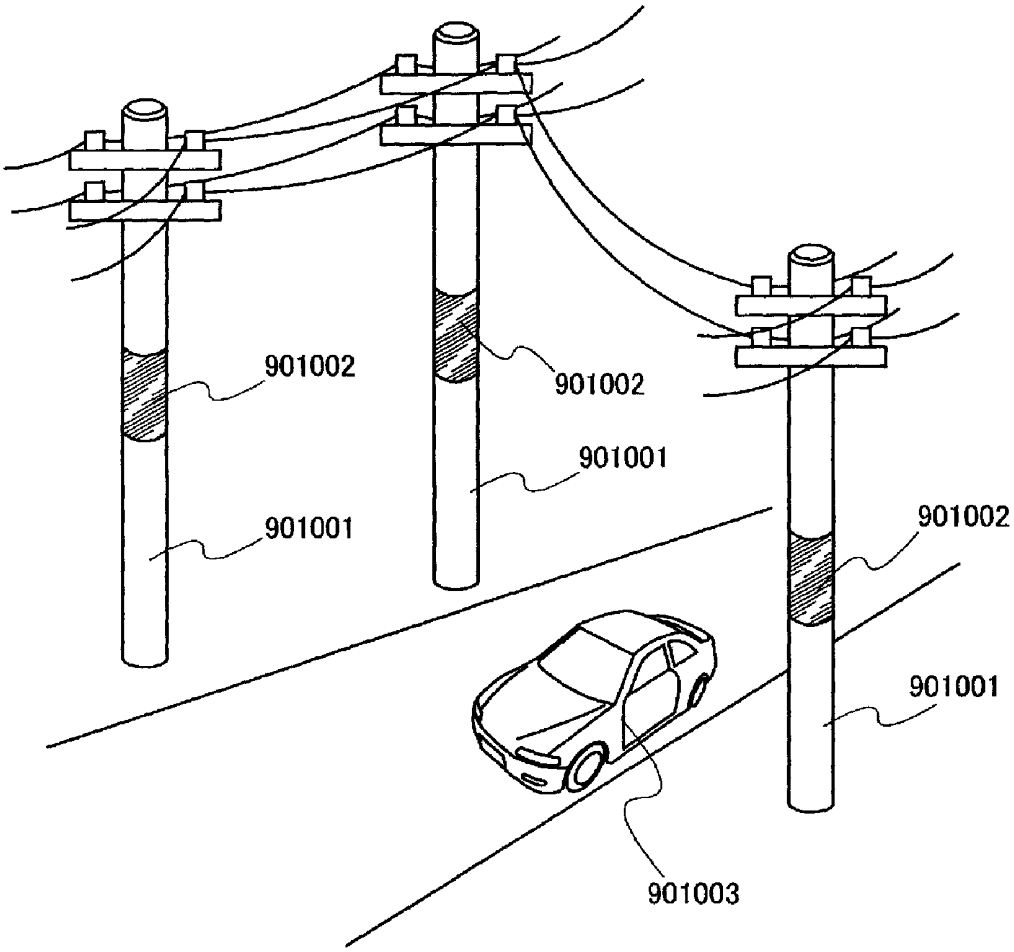


FIG. 34

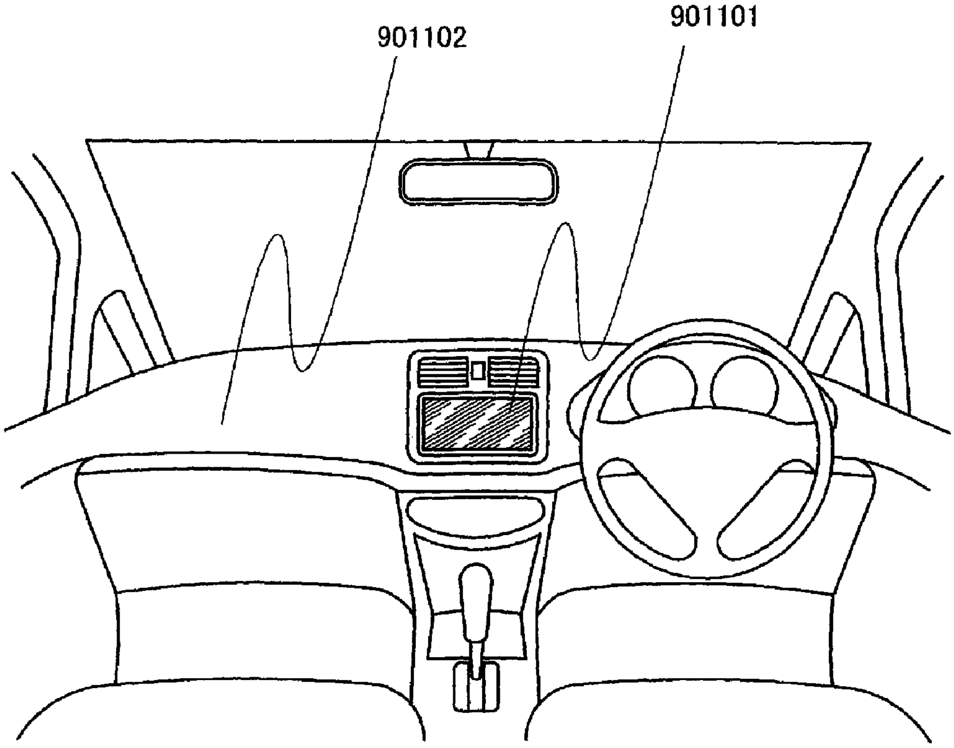


FIG. 35A

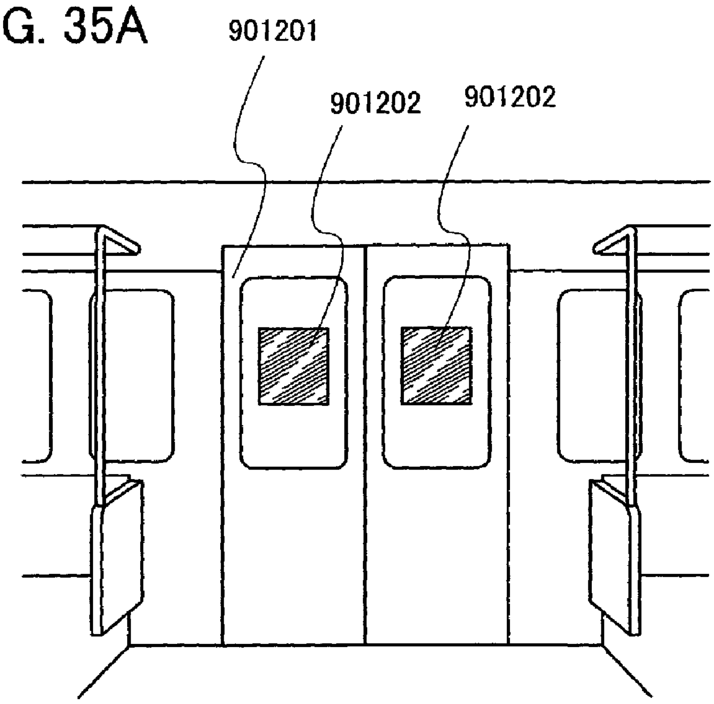


FIG. 35B

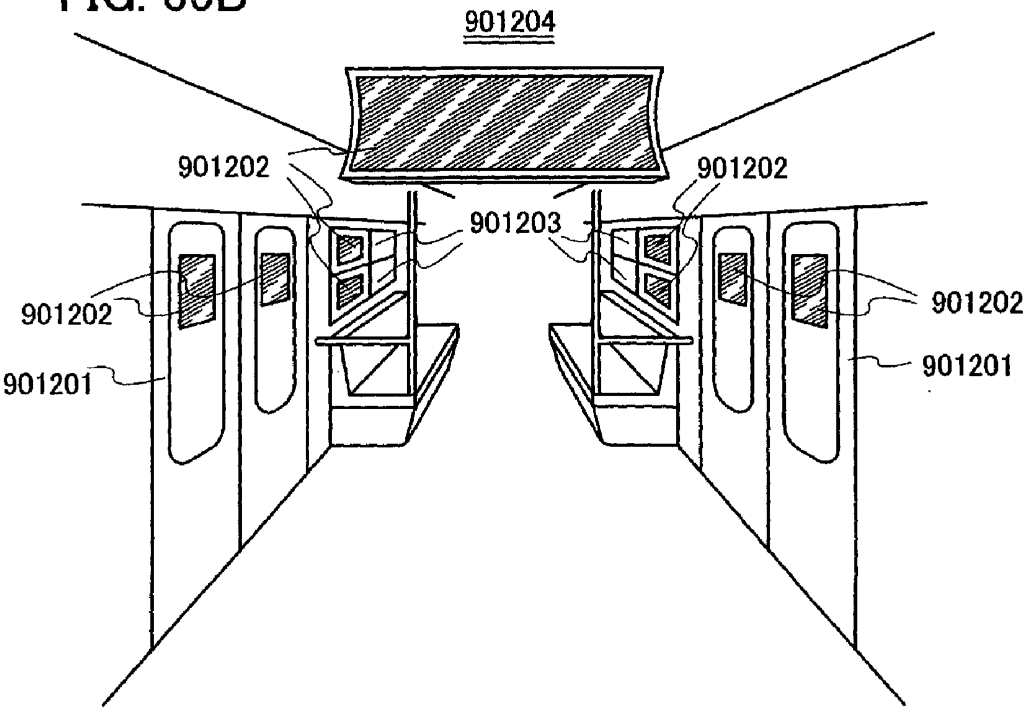


FIG. 36A

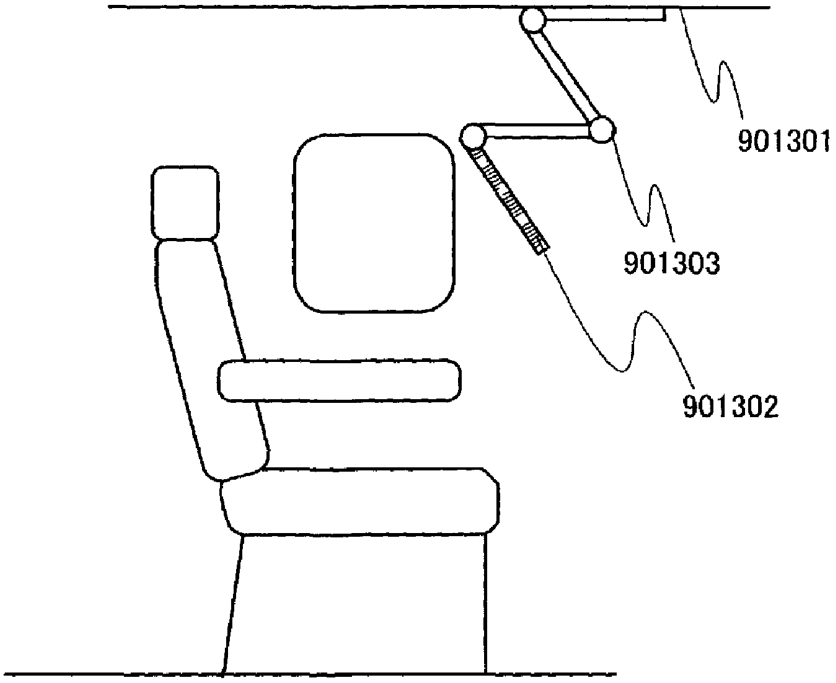


FIG. 36B

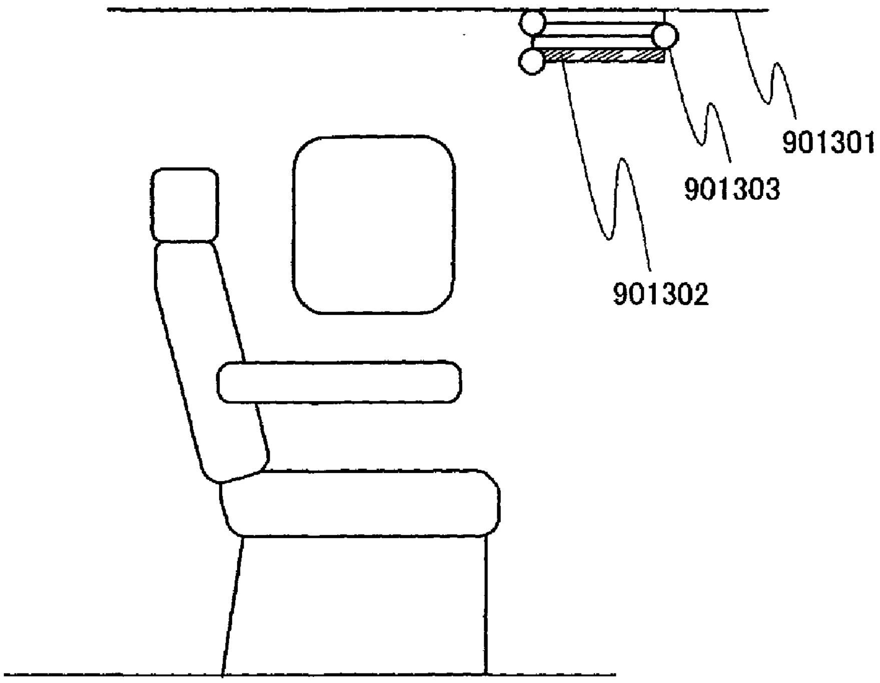


FIG. 37A

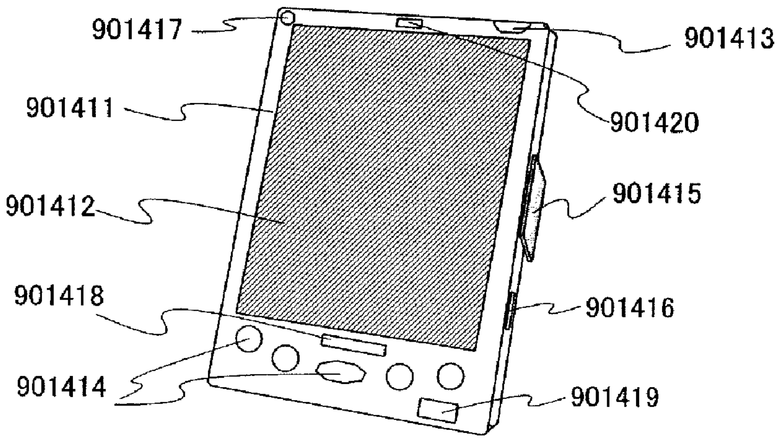


FIG. 37B

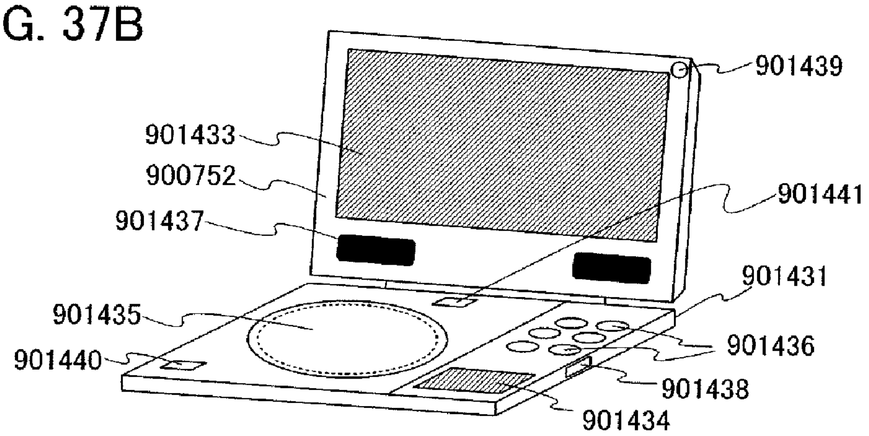


FIG. 37C

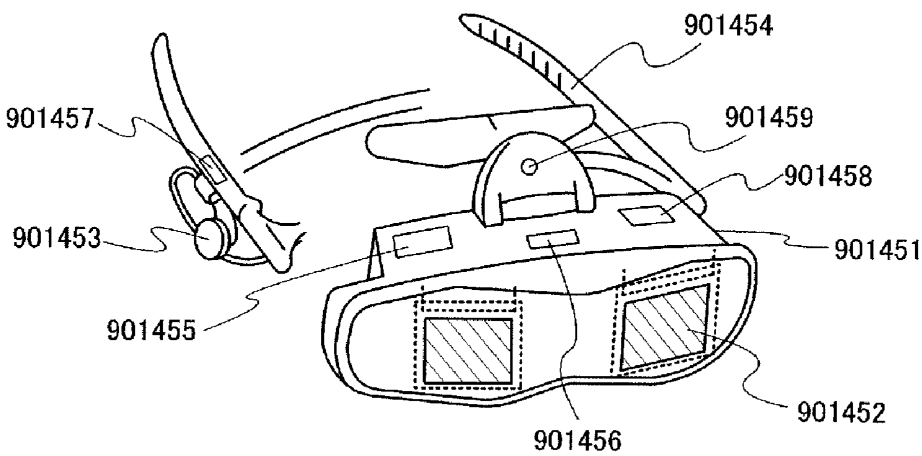


FIG. 38A

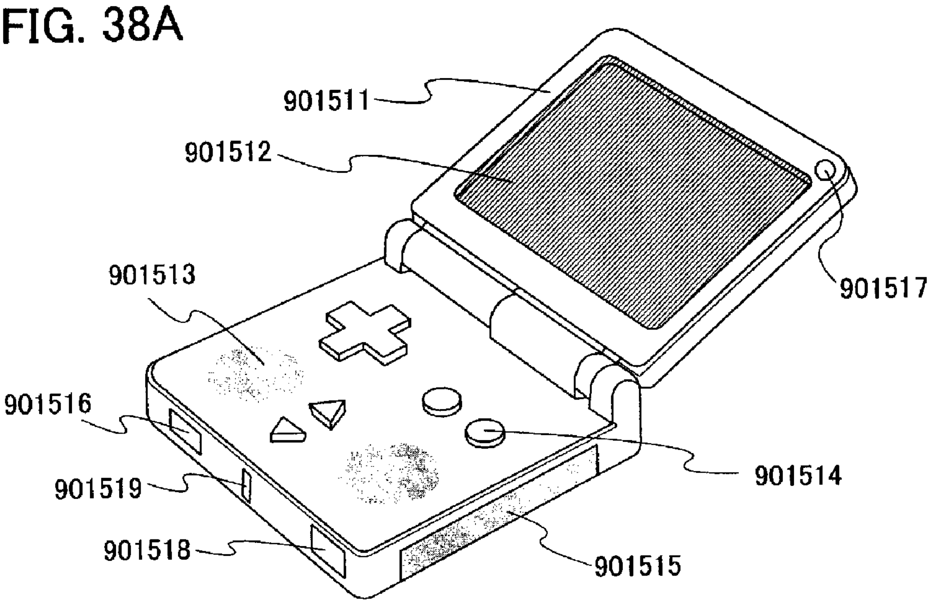


FIG. 38B

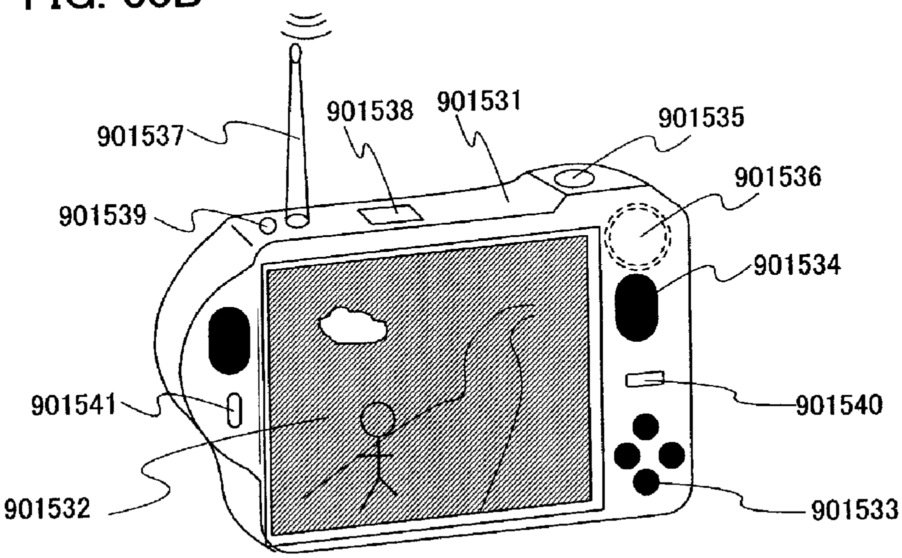
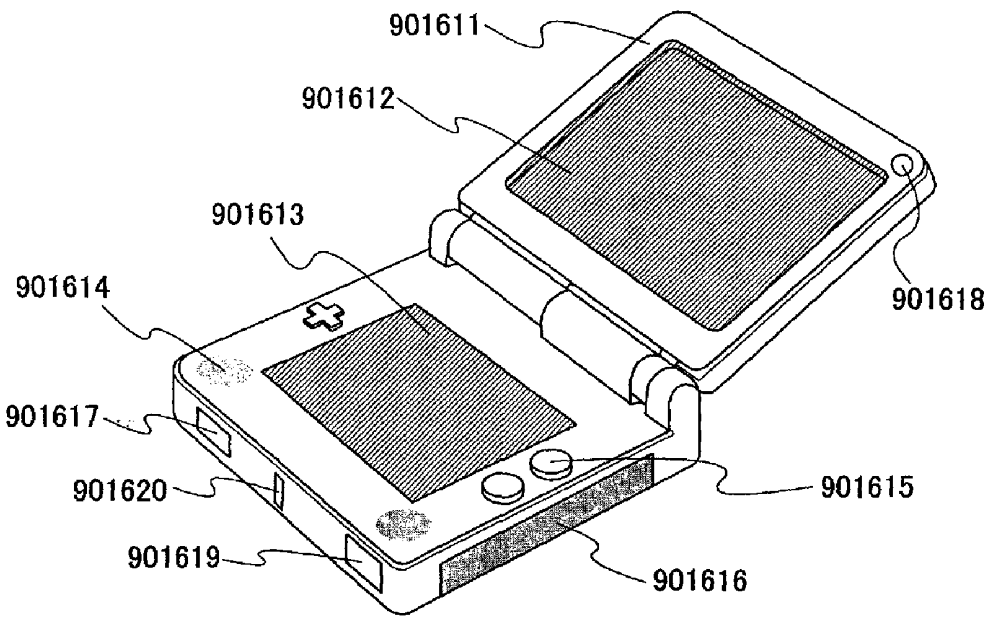


FIG. 39


901611
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901616

FIG. 40A

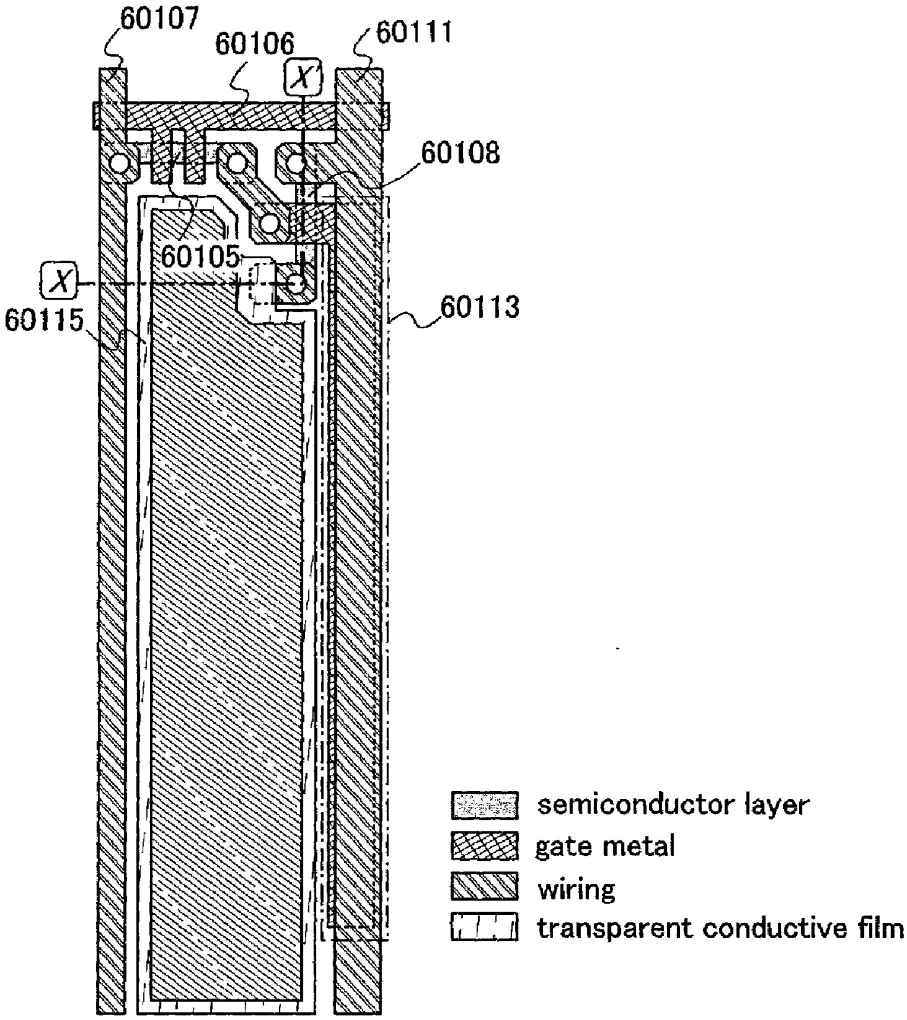
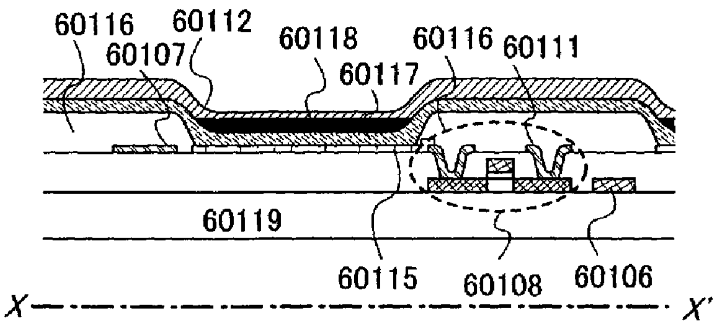


FIG. 40B



LIQUID CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an object, a method, or a method for producing an object. In particular, the present invention relates to a display device or a semiconductor device.

[0003] 2. Description of the Related Art

[0004] A liquid crystal display module which displays images by using a liquid crystal panel has been used for an image display portion of an electronic device such as a mobile phone. Further, a display module in which an organic electroluminescence (organic EL) panel is used instead of a liquid crystal panel has been put to practical use.

[0005] A display module is formed by connecting a display panel formed by using a liquid crystal element or an organic EL element and a circuit board on which a driver IC or a power supply IC is mounted with a flexible printed wiring board. A flexible printed wiring board is a resin film provided with wiring patterns formed thereover, and a driver IC is also directly mounted thereon in some cases.

[0006] An electronic device such as a mobile phone has become high functional, and an electronic device which is provided with a digital still camera or a video camera as well as a main screen and a sub screen on both surfaces of a folding housing has become the mainstream (for example, see Reference 1: Japanese Published Patent Application No. 2004-260433).

[0007] However, with high function and highly added value of an electronic device such as a mobile phone, the number of components which should be stored in a housing has been increased, and a proportion of a printed wiring board on which various IC chips, a CCD camera, and the like are mounted has not been negligible. Meanwhile, decrease in size, thickness, and weight of an electronic device such as a mobile phone has been necessary, which is incompatible with highly added value. Decrease in size and thickness of a display module and an electronic device on which the display module is mounted has been intended to be realized in Reference 2 (Japanese Published Patent Application No. 2007-47714).

SUMMARY OF THE INVENTION

[0008] However, in Reference 2, there is a problem in that decrease in size and thickness of a display module and an electronic device on which the display module is mounted is limited because a large number of IC chips are used.

[0009] In view of the foregoing problems, it is an object of the present invention to reduce the number of components such as IC chips so that decrease in size and thickness of a display module and an electronic device on which the display module is mounted is achieved. It is another object of the present invention to reduce the number of components such as IC chips so that an inexpensive display module and an electronic device on which the display module is mounted are provided.

[0010] An electronic device or a display module includes two display panels. One of the display panels (i.e., a peripheral portion of a display region of the one of the display panels) is provided with circuits which are necessary for operating the display panels or circuits which are necessary for an electronic device in which the display panels are incorporated. Then, the display panels or the electronic device in which the display panels are incorporated are/is driven by the circuits incorporated in the display panels.

[0011] A liquid crystal display device in accordance with one aspect of the present invention includes a first display panel including a first terminal and a first display screen having a first liquid crystal element; a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; and a substrate including a wiring. The circuit group is electrically connected to the first terminal through the second terminal and the wiring.

[0012] A liquid crystal display device in accordance with another aspect of the present invention includes a first display panel including a first terminal and a first display screen having a first liquid crystal element; a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; a substrate including a wiring; and an integrated circuit. The circuit group is electrically connected to the first terminal through the second terminal and the wiring. The integrated circuit is electrically connected to the second terminal through the wiring.

[0013] A liquid crystal display device in accordance with another aspect of the present invention includes a first display panel including a first terminal and a first display screen having a first liquid crystal element; a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; a substrate including a wiring; and a sensor. The circuit group is electrically connected to the first terminal through the second terminal and the wiring. The sensor is electrically connected to the second terminal through the wiring.

[0014] A liquid crystal display device in accordance with another aspect of the present invention includes a first display panel including a first terminal and a first display screen having a first liquid crystal element; a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; a substrate including a wiring; an integrated circuit; and a sensor. The circuit group is electrically connected to the first display panel through the wiring. The integrated circuit is electrically connected to the first display panel and the second display panel through the wiring. The circuit group is electrically connected to the first terminal through the second terminal and the wiring. The integrated circuit is electrically connected to the second terminal through the wiring. The sensor is electrically connected to the second terminal through the wiring.

[0015] A liquid crystal display device in accordance with another aspect of the present invention includes a first display panel including a first terminal, a level shifter, a driver circuit, and a first display screen having a first liquid crystal element; a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; and a substrate including a wiring. The circuit group is electrically connected to the first terminal through the second terminal and the wiring.

[0016] A liquid crystal display device in accordance with another aspect of the present invention includes a first display panel including a first terminal, a level shifter, a driver circuit, and a first display screen having a first liquid crystal element; a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; a substrate including a wiring; and an integrated circuit. The circuit group is electrically connected to the first terminal through the second terminal and the wiring. The integrated circuit is electrically connected to the second terminal through the wiring.

[0017] A liquid crystal display device in accordance with another aspect of the present invention includes a first display panel including a first terminal, a level shifter, a driver circuit, and a first display screen having a first liquid crystal element; a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; a substrate including a wiring; and a sensor. The circuit group is electrically connected to the first terminal through the second terminal and the wiring. The sensor is electrically connected to the second terminal through the wiring.

[0018] A liquid crystal display device in accordance with another aspect of the present invention includes a first display panel including a first terminal, a level shifter, a driver circuit, and a first display screen having a first liquid crystal element; a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; a substrate including a wiring; an integrated circuit; and a sensor. The circuit group is electrically connected to the first display panel through the wiring. The integrated circuit is electrically connected to the first display panel through the wiring. The circuit group is electrically connected to the first terminal through the second terminal and the wiring. The integrated circuit is electrically connected to the second terminal through the wiring. The sensor is electrically connected to the second terminal through the wiring.

[0019] Note that various types of switches can be used as a switch. An electrical switch, a mechanical switch, and the like are given as examples. That is, any element can be used as long as it can control a current flow, without limiting to a certain element. For example, a transistor (e.g., a bipolar transistor or a MOS transistor), a diode (e.g., a PN diode, a PIN diode, a Schottky diode, an MIM (metal insulator metal) diode, an MIS (metal insulator semiconductor) diode, or a diode-connected transistor), a thyristor, or the like can be used as a switch. Alternatively, a logic circuit combining such elements can be used as a switch.

[0020] In the case of using a transistor as a switch, polarity (a conductivity type) of the transistor is not particularly limited because it operates just as a switch. However, a transistor of polarity with smaller off-current is preferably used when off-current is to be suppressed. Examples of a transistor with smaller off-current are a transistor provided with an LDD region, a transistor with a multi-gate structure, and the like. In addition, it is preferable that an N-channel transistor be used when a potential of a source terminal is closer to a potential of a low-potential-side power supply (e.g., V_{ss}, GND, or 0 V), while a P-channel transistor be used when the potential of the source terminal is closer to a potential of a high-potential-side power supply (e.g., V_{dd}). This is because the absolute value of gate-source voltage can be increased when the potential of the source terminal is closer to a potential of a low-potential-side power supply in an N-channel transistor and when the potential of the source terminal is closer to a potential of a high-potential-side power supply in a P-channel transistor, so that the transistor can be easily operated as a switch. This is also because the transistor does not often perform a source follower operation, so that reduction in output voltage does not often occur.

[0021] Note that a CMOS switch may be used as a switch by using both N-channel and P-channel transistors. When a CMOS switch is used, the switch can more precisely operate as a switch because current can flow when either the P-channel transistor or the N-channel transistor is turned on. For example, voltage can be appropriately output regardless of whether voltage of an input signal to the switch is high or low. In addition, since a voltage amplitude value of a signal for turning on or off the switch can be made smaller, power consumption can be reduced.

[0022] Note that when a transistor is used as a switch, the switch includes an input terminal (one of a source terminal and a drain terminal), an output terminal (the other of the source terminal and the drain terminal), and a terminal for controlling conduction (a gate terminal). On the other hand, when a diode is used as a switch, the switch does not have a terminal for controlling conduction in some cases. Therefore, when a diode is used as a switch, the number of wirings for controlling terminals can be further reduced compared to the case of using a transistor as a switch.

[0023] Note that when it is explicitly described that "A and B are connected", the case where A and B are electrically connected, the case where A and B are functionally connected, and the case where A and B are directly connected are included therein. Here, each of A and B corresponds to an object (e.g., a device, an element, a circuit, a wiring, an electrode, a terminal, a conductive film, or a layer). Accordingly, another element may be interposed between elements having a connection relation shown in drawings and texts, without limiting to a predetermined connection relation, for example, the connection relation shown in the drawings and the texts.

[0024] For example, in the case where A and B are electrically connected, one or more elements which enable electric connection between A and B (e.g., a switch, a transistor, a capacitor, an inductor, a resistor, and/or a diode) may be provided between A and B. In addition, in the case where A and B are functionally connected, one or more circuits which enable functional connection between A and B (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 dc-dc converter, a step-up dc-dc converter, or a step-down dc-dc converter) or a level shifter circuit for changing a potential level of a signal, a voltage source, a current source, a switching circuit, or an amplifier circuit such as a circuit which can increase signal amplitude, the amount of current, or the like (e.g., an operational amplifier, a differential amplifier circuit, a source follower circuit, or a buffer circuit), a signal generating circuit, a memory circuit, and/or a control circuit) may be provided between A and B. Alternatively, in the case where A and B are directly connected, A and B may be directly connected without interposing another element or another circuit therebetween.

[0025] Note that when it is explicitly described that "A and B are directly connected", the case where A and B are directly connected (i.e., the case where A and B are connected without interposing another element or another circuit therebetween) and the case where A and B are electrically connected (i.e., the case where A and B are connected by interposing another element or another circuit therebetween) are included therein.

[0026] Note that when it is explicitly described that "A and B are electrically connected", the case where A and B are electrically connected (i.e., the case where A and B are connected by interposing another element or another circuit therebetween), the case where A and B are functionally connected (i.e., the case where A and B are functionally connected by interposing another circuit therebetween), and the case where A and B are directly connected (i.e., the case where A and B are connected without interposing another element or another circuit therebetween) are included therein. That is, when it is explicitly described that "A and B are electrically connected", the description is the same as the case where it is explicitly only described that "A and B are connected".

[0027] Note that a display element, a display device which is a device having a display element, a light-emitting element, and a light-emitting device which is a device having a light-emitting element can use various types and can include various elements. For example, a display medium, whose contrast, luminance, reflectivity, transmittivity, or the like changes by an electromagnetic action, such as an EL element (e.g., an EL element including organic and inorganic materials, an organic EL element, or an inorganic EL element), an electron emitter, a liquid crystal element, electronic ink, an electrophoresis element, a grating light valve (GLV), a plasma display panel (PDP), a digital micromirror device (DMD), a piezoelectric ceramic display, or a carbon nanotube can be used as a display element, a display device, a light-emitting element, or a light-emitting device. Note that display devices using an EL element include an EL display; display devices using an electron emitter include a field emission display (FED), an SED-type flat panel display (SED: surface-conduction electron-emitter display), and the like; display devices using a liquid crystal element include a liquid crystal display (e.g., a transmissive liquid crystal display, a transflective liquid crystal display, a reflective liquid crystal display, a direct-view liquid crystal display, or a projection liquid crystal display); and display devices using electronic ink or an electrophoresis element include electronic paper.

[0028] Note that an EL element is an element having an anode, a cathode, and an EL layer interposed between the anode and the cathode. Note that as an EL layer, a layer utilizing light emission (fluorescence) from a singlet exciton, a layer utilizing light emission (phosphorescence) from a triplet exciton, a layer utilizing light emission (fluorescence) from a singlet exciton and light emission (phosphorescence) from a triplet exciton, a layer formed of an organic material, a layer formed of an inorganic material, a layer formed of an organic material and an inorganic material, a layer including a high-molecular material, a layer including a low molecular material, a layer including a low-molecular material and a high-molecular material, or the like can be used. Note that the present invention is not limited to this, and various EL elements can be used as an EL element.

[0029] Note that an electron emitter is an element in which electrons are extracted by high electric field concentration on a pointed cathode. For example, as an electron emitter, a Spindt type, a carbon nanotube (CNT) type, a metal-insulator-metal (MIM) type in which a metal, an insulator, and a metal are stacked, a metal-insulator-semiconductor (MIS) type in which a metal, an insulator, and a semiconductor are stacked, a MOS type, a silicon type, a thin film diode type, a diamond type, a surface conduction emitter SCD type, a thin film type in which a metal, an insulator, a semiconductor, and a metal are stacked, a HEED type, an EL type, a porous silicon type, a surface-conduction (SED) type, or the like can be used. However, the present invention is not limited to this, and various elements can be used as an electron emitter.

[0030] Note that a liquid crystal element is an element which controls transmission or non-transmission of light by optical modulation action of a liquid crystal and includes a pair of electrodes and a liquid crystal. Note that optical modulation action of a liquid crystal is controlled by an electric filed applied to the liquid crystal (including a horizontal electric field, a vertical electric field, and an oblique electric field). Note that the following can be used for a liquid crystal element: a nematic liquid crystal, a cholesteric liquid crystal, a smectic liquid crystal, a discotic liquid crystal, a thermotropic liquid crystal, a lyotropic liquid crystal, a low-molecular liquid crystal, a high-molecular liquid crystal, a ferroelectric liquid crystal, an anti-ferroelectric liquid crystal, a main-chain liquid crystal, a side-chain high-molecular liquid crystal, a plasma addressed liquid crystal (PALC), a banana-shaped liquid crystal, and the like. In addition, the following can be used as a diving method of a liquid crystal: a TN (twisted nematic) mode, an STN (super twisted nematic) mode, an IPS (in-plane-switching) mode, an FFS (fringe field switching) mode, an MVA (multi-domain vertical alignment) mode, a PVA (patterned vertical alignment) mode, an ASV (advanced super view) mode, an ASM (axially symmetric aligned microcell) mode, an OCB (optical compensated birefringence) mode, an ECB (electrically controlled birefringence) mode, an FLC (ferroelectric liquid crystal) mode, an AFLC (anti-ferroelectric liquid crystal) mode, a PDLC (polymer dispersed liquid crystal) mode, a guest-host mode, and the like. Note that the present invention is not limited to this, and various liquid crystal elements and driving methods can be used as a liquid crystal element and a driving method thereof.

[0031] Note that electronic paper corresponds to a device which displays an image by molecules which utilize optical anisotropy, dye molecular orientation, or the like; a device which displays an image by particles which utilize electrophoresis, particle movement, particle rotation, phase change, or the like; a device which displays an image by moving one end of a film; a device which displays an image by using coloring properties or phase change of molecules; a device which displays an image by using optical absorption by molecules; and a device which displays an image by using self-light emission by bonding electrons and holes. For example, the following can be used for electronic paper: microcapsule electrophoresis, horizontal electrophoresis, vertical electrophoresis, a spherical twisting ball, a magnetic twisting ball, a columnar twisting ball, a charged toner, electro liquid powder, magnetic electrophoresis, a magnetic thermosensitive type, an electrowetting type, a light-scattering (transparent-opaque change) type, a cholesteric liquid crystal and a photoconductive layer, a cholesteric liquid crystal device, a bistable nematic liquid crystal, a ferroelectric liquid crystal, a liquid crystal dispersed type with a dichroic dye, a movable film, coloring and decoloring properties of a leuco dye, a photochromic material, an electrochromic material, an electrodeposition material, flexible organic EL, and the like. Note that the present invention is not limited to this, and a variety of electronic paper can be used as electronic paper. Here, when microcapsule electrophoresis is used, defects of electrophoresis, which are aggregation and precipitation of phoresis particles, can be solved. Electro liquid powder has advantages such as high-speed response, high reflectivity, wide viewing angle, low power consumption, and memory properties.

[0032] Note that a plasma display panel has a structure in which a substrate having a surface provided with an electrode and a substrate having a surface provided with an electrode and a minute groove in which a phosphor layer is formed face each other at a narrow interval and a rare gas is sealed therein. Note that display can be performed by applying voltage between the electrodes to generate an ultraviolet ray so that a phosphor emits light. Note that the plasma display panel may be a DC-type PDP or an AC-type PDP. For the plasma display panel, AWS (address while sustain) driving, ADS (address display separated) driving in which a subframe is divided into a reset period, an address period, and a sustain period, CLEAR (high-contrast, low energy address and reduction of false contour sequence) driving, ALIS (alternate lighting of surfaces) method, TERES (technology of reciprocal sustainer) driving, or the like can be used. Note that the present invention is not limited to this, and various plasma display panels can be used as a plasma display panel.

[0033] Note that electroluminescence, a cold cathode fluorescent lamp, a hot cathode fluorescent lamp, an LED, a laser light source, a mercury lamp, or the like can be used as a light source of a display device in which a light source is necessary, such as a liquid crystal display (a transmissive liquid crystal display, a transflective liquid crystal display, a reflective liquid crystal display, a direct-view liquid crystal display, or a projection liquid crystal display), a display device using a grating light valve (GLV), or a display device using a digital micromirror device (DMD). Note that the present invention is not limited to this, and various light sources can be used as a light source.

[0034] Note that various types of transistors can be used as a transistor, without limiting to a certain type. For example, a thin film transistor (TFT) including a non-single crystal semiconductor film typified by amorphous silicon, polycrystalline silicon, microcrystalline (also referred to as semi-amorphous) silicon, or the like can be used. In the case of using the TFT, there are various advantages. For example, since the TFT can be formed at temperature lower than that of the case of using single-crystal silicon, manufacturing cost can be reduced or a manufacturing apparatus can be made larger. Since the manufacturing apparatus is made larger, the TFT can be formed using a large substrate. Therefore, many display devices can be formed at the same time at low cost. In addition, a substrate having low heat resistance can be used because of low manufacturing temperature. Therefore, the transistor can be formed using a light-transmitting substrate. Accordingly, transmission of light in a display element can be controlled by using the transistor formed using the light-transmitting substrate. Alternatively, part of a film which forms the transistor can transmit light because the film thickness of the transistor is thin. Therefore, the aperture ratio can be improved.

[0035] Note that when a catalyst (e.g., nickel) is used in the case of forming polycrystalline silicon, crystallinity can be further improved and a transistor having excellent electric characteristics can be formed. Accordingly, a gate driver circuit (e.g., a scan line driver circuit), a source driver circuit (e.g., a signal line driver circuit), and/or a signal processing circuit (e.g., a signal generation circuit, a gamma correction circuit, or a DA converter circuit) can be formed over the same substrate as a pixel portion.

[0036] Note that when a catalyst (e.g., nickel) is used in the case of forming microcrystalline silicon, crystallinity can be further improved and a transistor having excellent electric characteristics can be formed. At this time, crystallinity can be improved by just performing heat treatment without performing laser irradiation. Accordingly, a gate driver circuit (e.g., a scan line driver circuit) and part of a source driver circuit (e.g., an analog switch) can be formed over the same substrate. In addition, in the case of not performing laser irradiation for crystallization, crystallinity unevenness of silicon can be suppressed. Therefore, a clear image can be displayed.

[0037] Note that polycrystalline silicon and microcrystalline silicon can be formed without using a catalyst (e.g., nickel).

[0038] Note that it is preferable that crystallinity of silicon be improved to polycrystal, microcrystal, or the like in the whole panel; however, the present invention is not limited to this. Crystallinity of silicon may be improved only in part of the panel. Selective increase in crystallinity can be achieved by selective laser irradiation or the like. For example, only a peripheral driver circuit region excluding pixels may be irradiated with laser light. Alternatively, only a region of a gate driver circuit, a source driver circuit, or the like may be irradiated with laser light. Further alternatively, only part of a source driver circuit (e.g., an analog switch) may be irradiated with laser light. Accordingly, crystallinity of silicon can be improved only in a region in which a circuit needs to be operated at high speed. Since a pixel region is not particularly needed to be operated at high speed, even if crystallinity is not improved, the pixel circuit can be operated without problems. Since a region, crystallinity of which is improved, is small, manufacturing steps can be decreased, throughput can be increased, and manufacturing cost can be reduced. Since the number of necessary manufacturing apparatus is small, manufacturing cost can be reduced.

[0039] A transistor can be formed by using a semiconductor substrate, an SOI substrate, or the like. Thus, a transistor with few variations in characteristics, sizes, shapes, or the like, with high current supply capacity, and with a small size can be formed. When such a transistor is used, power consumption of a circuit can be reduced or a circuit can be highly integrated.

[0040] A transistor including a compound semiconductor or an oxide semiconductor such as ZnO, a-InGaZnO, SiGe, GaAs, IZO, ITO, or SnO, a thin film transistor obtained by thinning such a compound semiconductor or a oxide semiconductor, or the like can be used. Thus, manufacturing temperature can be lowered and for example, such a transistor can be formed at room temperature. Accordingly, the transistor can be formed directly on a substrate having low heat resistance, such as a plastic substrate or a film substrate. Note that such a compound semiconductor or an oxide semiconductor can be used for not only a channel portion of the transistor but also other applications. For example, such a compound semiconductor or an oxide semiconductor can be used as a resistor, a pixel electrode, or a light-transmitting electrode. Further, since such an element can be formed at the same time as the transistor, cost can be reduced.

[0041] A transistor formed by using an inkjet method or a printing method, or the like can be used. Accordingly, a transistor can be formed at room temperature, can be formed at a low vacuum, or can be formed using a large substrate. In addition, since the transistor can be formed without using a mask (a reticle), a layout of the transistor can be easily changed. Further, since it is not necessary to use a resist, material cost is reduced and the number of steps can be reduced. Furthermore, since a film is formed only in a necessary portion, a material is not wasted compared with a manufacturing method in which etching is performed after the film is formed over the entire surface, so that cost can be reduced.

[0042] A transistor including an organic semiconductor or a carbon nanotube, or the like can be used. Accordingly, such a transistor can be formed using a substrate which can be bent. Therefore, a device using a transistor including an organic semiconductor or a carbon nanotube, or the like can resist a shock.

[0043] Further, transistors with various structures can be used. For example, a MOS transistor, a junction transistor, a bipolar transistor, or the like can be used as a transistor. When a MOS transistor is used, the size of the transistor can be reduced. Thus, a large number of transistors can be mounted. When a bipolar transistor is used, large current can flow. Thus, a circuit can be operated at high speed.

[0044] Note that a MOS transistor, a bipolar transistor, and the like may be formed over one substrate. Thus, reduction in power consumption, reduction in size, high speed operation, and the like can be realized.

[0045] Furthermore, various transistors can be used.

[0046] Note that a transistor can be formed using various types of substrates without limiting to a certain type. For example, a single-crystal substrate, an SOI substrate, a glass substrate, a quartz substrate, a plastic substrate, a paper substrate, a cellophane substrate, a stone substrate, a wood substrate, a cloth substrate (including a natural fiber (e.g., silk, cotton, or hemp), a synthetic fiber (e.g., nylon, polyurethane, or polyester), a regenerated fiber (e.g., acetate, cupra, rayon, or regenerated polyester), or the like), a leather substrate, a rubber substrate, a stainless steel substrate, a substrate including a stainless steel foil, or the like can be used as a substrate. Alternatively, a skin (e.g., epidermis or corium) or hypodermal tissue of an animal such as a human being can be used as a substrate. Further alternatively, the transistor may be formed using one substrate, and then, the transistor may be transferred to another substrate. A single-crystal substrate, an SOI substrate, a glass substrate, a quartz substrate, a plastic substrate, a paper substrate, a cellophane substrate, a stone substrate, a wood substrate, a cloth substrate (including a natural fiber (e.g., silk, cotton, or hemp), a synthetic fiber (e.g., nylon, polyurethane, or polyester), a regenerated fiber (e.g., acetate, cupra, rayon, or regenerated polyester), or the like), a leather substrate, a rubber substrate, a stainless steel substrate, a substrate including a stainless steel foil, or the like can be used as a substrate to which the transistor is transferred. Alternatively, a skin (e.g., epidermis or corium) or hypodermal tissue of an animal such as a human being can be used as a substrate to which the transistor is transferred. Further alternatively, the transistor may be formed using one substrate and the substrate may be thinned by polishing. A single-crystal substrate, an SOI substrate, a glass substrate, a quartz substrate, a plastic substrate, a paper substrate, a cellophane substrate, a stone substrate, a wood substrate, a cloth substrate (including a natural fiber (e.g., silk, cotton, or hemp), a synthetic fiber (e.g., nylon, polyurethane, or polyester), a regenerated fiber (e.g., acetate, cupra, rayon, or regenerated polyester), or the like), a leather substrate, a rubber substrate, a stainless steel substrate, a substrate including a stainless steel foil, or the like can be used as a substrate to be polished. Alternatively, a skin (e.g., epidermis or corium) or hypodermal tissue of an animal such as a human being can be used as a substrate to be polished. When such a substrate is used, a transistor with excellent properties or a transistor with low power consumption can be formed, a device with high durability, high heat resistance can be provided, or reduction in weight or thickness can be achieved.

[0047] Note that a structure of a transistor can be various modes without limiting to a certain structure. For example, a multi-gate structure having two or more gate electrodes may be used. When the multi-gate structure is used, a structure where a plurality of transistors are connected in series is provided because channel regions are connected in series. With the multi-gate structure, off-current can be reduced or the withstand voltage of the transistor can be increased to improve reliability. Alternatively, with the multi-gate structure, drain-source current does not fluctuate very much even if drain-source voltage fluctuates when the transistor operates in a saturation region, so that a flat slope of voltage-current characteristics can be obtained. When the flat slope of the voltage-current characteristics is utilized, an ideal current source circuit or an active load having an extremely high resistance value can be realized. Accordingly, a differential circuit or a current mirror circuit having excellent properties can be realized. As another example, a structure where gate electrodes are formed above and below a channel may be used. When the structure where gate electrodes are formed above and below the channel is used, a channel region is increased, so that the amount of current flowing therethrough can be increased or a depletion layer can be easily formed to decrease subthreshold swing. When the gate electrodes are formed above and below the channel, a structure where a plurality of transistors are connected in parallel is provided.

[0048] Alternatively, a structure where a gate electrode is formed above a channel region, a structure where a gate electrode is formed below a channel region, a staggered structure, an inversely staggered structure, a structure where a channel region is divided into a plurality of regions, or a structure where channel regions are connected in parallel or in series can be used. Further alternatively, a source electrode or a drain electrode may overlap with a channel region (or part of it). When the structure where the source electrode or the drain electrode may overlap with the channel region (or part of it) is used, the case can be prevented in which electric charges are accumulated in part of the channel region, which would result in an unstable operation. Further alternatively, an LDD region may be provided. When the LDD region is provided, off-current can be reduced or the withstand voltage of the transistor can be increased to improve reliability. Further, when the LDD region is provided, drain-source current does not fluctuate very much even if drain-source voltage fluctuates when the transistor operates in the saturation region, so that a flat slope of voltage-current characteristics can be obtained.

[0049] Note that various types of transistors can be used as a transistor and the transistor can be formed using various types of substrates. Accordingly, all the circuits that are necessary to realize a predetermined function may be formed using the same substrate. For example, all the circuits that are necessary to realize the predetermined function may be formed using a glass substrate, a plastic substrate, a single-crystal substrate, an SOI substrate, or any other substrate. When all the circuits that are necessary to realize the predetermined function are formed using the same substrate, cost can be reduced by reduction in the number of component parts or reliability can be improved by reduction in the number of connections to circuit components. Alternatively, part of the circuits which are necessary to realize the predetermined function may be formed using one substrate and another part of the circuits which are necessary to realize the predetermined function may be formed using another substrate. That is, not all the circuits that are necessary to realize the predetermined function are required to be formed using the same substrate. For example, part of the circuits which are necessary to realize the predetermined function may be formed by transistors using a glass substrate and another part of the circuits which are necessary to realize the predetermined function may be formed using a single-crystal substrate, so that an IC chip formed by a transistor using the single-crystal substrate may be connected to the glass substrate by COG (chip on glass) and the IC chip may be provided over the glass substrate. Alternatively, the IC chip may be connected to the glass substrate by TAB (tape automated bonding) or a printed wiring board. When part of the circuits are formed using the same substrate in this manner, cost can be reduced by reduction in the number of component parts or reliability can be improved by reduction in the number of connections to circuit components. Further alternatively, when circuits with high driving voltage and high driving frequency, which consume large power, are formed using a single-crystal semiconductor substrate instead of forming such circuits using the same substrate and an IC chip formed by the circuit is used, increase in power consumption can be prevented.

[0050] Note that pixels are provided (arranged) in matrix in some cases. Here, description that pixels are provided (arranged) in matrix includes the case where the pixels are arranged in a straight line and the case where the pixels are arranged in a jagged line, in a longitudinal direction or a lateral direction. Thus, for example, in the case of performing full color display with three color elements (e.g., RGB), the following cases are included therein: the case where the pixels are arranged in stripes and the case where dots of the three color elements are arranged in a delta pattern. In addition, the case is also included therein in which dots of the three color elements are provided in Bayer arrangement. Note that the color elements are not limited to three colors, and color elements of more than three colors may be used. For example, RGBW (W corresponds to white), RGB plus one or more of yellow, cyan, and magenta, or the like may be used. Further, the sizes of display regions may be different between respective dots of color elements. Thus, power consumption can be reduced or the life of a display element can be prolonged.

[0051] Note that an active matrix method in which an active element is included in a pixel or a passive matrix method in which an active element is not included in a pixel can be used.

[0052] In an active matrix method, as an active element (a non-linear element), not only a transistor but also various active elements (non-linear elements) can be used. For example, an MIM (metal insulator metal), a TFD (thin film diode), or the like can also be used. Since such an element has few number of manufacturing steps, manufacturing cost can be reduced or yield can be improved. Further, since the size of the element is small, the aperture ratio can be improved, so that power consumption can be reduced or high luminance can be achieved.

[0053] Note that as a method other than an active matrix method, a passive matrix method in which an active element (a non-linear element) is not used can also be used. Since an active element (a non-linear element) is not used, manufacturing steps is few, so that manufacturing cost can be reduced or the yield can be improved. Further, since an active element (a non-linear element) is not used, the aperture ratio can be improved, so that power consumption can be reduced or high luminance can be achieved.

[0054] Note that a transistor is an element having at least three terminals of a gate, a drain, and a source. The transistor has a channel region between a drain region and a source region, and current can flow through the drain region, the channel region, and the source region. Here, since the source and the drain of the transistor change depending on the structure, the operating condition, and the like of the transistor, it is difficult to define which is a source or a drain. Therefore, in this specification, a region functioning as a source and a drain may not be called the source or the drain. In such a case, one of the source and the drain may be referred to as a first terminal and the other thereof may be referred to as a second terminal, for example. Alternatively, one of the source and the drain may be referred to as a first electrode and the other thereof may be referred to as a second electrode. Further alternatively, one of the source and the drain may be referred to as a source region and the other thereof may be called a drain region.

[0055] Note that a transistor may be an element having at least three terminals of a base, an emitter, and a collector. In this case, one of the emitter and the collector may be similarly referred to as a first terminal and the other terminal may be referred to as a second terminal.

[0056] Note that a gate corresponds to all or part of a gate electrode and a gate wiring (also referred to as a gate line, a gate signal line, a scan line, a scan signal line, or the like). A gate electrode corresponds to a conductive film which overlaps with a semiconductor which forms a channel region with a gate insulating film interposed therebetween. Note that part of the gate electrode overlaps with an LDD (lightly doped drain) region or the source region (or the drain region) with the gate insulating film interposed therebetween in some cases. A gate wiring corresponds to a wiring for connecting a gate electrode of each transistor to each other, a wiring for connecting a gate electrode of each pixel to each other, or a wiring for connecting a gate electrode to another wiring.

[0057] However, there is a portion (a region, a conductive film, a wiring, or the like) which functions as both a gate electrode and a gate wiring. Such a portion (a region, a conductive film, a wiring, or the like) may be referred to as either a gate electrode or a gate wiring. That is, there is a region where a gate electrode and a gate wiring cannot be clearly distinguished from each other. For example, in the case where a channel region overlaps with part of an extended gate wiring, the overlapped portion (region, conductive film, wiring, or the like) functions as both a gate wiring and a gate electrode. Accordingly, such a portion (a region, a conductive film, a wiring, or the like) may be referred to as either a gate electrode or a gate wiring.

[0058] Note that a portion (a region, a conductive film, a wiring, or the like) which is formed using the same material as a gate electrode, forms the same island as the gate electrode, and is connected to the gate electrode may also be referred to as a gate electrode. Similarly, a portion (a region, a conductive film, a wiring, or the like) which is formed using the same material as a gate wiring, forms the same island as the gate wiring, and is connected to the gate wiring may also be referred to as a gate wiring. In a strict detect, such a portion (a region, a conductive film, a wiring, or the like) does not overlap with a channel region or does not have a function of connecting the gate electrode to another gate electrode in some cases. However, there is a portion (a region, a conductive film, a wiring, or the like) which is formed using the same material as a gate electrode or a gate wiring, forms the same island as the gate electrode or the gate wiring, and is connected to the gate electrode or the gate wiring because of specifications or the like in manufacturing. Thus, such a portion (a region, a conductive film, a wiring, or the like) may also be referred to as either a gate electrode or a gate wiring.

[0059] Note that in a multi-gate transistor, for example, a gate electrode is often connected to another gate electrode by using a conductive film which is formed using the same material as the gate electrode. Since such a portion (a region, a conductive film, a wiring, or the like) is a portion (a region, a conductive film, a wiring, or the like) for connecting the gate electrode to another gate electrode, it may be referred to as a gate wiring, and it may also be referred to as a gate electrode because a multi-gate transistor can be considered as one transistor. That is, a portion (a region, a conductive film, a wiring, or the like) which is formed using the same material as a gate electrode or a gate wiring, forms the same island as the gate electrode or the gate wiring, and is connected to the gate electrode or the gate wiring may be referred to as either a gate electrode or a gate wiring. In addition, for example, part of a conductive film which connects the gate electrode and the gate wiring and is formed using a material which is different from that of the gate electrode or the gate wiring may also be referred to as either a gate electrode or a gate wiring.

[0060] Note that a gate terminal corresponds to part of a portion (a region, a conductive film, a wiring, or the like) of a gate electrode or a portion (a region, a conductive film, a wiring, or the like) which is electrically connected to the gate electrode.

[0061] Note that when a wiring is referred to as a gate wiring, a gate line, a gate signal line, a scan line, a scan signal line, there is the case in which a gate of a transistor is not connected to a wiring. In this case, the gate wiring, the gate line, the gate signal line, the scan line, or the scan signal line corresponds to a wiring formed in the same layer as the gate of the transistor, a wiring formed using the same material of the gate of the transistor, or a wiring formed at the same time as the gate of the transistor in some cases. As examples, there are a wiring for a storage capacitor, a power supply line, a reference potential supply line, and the like.

[0062] Note that a source corresponds to all or part of a source region, a source electrode, and a source wiring (also referred to as a source line, a source signal line, a data line, a data signal line, or the like). A source region corresponds to a semiconductor region including a large amount of p-type impurities (e.g., boron or gallium) or n-type impurities (e.g., phosphorus or arsenic). Therefore, a region including a small amount of p-type impurities or n-type impurities, namely, an LDD (lightly doped drain) region is not included in the source region. A source electrode is part of a conductive layer which is formed using a material different from that of a source region and is electrically connected to the source region. However, there is the case where a source electrode and a source region are collectively referred to as a source electrode. A source wiring is a wiring for connecting a source electrode of each transistor to each other, a wiring for connecting a source electrode of each pixel to each other, or a wiring for connecting a source electrode to another wiring.

[0063] However, there is a portion (a region, a conductive film, a wiring, or the like) functioning as both a source electrode and a source wiring. Such a portion (a region, a conductive film, a wiring, or the like) may be referred to as either a source electrode or a source wiring. That is, there is a region where a source electrode and a source wiring cannot be clearly distinguished from each other. For example, in the case where a source region overlaps with part of an extended source wiring, the overlapped portion (region, conductive film, wiring, or the like) functions as both a source wiring and a source electrode. Accordingly, such a portion (a region, a conductive film, a wiring, or the like) may be referred to as either a source electrode or a source wiring.

[0064] Note that a portion (a region, a conductive film, a wiring, or the like) which is formed using the same material as a source electrode, forms the same island as the source electrode, and is connected to the source electrode, or a portion (a region, a conductive film, a wiring, or the like) which connects a source electrode and another source electrode may also be referred to as a source electrode. Further, a portion which overlaps with a source region may be referred to as a source electrode. Similarly, a portion (a region, a conductive film, a wiring, or the like) which is formed using the same material as a source wiring, forms the same island as the source wiring, and is connected to the source wiring may also be referred to as a source wiring. In a strict sense, such a portion (a region, a conductive film, a wiring, or the like) does not have a function of connecting the source electrode to another source electrode in some cases. However, there is a portion (a region, a conductive film, a wiring, or the like) which is formed using the same material as a source electrode or a source wiring, forms the same island as the source electrode or the source wiring, and is connected to the source electrode or the source wiring because of specifications or the like in manufacturing. Thus, such a portion (a region, a conductive film, a wiring, or the like) may also be referred to as either a source electrode or a source wiring.

[0065] For example, part of a conductive film which connects a source electrode and a source wiring and is formed using a material which is different from that of the source electrode or the source wiring may be referred to as either a source electrode or a source wiring.

[0066] Note that a source terminal corresponds to part of a source region, a source electrode, or a portion (a region, a conductive film, a wiring, or the like) which is electrically connected to the source electrode.

[0067] Note that when a wiring is referred to as a source wiring, a source line, a source signal line, a data line, a data signal line, there is the case in which a source (a drain) of a transistor is not connected to a wiring. In this case, the source wiring, the source line, the source signal line, the data line, or the data signal line corresponds to a wiring formed in the same layer as the source (the drain) of the transistor, a wiring formed using the same material of the source (the drain) of the transistor, or a wiring formed at the same time as the source (the drain) of the transistor in some cases. As examples, there are a wiring for a storage capacitor, a power supply line, a reference potential supply line, and the like.

[0068] Note that the same can be said for a drain.

[0069] Note that a semiconductor device corresponds to a device having a circuit including a semiconductor element (e.g., a transistor, a diode, or a thyristor). The semiconductor device may also include all devices that can function by utilizing semiconductor characteristics. In addition, the semiconductor device corresponds to a device having a semiconductor material.

[0070] Note that a display element corresponds to an optical modulation element, a liquid crystal element, a light-emitting element, an EL element (an organic EL element, an inorganic EL element, or an EL element including organic and inorganic materials), an electron emitter, an electrophoresis element, a discharging element, a light-reflective element, a light diffraction element, a digital micromirror device (DMD), or the like. Note that the present invention is not limited to this.

[0071] Note that a display device corresponds to a device having a display element. The display device may include a plurality of pixels each having a display element. Note that that the display device may also include a peripheral driver circuit for driving the plurality of pixels. The peripheral driver circuit for driving the plurality of pixels may be formed over the same substrate as the plurality of pixels. The display device may also include a peripheral driver circuit provided over a substrate by wire bonding or bump bonding, namely, an IC chip connected by chip on glass (COG) or an IC chip connected by TAB or the like. Further, the display device may also include a flexible printed circuit (FPC) to which an IC chip, a resistor, a capacitor, an inductor, a transistor, or the like is attached. Note also that the display device includes a printed wiring board (PWB) which is connected through a flexible printed circuit (FPC) and to which an IC chip, a resistor, a capacitor, an inductor, a transistor, or the like is attached. The display device may also include an optical sheet such as a polarizing plate or a retardation plate. The display device may also include a lighting device, a housing, an audio input and output device, a light sensor, or the like. Here, a lighting device such as a backlight unit may include a light guide plate, a prism sheet, a diffusion sheet, a reflective sheet, a light source (e.g., an LED or a cold cathode fluorescent lamp), a cooling device (e.g., a water cooling device or an air cooling device), or the like.

[0072] Note that a lighting device corresponds to a device having a backlight unit, a light guide plate, a prism sheet, a diffusion sheet, a reflective sheet, or a light source (e.g., an LED, a cold cathode fluorescent lamp, or a hot cathode fluorescent lamp), a cooling device, or the like.

[0073] Note that a light-emitting device corresponds to a device having a light-emitting element and the like. In the case of including a light-emitting element as a display element, the light-emitting device is one of specific examples of a display device.

[0074] Note that a reflective device corresponds to a device having a light-reflective element, a light diffraction element, light-reflective electrode, or the like.

[0075] Note that a liquid crystal display device corresponds to a display device including a liquid crystal element. Liquid crystal display devices include a direct-view liquid crystal display, a projection liquid crystal display, a transmissive liquid crystal display, a reflective liquid crystal display, a transflective liquid crystal display, and the like.

[0076] Note that a driving device corresponds to a device having a semiconductor element, an electric circuit, or an electronic circuit. For example, a transistor which controls input of a signal from a source signal line to a pixel (also referred to as a selection transistor, a switching transistor, or the like), a transistor which supplies voltage or current to a pixel electrode, a transistor which supplies voltage or current to a light-emitting element, and the like are examples of the driving device. A circuit which supplies a signal to a gate signal line (also referred to as a gate driver, a gate line driver circuit, or the like), a circuit which supplies a signal to a source signal line (also referred to as a source driver, a source line driver circuit, or the like) are also examples of the driving device.

[0077] Note that a display device, a semiconductor device, a lighting device, a cooling device, a light-emitting device, a reflective device, a driving device, and the like overlap with each other in some cases. For example, a display device includes a semiconductor device and a light-emitting device in some cases. Alternatively, a semiconductor device includes a display device and a driving device in some cases.

[0078] Note that when it is explicitly described that "B is formed on A" or "B is formed over A", it does not necessarily mean that B is formed in direct contact with A. The description includes the case where A and B are not in direct contact with each other, i.e., the case where another object is interposed between A and B. Here, each of A and B corresponds to an object (e.g., a device, an element, a circuit, a wiring, an electrode, a terminal, a conductive film, or a layer).

[0079] Accordingly, for example, when it is explicitly described that "a layer B is formed on (or over) a layer A", it includes both the case where the layer B is formed in direct contact with the layer A, and the case where another layer (e.g., a layer C or a layer D) is formed in direct contact with the layer A and the layer B is formed in direct contact with the layer C or D. Note that another layer (e.g., a layer C or a layer D) may be a single layer or a plurality of layers.

[0080] Similarly, when it is explicitly described that "B is formed above A", it does not necessarily mean that B is formed in direct contact with A, and another object may be interposed therebetween. Thus, for example, when it is described that "a layer B is formed above a layer A", it includes both the case where the layer B is formed in direct contact with the layer A, and the case where another layer (e.g., a layer C or a layer D) is formed in direct contact with the layer A and the layer B is formed in direct contact with the layer C or D. Note that another layer (e.g., a layer C or a layer D) may be a single layer or a plurality of layers.

[0081] Note that when it is explicitly described that "B is formed in direct contact with A", it includes not the case where another object is interposed between A and B but the case where B is formed in direct contact with A.

[0082] Note that the same can be said when it is described that B is formed below or under A.

[0083] Note that when an object is explicitly described in a singular form, the object is preferably singular. Note that the present invention is not limited to this, and the object can be plural. Similarly, when an object is explicitly described in a plural form, the object is preferably plural. Note that the present invention is not limited to this, and the object can be singular.

[0084] One of two display panels (i.e., a peripheral portion of a display region of the one of the display panels) is provided with a circuit which is necessary for operating the display panels or a circuit which is necessary for an electronic device in which the display panels are incorporated. Thus, a display module can be made smaller. Further, since the number of electronic components which are mounted on the display module can be reduced, the display module can be made thinner.

BRIEF DESCRIPTION OF THE DRAWINGS

[0085] In the accompanying drawings:

[0086] FIGS. **1**A and **1**B illustrate structures of display modules of the present invention;

[0087] FIG. **2** illustrates a structure of a display module of the present invention;

[0088] FIGS. **3**A and **3**B illustrate structures of display modules of the present invention;

[0089] FIG. **4** illustrates a structure of a display module of the present invention;

[0090] FIG. **5** illustrates a structure of a display module of the present invention;

[0091] FIGS. **6**A and **6**B illustrate structures of display modules of the present invention;

[0092] FIG. **7** illustrates a structure of a display module of the present invention;

[0093] FIGS. **8**A and **8**B illustrate structures of display modules of the present invention;

[0094] FIG. **9** illustrates a structure of a display module of the present invention;

[0095] FIGS. **10**A and **10**B illustrate structures of display modules of the present invention;

[0096] FIG. **11** illustrates a structure of a display module of the present invention;

[0097] FIGS. **12**A and **12**B illustrate structures of display modules of the present invention;

[0098] FIGS. **13**A and **13**B illustrate an SOI substrate used in the present invention;

[0099] FIGS. **14**A and **14**B illustrate an SOI substrate used in the present invention;

[0100] FIGS. **15**A to **15**C illustrate an SOI substrate used in the present invention;

[0101] FIG. **16** illustrates an SOI substrate used in the present invention;

[0102] FIGS. **17**A to **17**C illustrate an SOI substrate used in the present invention;

[0103] FIGS. **18**A to **18**E illustrate an SOI substrate used in the present invention;

[0104] FIGS. **19**A and **19**B illustrate an SOI substrate used in the present invention;

[0105] FIGS. **20**A to **20**C illustrate an SOI substrate used in the present invention;

[0106] FIGS. **21**A and **21**B illustrate an SOI substrate used in the present invention;

[0107] FIGS. **22**A to **22**C illustrate an SOI substrate used in the present invention;

[0108] FIGS. **23**A and **23**B illustrate an SOI substrate used in the present invention;

[0109] FIG. **24** illustrates an electronic device of the present invention;

[0110] FIG. **25** illustrates an electronic device of the present invention;

[0111] FIGS. **26**A and **26**B illustrate electronic devices of the present invention;

[0112] FIGS. **27**A and **27**B illustrate an electronic device of the present invention;

[0113] FIG. **28** illustrates an electronic device of the present invention;

[0114] FIG. **29** illustrates an electronic device of the present invention;

[0115] FIGS. **30**A to **30**C illustrate electronic devices of the present invention;

[0116] FIG. **31** illustrates an electronic device of the present invention;

[0117] FIG. **32** illustrates an electronic device of the present invention;

[0118] FIG. **33** illustrates an electronic device of the present invention;

[0119] FIG. **34** illustrates an electronic device of the present invention;

[0120] FIGS. **35**A and **35**B illustrate an electronic device of the present invention;

[0121] FIGS. **36**A and **36**B illustrate an electronic device of the present invention;

[0122] FIGS. **37**A to **37**C illustrate electronic devices of the present invention;

[0123] FIGS. **38**A and **38**B illustrate electronic devices of the present invention;

[0124] FIG. **39** illustrates an electronic device of the present invention; and

[0125] FIGS. **40**A and **40**B illustrate a pixel of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0126] Hereinafter, the present invention will be described by way of embodiment modes with reference to the drawings. Note that the present invention can be implemented in various different ways and it will be readily appreciated by those skilled in the art that various changes and modifications are possible without departing from the spirit and the scope of the present invention. Therefore, the present invention should not be construed as being limited to the description of the embodiment modes of the present invention. Note that in structures of the present invention described hereinafter, like portions or portions having similar functions are denoted by common reference numerals in different drawings, and detailed description thereof is omitted.

Embodiment Mode 1

[0127] Display modules of this embodiment mode are described with reference to FIGS. **1**A and **1**B, and FIG. **2**. FIGS. **1**A and **1**B, and FIG. **2** show structures of the display modules of this embodiment mode. FIGS. **1**A and **1**B are cross-sectional views of the display modules; FIG. **1**A is a cross-sectional view of display panels which are provided in the same plane; and FIG. **1**B is a cross-sectional view of the display panels which are provided back to back. FIG. **2** is a top view of the display module when it is seen from one direction. Note that since the display modules shown in FIGS. **1**A and **1**B are the same except for positions of the display panels, reference numerals are commonly used.

[0128] Each of the display module shown in FIG. **1**A and the display module shown in FIG. **1**B includes a first display panel **102**, a second display panel **104**, and a signal processing circuit board **106**. The first display panel **102** and the second display panel **104** are provided so that images including characters, diagrams, symbols, and the like are displayed on different sides. The first display panel **102** and the second display panel **104** are different in screen size. One of the first display panel **102** and the second display panel **104** forms a main screen, and the other of the first display panel **102** and the second display panel **104** forms a sub screen.

[0129] In FIGS. **1**A and **1**B, external dimensions of the first display panel **102** and the second display panel **104** are made different from each other, and the external dimension (i.e., a panel area) of one of the first display panel **102** and the second display panel **104** is made smaller than that of the other of the first display panel **102** and the second display panel **104**. Typically, the second display panel **104** which forms the sub screen is made smaller than the first display panel **102** which forms the main screen. In addition, in order to form a compact display module, the first display panel **102** and the second display panel **104** are provided back to back to be disposed in contact with each other or adjacent to each other, as shown in FIG. **1**B. For example, the second display panel **104** is provided on an inner side of the first display panel **102**.

[0130] The signal processing circuit board **106** shown in FIGS. **1**A and **1**B is connected to a terminal **118** of the first display panel **102** through a conductive member **120** by a first terminal **112**. When the conductive member **120** is sandwiched between the first terminal **112** and the terminal **118**, the conductive member **120** exhibits electrically anisotropic properties in which electric resistance between both the terminals is decreased and adjacent terminals are electrically insulated. Such a conductive member **120** is provided by using, for example, a material in which conductive fine particles (or fine particles having conductive surfaces) are dispersed in a resin medium at a concentration that the conductive fine particles are localized so as not to interact with each other. In this case, when an interval between the first terminal **112** and the terminal **118** is approximately the same as the size of the conductive fine particles, both the terminals are conducted. Similarly, a second terminal **134** of the signal processing circuit board **106** is connected to a terminal **148** of the second display panel **104** through the conductive member **120**.

[0131] Note that an anisotropic conductive material can be used as the conductive member **120**. An anisotropic conductive material has three functions of adhesion, conductivity, and insulation. In particular, a high molecular material called an ACF (anisotropic conductive film) or an ACP (anisotropic conductive paste) has conductivity in a thickness direction and insulating properties in a plane direction by thermocompression bonding processing.

[0132] The signal processing circuit board **106** has a surface in which the terminal **118** of the first display panel **102** and the terminal **148** of the second display panel **104** are electrically connected by a wiring extending from these connection portions. In this case, the second terminal **134** which is electrically connected to the terminal **148** of the second display panel **104** is provided over the first display panel **102**. When a surface of the first display panel **102**, which is opposite to a display surface, is effectively used as shown in FIG. **1**B, a compact display module can be formed.

[0133] As shown in FIG. **1**B, in order to connect the terminal **148** of the second display panel **104** and the first terminal **112** which is electrically connected to the terminal **118** of the first display panel **102**, the signal processing circuit board **106** is preferably formed by using a flexible substrate **114** which forms an insulating surface. A polyimide film is typically used as the flexible substrate **114**; however, another resin film or fiber-reinforced plastic may be used. The thickness of the flexible substrate **114** may be 30 to 300 μm, typically 80 to 160 μm. When the second display panel **104** which is disposed inside the signal processing circuit board **106** is thicker than the signal processing circuit board **106**, an opening portion which is obtained by cutting part of the signal processing circuit board **106** out may be provided so that the second terminal **134** overlaps with the terminal **148** of the second display panel **104**.

[0134] The second display panel **104** shown in FIGS. **1**A and **1**B is provided with a circuit unit **401**. The circuit unit **401** is electrically connected to the terminal **148** of the second display panel **104**. Examples of the circuit unit **401** are various circuits such as a driver circuit of a display panel, a timing controller, an audio/image signal processing circuit, a memory, a power supply circuit, a high-frequency circuit, a filter, a security circuit, a central processing unit (CPU), an amplifier circuit, and an interface circuit for connecting another external device such as optical communication, LAN, or USB. Note that in this specification, a circuit having any one of or a plurality of functions of a driver circuit of a display panel, a timing controller, an audio/image signal processing circuit, a memory, a power supply circuit, a high-frequency circuit, a filter, a security circuit, a central processing unit (CPU), an amplifier circuit, and an interface circuit for connecting another external device such as optical communication, LAN, or USB is also referred to as a circuit group.

[0135] FIG. **2** shows a timing controller **401***a* which controls a signal transmitted to the display panel, an audio/image processor **401***b* which controls a signal transmitted to the timing controller **401***a*, a CPU **401***c*, a memory **401***d*, a power supply IC **401***e*, a power transistor **401***f*, a capacitor **401***g*, and a coil **401***h* as the circuit unit **401**. The timing controller **401***a* selects a place to which a signal is transmitted by a switching switch or a program and can be shared between the first display panel **102** and the second display panel **104**. The CPU **401***c* controls a key input signal and a power supply system.

[0136] In the first display panel **102**, a display portion **124** and the terminal **118** are formed over a first substrate **122**. Besides, a scan line driver circuit **128** and a signal line driver circuit **126** may be formed. Needless to say, part of or all these driver circuits may be formed in the second display panel **104** as the circuit unit **401** or part of the circuit unit **401**. In the display portion **124**, a plurality of dots (hereinafter also referred to as pixels), which are the minimum units of image display, are arranged two-dimensionally in an X direction and a Y direction. The display portion **124** includes a driving element array **124***a* and a display element array **124***b* as components. When further subdivided, the driving element array **124***a* includes a switching element which controls ON/OFF of a signal, and a non-linear element which controls a current flow may be combined when needed.

[0137] The scan line driver circuit **128** and/or the signal line driver circuit **126** can be formed by using the same element as the driving element array **124***a*. In this case, a transistor, more preferably a thin film transistor (hereinafter referred to as a TFT) is often used as the element. Needless to say, a capacitor, a resistor, or an inductor may also be included. The terminal **118** is also formed by using the same conductive layer as an electrode or a wiring of these elements.

[0138] A transistor is often used as a typical switching element. A transistor can have a single-drain structure in which a channel formation region is provided between a pair of a source and a drain, an LDD structure in which a low-concentration drain (LDD) is provided between a channel formation region and a drain, or the like. Alternatively, a transistor may have a multi-gate structure in which a plurality of gate electrodes are interposed (a plurality of channel formation regions are arranged in series) between a pair of a source and a drain. In addition, single-crystal silicon, polycrystalline silicon, or amorphous silicon can be used for a semiconductor layer included in a transistor. As a structure of a transistor, a bottom-gate structure in which a semiconductor layer is formed after forming a gate electrode may be used as well as a top-gate structure in which a gate electrode is formed after forming a semiconductor layer. The bottom-gate structure is particularly preferable in the case of using amorphous silicon. Note that the present invention is not limited to this, and various elements can be used as a switching element.

[0139] The display element array **124***b* can be formed by using an element, optical characteristics of which are changed by electric action (e.g., a liquid crystal element), an element which emits light by carrier injection (e.g., an electroluminescence element (hereinafter also referred to as an EL element), a light-emitting diode, or a light-emitting transistor), an element which discharges electric charge (e.g., an electron source element), or the like. Note that the present invention is not limited to this, and various elements can be used as the display element array **124***b*.

[0140] In the second display panel **104**, a display portion **136**, the circuit unit **401**, and the terminal **148** are formed on a second substrate **142**. Besides, a scan line driver circuit **138** and a signal line driver circuit **140** may be formed. A driving element array **136***a* and a display element array **136***b* in the display portion **136** have the same structures as the driving element array and the display element array in the first display panel **102**. As for the structure of such a display portion, the first display panel **102** and the second display panel **104** can be formed by using the same kind of driving element arrays and display element arrays, or may be formed by using different kinds of driving element arrays and display element arrays. For example, the display element arrays in both the first display panel **102** and the second display panel **104** can be formed by using EL elements, or one of them may be formed by using a liquid crystal element. In order to reduce the area of the circuit unit **401** formed on the second display panel **104**, it is preferable that a circuit be shared between the first display panel **102** and the second display panel **104**. In that case, it is preferable to use the same kind of display element arrays as in the case of forming both the display element arrays by using EL elements. Note that description "sharing of a circuit between the first display panel **102** and the second display panel **104**" corresponds to forming of a structure in which a circuit for driving the display panels, for example, a timing controller, an audio/image signal processing circuit, a memory, a power supply circuit, a high-frequency circuit, a filter, a security circuit, a central processing unit (CPU), an amplifier circuit, or the like is operated by using the same circuit group.

[0141] Here, a single-crystal semiconductor layer (an SOI layer) with uniform crystal orientation, which is bonded over a substrate having an insulating surface or an insulating substrate, is preferably used as a semiconductor layer of a transistor included in the circuit unit **401**. Thus, the crystal orientation of the single-crystal semiconductor layer is uniform, so that high-performance field-effect transistors which are uniform can be obtained. That is, variation in values of important transistor characteristics, such as the threshold voltage and mobility can be suppressed, so that high performance such as high mobility can be achieved. When the transistor in which the single-crystal semiconductor layer (the SOI layer) with uniform crystal orientation, which is bonded over the substrate having an insulating surface or the insulating substrate, is used for the circuit unit **401**, power consumption of the circuit unit **401** can be reduced and processing speed of the circuit unit **401** can be increased. Note that the present invention is not limited to this, and a variety of silicon such as single-crystal silicon, polycrystalline silicon, microcrystalline silicon, and non-crystal silicon can be used as the semiconductor layer of the transistor included in the circuit unit **401**.

[0142] Note that a transistor in which a single-crystal semiconductor layer (an SOI layer) with uniform crystal orientation, which is bonded over a substrate having an insulating surface or an insulating substrate, can be used as elements included in the driving element array **136***a,* the scan line driver circuit **138**, and the signal line driver circuit **140** formed in the second display panel **104**. Similarly, a transistor in which a single-crystal semiconductor layer (an SOI layer) with uniform crystal orientation, which is bonded over a substrate having an insulating surface or an insulating substrate, can be used as elements included in the driving element array **124***a,* the scan line driver circuit **128**, and the signal line driver circuit **126** formed in the first display panel **102**.

[0143] Various combinations can be applied to the first display panel **102** and the second display panel **104**. For example, the driving element array **124***a* of the first display panel **102** can be formed by using a TFT to obtain a so-called active matrix driving panel, and the second display panel **104** can also be the active matrix driving panel. In this combination, the driving element array **136***a* of the second display panel **104** may be omitted to obtain a passive matrix panel or a segment display panel.

[0144] The first display panel **102** and the second display panel **104** can be made different in screen size and number of pixels. For example, in a usage as a mobile phone, the first display panel **102** can be a 2.4-inch type having the number of pixels of 320×240 as a QVGA (the number of pixels of 320×240×3 (RGB)), and the second display panel **104** can be a 1.1-inch type having the number of pixels of 128×96. In addition, in a usage as a computer provided with an opening and closing display screen, such as a notebook computer, the first display panel **102** can be a 15-inch type having the number of pixels of 1024×768 as an XGA (the number of pixels of 1024×768×3 (RGB)), and the second display panel **104** can be a 3-inch type having the number of pixels of 320×240 as a QVGA. Besides, the screen size and the number of pixels of the first display panel **102** and the second display panel **104** can be combined as appropriate to be applied to various electronic devices.

[0145] In the first display panel **102**, at least the display portion **124** is covered with a first sealing substrate **130**. The first sealing substrate **130** is fixed to the first substrate **122** with a sealing material **132**. This structure is preferably employed particularly in the case of using an EL element for the display element array **124***b.* The first substrate **122** has a function of maintaining mechanical strength as a flat display panel as well as a function of fixing the display portion **124**, the scan line driver circuit **128**, the signal line driver circuit **126**, and the terminal **118** by organically connecting them. Mechanical strength corresponds to thickness which prevents the display module from being easily damaged due to a shock or vibration when the display module is incorporated in a housing of an electronic device or the like, or sufficient strength which prevents the display module from being damaged in handling of a device in manufacturing. In this case, when the first substrate **122** has certain thickness to maintain the mechanical strength, the first sealing substrate **130** can be thinner than the first substrate **122**. Note that when the first sealing substrate **130** is made thinner, strength thereof may be supplemented by combining a reinforcing material such as a resin film with the first sealing substrate **130**.

[0146] Similarly, in the second display panel **104**, a second sealing substrate **144** is fixed to the second substrate **142** with the sealing material **132**. In this case, when the second substrate **142** has certain thickness to maintain mechanical strength, the second sealing substrate **144** can be thinner than the second substrate **142**. Further, when the second display panel **104** is smaller than the first display panel **102**, the second substrate **142** can be thinner than the first substrate **122**, and the second sealing substrate **144** can be thinner than the first sealing substrate **130**.

[0147] Note that in the second display panel **104**, the circuit unit **401** is covered with the second sealing substrate **144**. Therefore, the circuit unit **401** can be prevented from being damaged in manufacturing steps. In addition, a material included in the circuit unit **401** can be prevented from being oxidized. Note that the present invention is not limited to this, and the circuit unit **401** is not necessarily covered with the second sealing substrate **144** in the second display panel **104**. FIGS. **12**A and **12**B are cross-sectional views of display modules in this case. FIGS. **12**A and **12**B are cross-sectional views of the display modules; FIG. **12**A is a cross-sectional view of display panels which are provided in the same plane; and FIG. **12**B is a cross-sectional view of the display panels which are provided back to back. Note that since the display modules shown in FIGS. **12**A and **12**B are the same except for positions of the display panels, reference numerals are commonly used. In the display modules shown in FIGS. **12**A and **12**B, the second sealing substrate **144** can be made smaller because the circuit unit **401** is not sealed, unlike the display modules shown in FIGS. **1**A and **1**B. In addition, parasitic capacitance of the circuit unit **401** can be reduced.

[0148] When the first sealing substrate **130** of the first display panel **102** and the second sealing substrate **144** of the second display panel **104** shown in FIGS. **12**A and **12**B are disposed in contact with each other, both the sealing substrates can be further thinned. Alternatively, the sealing substrate of the second display panel **104** may be omitted, and the first sealing substrate **130** may be shared between the first display panel **102** and the second display panel **104**.

[0149] For example, the first substrate **122** and the first sealing substrate **130** shown in FIGS. **12**A and **12**B are each formed by using a glass substrate having a thickness of 0.5 mm; the second substrate **142** is formed by using a glass substrate having a thickness of 0.5 mm; and the second sealing substrate **144** is formed by using a glass substrate having a thickness of 0.3 mm. Then, the total thickness is 1.8 mm. In consideration of the flexible substrate **114** having a thickness of 30 to 300 μm, the total thickness is approximately 2 mm. In consideration of thicknesses of the driving element array and the display element array in the display portion and the sealing material, the total thickness thereof is less than 1 mm. Therefore, the thickness of the display module in this embodiment mode can be 3 mm or less. In a display module, it is necessary to determine the thickness of a glass substrate, which influences the thickness most, in consideration of the display panel size; however, the thickness can be freely selected in the range of 0.1 to 2 mm, preferably 0.4 to 0.7 mm.

[0150] FIGS. **1**A and **1**B, and FIG. **2** each show the case in which the second display panel **104** is provided with circuits and various elements which are necessary for operating the first display panel **102** and the second display panel **104** or circuits and various elements which are necessary for an electronic device in which the first display panel **102** and the second display panel **104** are incorporated as the circuit unit **401**. However, the present invention is not limited to this, and various structures can be used for the display module. Some examples of display modules which are different from those in FIGS. **1**A and **1**B, and FIG. **2** are described below.

[0151] First, the case in which part of the circuit unit **401** is mounted on a display module as an IC chip is described with reference to FIGS. **3**A and **3**B, FIG. **4**, and FIG. **5**. Note that as an IC chip, there are a driver circuit of a display panel, a timing controller, an audio/image signal processing circuit, a memory, a power supply circuit, a high-frequency circuit, a filter, a security circuit, a central processing unit (CPU), an amplifier circuit, and an interface circuit for connecting another external device such as optical communication, LAN, or USB, for example.

[0152] FIGS. **3**A and **3**B, FIG. **4**, and FIG. **5** show structures of display modules. FIGS. **3**A and **3**B are cross-sectional views of the display modules; FIG. **3**A is a cross-sectional view of display panels which are provided in the same plane; and FIG. **3**B is a cross-sectional view of the display panels which are provided back to back. FIG. **4** is a top view of the display module when it is seen from one direction. FIG. **5** is a top view of a display module which is different from a display nodule of FIG. **4** when it is seen from one direction. Note that structures which are the same as the structures in FIGS. **1**A and **1**B, and FIG. **2** are denoted by common reference numerals, and description thereof is omitted.

[0153] The signal processing circuit board **106** shown in FIGS. **3**A and **3**B is connected to the terminal **118** of the first display panel **102** through the conductive member **120** by the first terminal **112**. The signal processing circuit board **106** has a surface on which an IC chip **108** is mounted by a wiring **116** extending from this connection portion. The IC chip **108** is prepared as an individual component and is mounted so as to be electrically connected to the connection portion of the wiring **116** which is arranged as appropriate. As a method for mounting the IC chip **108**, a connection method such as face down bonding or wire bonding is applied. The IC chip **108** is mounted so that a mounted surface overlaps with the first display panel **102**. In this case, the second terminal **134** which is electrically connected to the terminal **148** of the second display panel **104** is provided over the first display panel **102**.

[0154] FIG. **4** shows the CPU **108***c* and the memory **108***d* which are mounted on the signal processing circuit board **106**. Besides, driver ICs (for scan line driving and signal line driving) of the first display panel **102** and the second display panel **104** can be mounted thereon. As the circuit unit **401**, the timing controller **401***a* which controls a signal transmitted to the display panel, the audio/image processor **401***b* which controls a signal transmitted to the timing controller **401***a*, the power supply IC **401***e*, the power transistor **401***f*, the capacitor **401***g*, and the coil **401***h* are shown. In FIG. **4**, when a large-scale CPU (in which the number of transistors is large) is mounted on the display module as the IC chip, the area of the circuit unit can be decreased. When a CPU in which high-speed operations are necessary is mounted on the display module as the IC chip, yield can be improved. When the memory is mounted on the display module as the IC chip, steps of forming the second display panel can be simplified.

[0155] An example which is different from that of FIG. **4** is described. FIG. **5** shows a power supply IC **108***e*, a power transistor **108***f*, a capacitor **108***g*, and a coil **108***h* which are mounted on the signal processing circuit board **106**. As the circuit unit **401**, the timing controller **401***a* which controls a signal transmitted to the display panel, the audio/image processor **401***b* which controls a signal transmitted to the timing controller **401***a*, the CPU **401***c*, the memory **401***d* are shown. In FIG. **5**, when power supply-type circuits and elements are mounted on the display module as the IC chip, the power supply-type circuits and elements can be formed by using bipolar transistors having high current supply capability. Since it is not necessary to form bipolar transistors for the circuit unit, steps of forming the second display panel can be simplified.

[0156] Note that FIGS. **4** and **5** are examples. Therefore, the present invention is not limited to the structures shown in FIGS. **4** and **5**. As the display module, a structure can be used in which the second display panel **104** is provided with part of circuits and various elements which are necessary for operating the first display panel **102** and the second display panel **104** or part of circuits and various elements which are necessary for an electronic device in which the first display panel **102** and the second display panel **104** are incorporated, and another part thereof is mounted on the signal processing circuit board **106** as the IC chip **108**.

[0157] Next, the case of mounting a sensor chip on a display module is described with reference to FIGS. **6**A and **6**B, and FIG. **7**. Note that there are various kinds of sensor chips such as an optical sensor, a CCD module (camera), a temperature sensor, a humidity sensor, an acceleration sensor, a vibration sensor, a direction sensor, a gas sensor, and a particulate sensor (e.g., a smoke sensor or a pollen sensor), for example.

[0158] FIGS. **6**A and **6**B, and FIG. **7** show structures of display modules. FIGS. **6**A and **6**B are cross-sectional views of the display modules; FIG. **6**A is a cross-sectional view of display panels which are provided in the same plane; and FIG. **6**B is a cross-sectional view of the display panels which are provided back to back. FIG. **7** is a top view of the display module when it is seen from one direction. Note that structures which are the same as the structures in FIGS. **1**A to **5** are denoted by common reference numerals, and description thereof is omitted.

[0159] The signal processing circuit board **106** shown in FIGS. **6**A and **6**B is connected to the terminal **118** of the first display panel **102** through the conductive member **120** by the first terminal **112**. The signal processing circuit board **106** has a surface on which a sensor chip **110** is mounted by the wiring **116** extending from this connection portion. The sensor chip **110** is prepared as an individual component and is mounted so as to be electrically connected to the connection portion of the wiring **116** which is arranged as appropriate. As a method for mounting the sensor chip **110**, a connection method such as face down bonding or wire bonding is applied. The sensor chip **110** is mounted so that a mounted surface overlaps with the first display panel **102**. In this case, the second terminal **134** which is electrically connected to the terminal **148** of the second display panel **104** is provided over the first display panel **102**.

[0160] FIG. **7** shows a CCD module **110***a* and an optical sensor **110***b* which are mounted on the signal processing circuit board **106**. When the CCD module **110***a* is mounted on the display module, the display module can have a function as a still camera or a video camera. When the optical sensor **110***b* is mounted on the display module, luminance of the display panel can be changed by change in ambient luminance.

[0161] Next, the case in which part of the circuit unit **401** is mounted on the display module as the IC chip and the sensor chip is mounted on the display module is described with reference to FIGS. **8**A and **8**B, and FIG. **9**.

[0162] FIGS. **8**A and **8**B, and FIG. **9** show structures of display modules. FIGS. **8**A and **8**B are cross-sectional views of the display modules; FIG. **8**A is a cross-sectional view of display panels which are provided in the same plane; FIG. **8**B is a cross-sectional view of the display panels which are provided back to back. FIG. **9** is a top view of the display module when it is seen from one direction. Note that structures which are the same as the structures in FIGS. **1**A to **7** are denoted by common reference numerals, and description thereof is omitted.

[0163] The signal processing circuit board **106** shown in FIGS. **8**A and **8**B is connected to the terminal **118** of the first display panel **102** through the conductive member **120** by the first terminal **112**. The signal processing circuit board **106** has a surface on which the IC chip **108** and the sensor chip **110** are mounted by a wiring **116** extending from this connection portion. The IC chip **108** and the sensor chip **110** are prepared as individual components and are mounted so as to be electrically connected to the connection portion of the wiring **116** which is arranged as appropriate. As a method for mounting the IC chip **108** and the sensor chip **110**, a connection method such as face down bonding or wire bonding is applied. The IC chip **108** and the sensor chip **110** are mounted so that a mounted surface overlaps with the first display panel **102**. In this case, the second terminal **134** which is electrically connected to the terminal **148** of the second display panel **104** is provided over the first display panel **102**.

[0164] FIG. **9** shows the CCD module **110***a*, the optical sensor **110***b*, the CPU **108***c*, and the memory **108***d* which are mounted on the signal processing circuit board **106**. Besides, driver ICs (for scan line driving and signal line driving) of the first display panel **102** and the second display panel **104** can be mounted thereon. As the circuit unit **401**, the timing controller **401***a* which controls a signal transmitted to the display panel, the audio/image processor **401***b* which controls a signal transmitted to the timing controller **401***a*, the power supply IC **401***e*, the power transistor **401***f*, the capacitor **401***g*, and the coil **401***h* are shown. When the CCD module **110***a* is mounted on the display module, the display module can have a function as a still camera or a video camera. When the optical sensor **110***b* is mounted on the display module, luminance of the display panel can be changed by change in ambient luminance. When a large-scale CPU (in which the number of transistors is large) is mounted on the display module as the IC chip, the area of the circuit unit can be decreased. When a CPU in which high-speed operations are necessary is mounted on the display module as the IC chip, yield can be improved. When the memory is mounted on the display module as the IC chip, steps of forming the second display panel can be simplified.

[0165] Note that FIGS. **8**A and **8**B, and FIG. **9** are examples. Therefore, the present invention is not limited to the structures shown in FIGS. **8**A and **8**B, and FIG. **9**. As the display module, a structure can be used in which the second display panel **104** is provided with part of circuits and various elements which are necessary for operating the first display panel **102** and the second display panel **104** or part of circuits and various elements which are necessary for an electronic device in which the first display panel **102** and the second display panel **104** are incorporated, and another part thereof is mounted on the signal processing circuit board **106** as the IC chip **108**.

[0166] As described above, one of two display panels provided back to back is provided with circuits and various elements which are necessary for operating the display panels or circuits and various elements which are necessary for an electronic device in which the display panels are incorporated. Thus, electronic components (IC chips) which are mounted can be reduced or eliminated. Since the electronic components are reduced or eliminated, an inexpensive display module can be provided at low cost. In addition, since the electronic components are reduced or eliminated, a display module can be made smaller. Further, since the electronic components are reduced or eliminated, a display module can be made thinner.

[0167] Note that although this embodiment mode is described with reference to various drawings, the contents (or may be part of the contents) described in each drawing can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in another drawing. Further, even more drawings can be formed by combining each part with another part in the above-described drawings.

[0168] Similarly, the contents (or may be part of the contents) described in each drawing of this embodiment mode can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in a drawing in another embodiment mode. Further, even more drawings can be formed by combining each part with part of another embodiment mode in the drawings of this embodiment mode.

[0169] Note that this embodiment mode shows an example of an embodied case of the contents (or may be part of the contents) described in other embodiment modes, an example of slight transformation thereof, an example of partial modification thereof, an example of improvement thereof, an example of detailed description thereof, an application example thereof, an example of related part thereof, or the like. Therefore, the contents described in other embodiment modes can be freely applied to, combined with, or replaced with this embodiment mode.

Embodiment Mode 2

[0170] In this embodiment mode, display modules including a plurality of liquid crystal display panels which form a main screen and a sub screen are described with reference to FIGS. **10**A and **10**B. FIGS. **10**A and **10**B are cross-sectional views of the display modules; FIG. **10**A is a cross-sectional view of display panels which are provided in the same plane; and FIG. **10**B is a cross-sectional view of the display panels which are provided back to back. Note that since the display modules shown in FIGS. **10**A and **10**B are the same except for positions of the display panels, reference numerals are commonly used. Note that structures which are the same as the structures in FIGS. **1**A to **9** are denoted by common reference numerals, and description thereof is omitted.

[0171] Each of the display modules of this embodiment mode shown in FIGS. **10**A and **10**B includes a first display panel **302**, a second display panel **304**, and the signal processing circuit board **106** including a timing controller of both the display panels. The first display panel **302** and the second display panel **304** are provided so that images including characters, diagrams, symbols, and the like are displayed on different sides. Note that the first display panel **302** and the second display panel **304** are different in screen size. One of the first display panel **302** and the second display panel **304** forms a main screen, and the other of the first display panel **302** and the second display panel **304** forms a sub screen.

[0172] In FIGS. **10**A and **10**B, external dimensions of the first display panel **302** and the second display panel **304** are made different from each other, and the external dimension (i.e., panel area) of one of the first display panel **302** and the second display panel **304** is made smaller than that of the other of the first display panel **302** and the second display panel **304**. Typically, the second display panel **304** which forms the sub screen is made smaller than the first display panel **302** which forms the main screen. In addition, in order to form a compact display module, the first display panel **302** and the second display panel **304** are provided back to back with a backlight unit **308** interposed therebetween, as shown in FIG. **10**B. The backlight unit **308** has a structure in which a light guide plate is combined with a diffusion plate, a lens sheet, and the like to emit light from a light source **310** across surfaces. In this case, each of the first display panel **302** and the second display panel **304** may be provided with the backlight unit **308**.

[0173] The signal processing circuit board **106** shown in FIGS. **10**A and **10**B is connected to a terminal **318** of the first display panel **302** through the conductive member **120** by the first terminal **112**. When the conductive member **120** is sandwiched between the first terminal **112** and the terminal **318**, the conductive member **120** exhibits electrically anisotropic properties in which electric resistance between both the terminals is decreased and adjacent terminals are electrically insulated. Such a conductive member **120** is provided by using, for example, a material in which conductive fine particles (or fine particles having conductive surfaces) are dispersed in a resin medium at a concentration that the conductive fine particles localized so as not to interact with each other. In this case, when an interval between the first terminal **112** and the terminal **318** is approximately the same as the size of the conductive fine particles, both the terminals are conducted. Similarly, the signal processing circuit board **106** is connected to a terminal **348** of the second display panel **304** through the conductive member **120** by using a second terminal **334**.

[0174] The signal processing circuit board **106** has a surface in which the terminal **318** of the first display panel **302** and the terminal **348** of the second display panel **304** are electrically connected by a wiring extending from these connection portions. In this case, the second terminal **334** which is electrically connected to the terminal **348** of the second display panel **304** is provided over the first display panel **302**. When a surface of the first display panel **302**, which is opposite to a display surface, is effectively used as shown in FIG. **10**B, a compact display module can be formed.

[0175] As shown in FIG. **10**B, in order to connect the terminal **348** of the second display panel **304** and the first terminal **112** which is electrically connected to the terminal **318** of the first display panel **302**, the signal processing circuit board **106** is preferably formed by using the flexible substrate **114** which forms an insulating surface. A polyimide film is typically used as the flexible substrate **114**; however, another resin film or fiber-reinforced plastic may be used. The thickness of the flexible substrate **114** may be 30 to 300 μm, typically 80 to 160 μm. When the second display panel **304** which is disposed inside the signal processing circuit board **106** is thicker than the signal processing circuit board **106**, the opening portion which is obtained by cutting part of the signal processing circuit board **106** out may be provided so that the second terminal **334** overlaps with the terminal **348** of the second display panel **304**.

[0176] The second display panel **304** shown in FIGS. **10**A and **10**B is provided with the circuit unit **401**. The circuit unit **401** is electrically connected to the terminal **348** of the second display panel **304**. Here, examples of the circuit unit **401** are various circuits such as a driver circuit of a display panel, a timing controller, an audio/image signal processing circuit, a memory, a power supply circuit, a high-frequency circuit, a filter, a security circuit, a central processing unit (CPU), an amplifier circuit, an interface circuit for connecting another external device such as optical communication, LAN, or USB, and a backlight control unit.

[0177] In the first display panel **302**, a display portion **324** and the terminal **318** are formed over a first substrate **322**. Besides, a scan line driver circuit **328** (and a signal line driver circuit **326**) may be formed. Needless to say, part of or all these driver circuits may be formed in the second display panel **304** as the circuit unit **401** or part of the circuit unit **401**. In the display portion **324**, a plurality of pixels are arranged two-dimensionally in an X direction and a Y direction. The display portion **324** includes a driving element array **324***a*, a display element array **324***b*, and a color filter array **324***c* as components.

[0178] The driving element array **324***a* includes a switching element which controls ON/OFF of a signal, and a nonlinear element which controls a current flow may be combined when needed. A transistor is often used as a typical switching element. A transistor can have a single-drain structure in which a channel formation region is provided between a pair of a source and a drain, an LDD structure in which a low-concentration drain (LDD) is provided between a channel formation region and a drain, or the like. Alternatively, a transistor may have a multi-gate structure in which a plurality of gate electrodes are interposed (a plurality of channel formation regions are arranged in series) between a pair of a source and a drain. In addition, single-crystal silicon, polycrystalline silicon, or amorphous silicon can be used for a semiconductor layer included in a transistor. As a structure of a transistor, a bottom-gate structure in which a semiconductor layer is formed after forming a gate electrode may be used as well as a top-gate structure in which a gate electrode is formed after forming a semiconductor layer. The bottom-gate structure is particularly preferable in the case of using amorphous silicon.

[0179] Note that for the driving element array **324***a*, an MIM element may be used as well as a transistor. Note that the display portion **324** is a passive matrix type, the driving element array **324***a* can be omitted.

[0180] The display element array **324***b* is formed by using a liquid crystal element, optical characteristics of which are changed by electric action. A liquid crystal element is formed by a liquid crystal material which is filled between a pair of electrodes. The liquid crystal material is interposed between the first substrate **322** and a second substrate **330** and is sealed with a sealing material **332**. The liquid crystal element which is interposed between a counter electrode and a pixel electrode is supplied with voltage which is a potential difference between both the electrodes, and a polarization state of light which is transmitted through a liquid crystal is changed in accordance with the voltage. That is, when light from the backlight unit **308** is transmitted through the liquid crystal and polarizing plates **306**, light and dark in accordance with the polarization state of light are displayed. When the color filter array **324***c* is combined with this, color display can be performed. As the liquid crystal material, a TN liquid crystal is typically used. In this manner, a liquid crystal panel is completed. In this case, when the structure of the pixel electrode is changed, the display element array **324***b* which is operated in an MVA mode or an IPS mode can be employed.

[0181] In the second display panel **304**, a display portion **336**, the circuit unit **401**, and the terminal **348** are formed on a second substrate **142**. Besides, a driver circuit **340** may be formed. A driving element array **336***a*, a display element array **336***b*, and a color filter array **336***c* of the display portion **336** and the driver circuit **340** in the second substrate **342** of the second display panel **304** can be formed by using the same components as those in the first display panel **302**. In order to reduce the area of the circuit unit **401** formed in the second display panel **304**, it is preferable that a circuit be shared between the first display panel **302** and the second display panel **304**. In that case, it is preferable to use the same kind of display element arrays as in the case of forming both the display element arrays by using liquid crystal elements.

[0182] Here, a single-crystal semiconductor layer (an SOI layer) with uniform crystal orientation, which is bonded over a substrate having an insulating surface or an insulating substrate, is preferably used as a semiconductor layer of a transistor included in the circuit unit **401**. Thus, the crystal orientation of the single-crystal semiconductor layer is uniform, so that high-performance field-effect transistors which are uniform can be obtained. That is, variation in values of important transistor characteristics, such as the threshold voltage and mobility can be suppressed, so that high performance such as high mobility can be achieved. When the transistor in which the single-crystal semiconductor layer (the SOI layer) with uniform crystal orientation, which is bonded over the substrate having an insulating surface or the insulating substrate, is used for the circuit unit **401**, power consumption of the circuit unit **401** can be reduced and processing speed of the circuit unit **401** can be increased. Note that the present invention is not limited to this, and a variety of silicon such as single-crystal silicon, polycrystalline silicon, microcrystalline silicon, and non-crystal silicon can be used as the semiconductor layer of the transistor included in the circuit unit **401**.

[0183] Note that a transistor in which a single-crystal semiconductor layer (an SOI layer) with uniform crystal orientation, which is bonded over a substrate having an insulating surface or an insulating substrate, can be used as elements included in the driving element array **336*a*** and the driver circuit **340** formed on the second display panel **304**. Similarly, a transistor in which a single-crystal semiconductor layer (an SOI layer) with uniform crystal orientation, which is bonded over a substrate having an insulating surface or an insulating substrate, can be used as elements included in the driving element array **3224*a*** and the scan line driver circuit **328** (and the signal line driver circuit **326**) formed in the first display panel **302**.

[0184] The first display panel **302** and the second display panel **304** can be made different in screen size and number of pixels. For example, in a usage as a mobile phone, the first display panel **302** can be a 2.1-inch type having the number of pixels of 320×240 as a QVGA (the number of pixels of 320×240×3 (RGB)), and the second display panel **304** can be a 0.9-inch type having the number of pixels of 88×64. In addition, in a usage as a computer provided with an opening and closing display screen, such as a notebook computer, the first display panel **302** can be a 15-inch type having the number of pixels of 1024×768 as an XGA (the number of pixels of 1024×768×3 (RGB)), and the second display panel **304** can be a 3-inch type having the number of pixels of 320×240 as a QVGA. Besides, the screen sizes and the number of pixels of the first display panel **302** and the second display panel **304** can be combined as appropriate to be applied to various electronic devices.

[0185] The light source **310** of the backlight unit **308** can also be incorporated in the circuit unit **401** formed in the second display panel **304**. As the light source **310**, a cold cathode fluorescent lamp or an electroluminescence (EL) light source can be used as well as a light-emitting diode (LED). In addition, a light-shielding plate **312** is provided between the backlight unit **308**, and the second display panel **304** and the signal processing circuit substrate **106**. In this structure, light of the backlight unit **308** is prevented from leaking to the second display panel **304** side having a smaller area than the first display panel **302**. An opening portion is formed in the light-shielding plate **312** so that light from the backlight unit **308** reaches a display screen of the second display panel **304**.

[0186] Note that similarly to Embodiment Mode 1, part of the circuit unit **401** may be mounted on the display module as an IC chip. A sensor chip may be mounted on the display module. Part of the circuit unit **401** may be mounted on the display module as an IC chip and the sensor chip may also be mounted on the display module. Note that as an IC chip, there are a driver circuit of a display panel, a timing controller, an audio/image signal processing circuit, a memory, a power supply circuit, a high-frequency circuit, a filter, a security circuit, a central processing unit (CPU), an amplifier circuit, and an interface circuit for connecting another external device such as optical communication, LAN, or USB, for example. Note that there are various kinds of sensor chips such as an optical sensor, a CCD module (camera), a temperature sensor, a humidity sensor, an acceleration sensor, a vibration sensor, a direction sensor, a gas sensor, and a particulate sensor (e.g., a smoke sensor or a pollen sensor), for example.

[0187] As described above, one of two display panels provided back to back is provided with circuits and various elements which are necessary for operating the display panel or circuits and various elements which are necessary for an electronic device in which the display panel is incorporated. Thus, electronic components (IC chips) which are mounted can be reduced or eliminated. Since the electronic components are reduced or eliminated, an inexpensive display module can be provided at low cost. In addition, since the electronic components are reduced or eliminated, a display module can be made smaller. Further, since the electronic components are reduced or eliminated, a display module can be made thinner.

[0188] Although the case in which a liquid crystal display panel is used is described in this embodiment mode, a field emission display (FED) using an electron emitter, an SED-type flat panel display (SED: surface-conduction electron-emitter display), or a display using a contrast medium (e.g., electronic ink) can be used.

[0189] Note that although this embodiment mode is described with reference to various drawings, the contents (or may be part of the contents) described in each drawing can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in another drawing. Further, even more drawings can be formed by combining each part with another part in the above-described drawings.

[0190] Similarly, the contents (or may be part of the contents) described in each drawing of this embodiment mode can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in a drawing in another embodiment mode. Further, even more drawings can be formed by combining each part with part of another embodiment mode in the drawings of this embodiment mode.

[0191] Note that this embodiment mode shows an example of an embodied case of the contents (or may be part of the contents) described in other embodiment modes, an example of slight transformation thereof, an example of partial modification thereof, an example of improvement thereof, an example of detailed description thereof, an application example thereof, an example of related part thereof, or the like. Therefore, the contents described in other embodiment modes can be freely applied to, combined with, or replaced with this embodiment mode.

Embodiment Mode 3

[0192] In this embodiment mode, operations of each of the display modules described in Embodiment Modes 1 and 2 are described with reference to FIG. **11**.

[0193] The display module includes a first display panel **1110** which forms a main screen and a second display panel **1120** which forms a sub screen. In addition, the first display panel **1110** includes a level shifter **1111**, a driving portion **1112**, and a display portion **1113**. The second display panel **1120** includes a circuit unit **1121**, a switching switch **1122**, a driving portion **1123**, and a display portion **1124**. Note that an IC chip is mounted on the display module. Alternatively, an IC chip is provided outside the display module. In this embodiment mode, an IC chip mounted on the display module and an IC chip provided outside the display module is collectively referred to as an external IC **1101**.

[0194] Note that the case is described in which polycrystalline silicon, microcrystalline silicon, or non-crystal silicon is used as a semiconductor layer of a transistor included in the first display panel **1110**, and a single-crystal semiconductor layer (an SOI layer) with uniform crystal orientation, which is bonded over a substrate having an insulating surface or an insulating substrate, is used as a semiconductor layer of a transistor included in the second display panel **1120**.

[0195] Operations of the display module are briefly described. A signal is input from the external IC **1101** to the circuit unit **1121** of the second display panel **1120**. A video signal, a clock signal, a start signal, or the like is included in this signal. The circuit unit **1121** outputs a signal for driving the first display panel **1110** or the second display panel **1120**. Then, the switching switch **1122** selects whether this signal is input to the driving portion **1112** of the first display panel **1110** through the level shifter **1111** or this signal is input to the driving portion **1123** of the second display panel **1120**. Then, when the signal is input to the driving portion **1112**, the driving portion **1112** drives the display portion **1113**. On the other hand, when the signal is input to the driving portion **1123**, the driving portion **1123** drives the display portion **1124**.

[0196] Operating voltage of the display module is described. The external IC **1101** is operated at low voltage (e.g., 0/3.3 V). This is because a single-crystal silicon is often used as semiconductor layers of transistors included in the external IC **1101**, so that the threshold voltage is low, mobility is high, and variation is small.

[0197] Here, a single-crystal semiconductor is used as the semiconductor layer of the transistor included in the second display panel **1120**. Therefore, the circuit unit **1121** can be operated at almost the same operating voltage as the external IC **1101**. Thus, power supply voltage, a clock signal, or the like can be shared between the circuit unit **1121** and the external IC **1101**. On the other hand, polycrystalline silicon, microcrystalline silicon, or non-crystal silicon is used as the semiconductor layer of the transistor included in the first display panel **1110**. Therefore, the driving portion **1112** needs operating voltage which is higher than the operating voltage of the circuit unit **1121** or the operating voltage of the external IC **1101**. Thus, the amplitude of the signal which is input from the circuit unit is increased by the level shifter **1111**. Then, the signal, the amplitude of which is increased, is input to the driving portion **1112**.

[0198] As described above, the first display panel **1110** includes the level shifter **1111** because high operating voltage is necessary. In addition, a polycrystalline semiconductor, a microcrystalline semiconductor, or a non-crystal semiconductor is used as the semiconductor layer of the transistor included in the first display panel **1110**. Therefore, the display module can be inexpensively manufactured at low cost.

[0199] Here, a semiconductor layer of a transistor included in the circuit unit **1121**, a semiconductor layer of a transistor included in the driving portion **1123**, and a semiconductor layer of a transistor included in the display portion **1124** are not necessarily the same. For example, the semiconductor layer of the transistor included in the circuit unit **1121** may be a single-crystal semiconductor, and each of the semiconductor layer of the transistor included in the driving portion **1123** and the semiconductor layer of the transistor included in the display portion **1124** may be a polycrystalline semiconductor, a microcrystalline semiconductor, or a non-crystal semiconductor. As another example, each of the semiconductor layer of the transistor included in the circuit unit **1121** and the semiconductor layer of the transistor included in the driving portion **1123** may be a single-crystal semiconductor, and the semiconductor layer of the transistor included in the display portion **1124** may be a polycrystalline semiconductor, a microcrystalline semiconductor, or a non-crystal semiconductor. Note that the present invention is not limited to this, and various structures can be used.

[0200] Note that it is preferable that crystallinity of the semiconductor layer of the transistor included in the circuit unit **1121** be higher than crystallinity of the semiconductor layer of the transistor included in the first display panel **1110**. This is because it is necessary that the second display panel **1120** be operated at higher speed than the first display panel **1110**. For example, the semiconductor layer of the transistor included in the second display panel **1120** can be a polycrystalline semiconductor and the semiconductor layer of the transistor included in the first display panel **1110** can be a microcrystalline semiconductor or a non-crystal semiconductor. Note that the present invention is not limited to this, and the same kind of semiconductor layers may be used as the semiconductor layer of the transistor included in the circuit unit **1121** and the semiconductor layer of the transistor included in the first display panel **1110**.

[0201] Note that although this embodiment mode is described with reference to various drawings, the contents (or may be part of the contents) described in each drawing can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in another drawing. Further, even more drawings can be formed by combining each part with another part in the above-described drawings.

[0202] Similarly, the contents (or may be part of the contents) described in each drawing of this embodiment mode can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in a drawing in another embodiment mode. Further, even more drawings can be formed by combining each part with part of another embodiment mode in the drawings of this embodiment mode.

[0203] Note that this embodiment mode shows an example of an embodied case of the contents (or may be part of the contents) described in other embodiment modes, an example of slight transformation thereof, an example of partial modification thereof, an example of improvement thereof, an example of detailed description thereof, an application example thereof, an example of related part thereof, or the like. Therefore, the contents described in other embodiment modes can be freely applied to, combined with, or replaced with this embodiment mode.

Embodiment Mode 4

[0204] FIGS. **13**A and **13**B each show an SOI substrate. In FIG. **13**A, a base substrate **2100** is a substrate having an insulating surface or an insulating substrate, and any of various glass substrates which are used in the electronics industry, such as aluminosilicate glass substrates, aluminoborosilicate glass substrates, and barium borosilicate glass substrates can be used. Alternatively, a quartz glass substrate or a semiconductor substrate such as a silicon wafer can be used. An SOI layer **2102** is a single-crystal semiconductor, and single-crystal silicon is typically used. Alternatively, a single-crystal semiconductor layer formed of silicon, germanium, or a compound semiconductor such as gallium arsenide or indium phosphide which can be separated from a single-crystal semiconductor substrate by a separation method of hydrogen ion introduction can be used.

[0205] Between the base substrate **2100** and the SOI layer **2102** described above, a bonding layer **2104** which has a smooth surface and forms a hydrophilic surface is provided. A silicon oxide film is suitable as the bonding layer **2104**. In particular, a silicon oxide film formed by a chemical vapor deposition method using an organic silane gas is preferable. As an organic silane gas, a silicon-containing compound such as tetraethoxysilane (TEOS) (chemical formula: $Si(OC_2H_5)_4$), tetramethylsilane (TMS) (chemical formula: $Si(CH_3)_4$), tetramethylcyclotetrasiloxane (TMCTS), octamethylcyclotetrasiloxane (OMCTS), hexamethyldisilazane (HMDS), triethoxysilane (chemical formula: $SiH(OC_2H_5)_3$), or trisdimethylaminosilane (chemical formula: $SiH(N(CH_3)_2)_3$) can be used.

[0206] The bonding layer **2104** which has a smooth surface and forms a hydrophilic surface is provided with a thickness of 5 to 500 nm. With such a thickness, roughness of a surface on which the bonding layer **2104** is formed can be smoothed and smoothness of a growth surface of the film can be ensured. In addition, distortion between a substrate and the SOI layer which are bonded to each other can be reduced. The base substrate **2100** may be provided with a similar silicon oxide film. That is, when the SOI layer **2102** is bonded to the base substrate **2100** which is a substrate having an insulating surface or an insulating substrate, the base substrate **2100** and the SOI layer **2102** can be firmly bonded to each other when the bonding layer **2104** formed of a silicon oxide film which is preferably formed using organic silane as a material is provided on either one or both surfaces of the base substrate **2100** and the SOI layer **2102** which are to be bonded.

[0207] FIG. **13**B shows a structure in which the base substrate **2100** is provided with a silicon nitride layer **2105** and the bonding layers **2104**. In the case of bonding the SOI layer **2102** to the base substrate **2100**, the SOI layer **2102** can be prevented from being contaminated by diffusion of impurities such as mobile ions like alkali metal or alkaline earth metal from a glass substrate which is used as the base substrate **2100**. A bonding layer **2104** on the base substrate **2100** side may be provided as appropriate.

[0208] FIG. **14**A shows a structure in which a nitrogen-containing insulating layer **2120** is provided between the SOI layer **2102** and the bonding layer **2104**. The nitrogen-containing insulating layer **2120** is formed by stacking one or a plurality of films selected from a silicon nitride film, a silicon nitride oxide film, and a silicon oxynitride film. For example, the nitrogen-containing insulating layer **2120** can be formed by stacking a silicon oxynitride film and a silicon nitride oxide film from the SOI layer **2102** side. The bonding layer **2104** is provided in order to form a bond with the base substrate **2100**, whereas the nitrogen-containing insulating layer **2120** is preferably provided in order to prevent the SOI layer **2102** from being contaminated by diffusion of impurities such as mobile ions or moisture.

[0209] Note that here, a silicon oxynitride film corresponds to a film which contains much oxygen than nitrogen, and in the case where measurement is performed using Rutherford backscattering spectrometry (RBS) and hydrogen forward scattering (HFS), includes oxygen, nitrogen, silicon, and hydrogen at concentrations ranging from 50 to 70 at. %, 0.5 to 15 at. %, 25 to 35 at. %, and 0.1 to 10 at. %, respectively. Further, a silicon nitride oxide film corresponds to a film which contains much nitrogen than oxygen and includes oxygen, nitrogen, silicon, and hydrogen at concentrations ranging from 5 to 30 at. %, 20 to 55 at. %, 25 to 35 at. %, and 10 to 30 at. %, respectively, in the case where measurement is performed using RBS and HFS. Note that percentages of nitrogen, oxygen, silicon, and hydrogen fall within the ranges given above if the total number of atoms contained in the silicon oxynitride film or the silicon nitride oxide film is defined as 100 at. %.

[0210] FIG. **14**B shows a structure in which the base substrate **2100** is provided with the bonding layer **2104**. Between the base substrate **2100** and the bonding layer **2104**, the barrier layer **2105** is preferably provided. The silicon nitride layer **2105** is provided in order to prevent the SOI layer **2102** from being contaminated by diffusion of impurities such as mobile ions like alkali metal or alkaline earth metal from a glass substrate which is used as the base substrate **2100**. In addition, the SOI layer **2102** is provided with a silicon oxide film **2121**. This silicon oxide film **2121** forms a bond with the bonding layer **2104** to fix the SOI layer **2102** over the base substrate **2100**. The silicon oxide film **2121** is preferably formed by thermal oxidation. Alternatively, similarly to the bonding layer **2104**, the silicon oxide film **2121** may be formed by a chemical vapor deposition method using TEOS. Further alternatively, as the silicon oxide film **2121**, chemical oxide can be used. Chemical oxide can be formed by, for example, performing treatment on a surface of a semiconductor substrate by using ozone-containing water. Chemical oxide is preferable because it reflects flatness of the surface of the semiconductor substrate.

[0211] A method for manufacturing such an SOI substrate is described with reference to FIGS. **15**A to **15**C and FIG. **16**.

[0212] A semiconductor substrate **2101** shown in FIG. **15**A is cleaned, and ions which are accelerated by an electric field are introduced into reach a predetermined depth from the surface of the semiconductor substrate **2101** to form a ion-doping layer **2103**. Ions are introduced in consideration of the thickness of an SOI layer which is to be transferred to a base substrate. The thickness of the SOI layer is 5 to 500 nm, preferably 10 to 200 nm. Accelerating voltage for introducing ions into the semiconductor substrate **2101** is set in consideration of such a thickness. The ion-doping layer **2103** is formed by introducing ions of hydrogen, helium, or halogen typified by fluorine. In this case, it is preferable to introduce one kind of ions or plural kinds of ions of different mass numbers consisting of a single kind of atoms. In the case of introducing hydrogen ions, the hydrogen ions preferably include H^+, H_2^+, and H_3^+ ions with a high proportion of H_3^+ ions. With a high proportion of H_3^+ ions, introducing efficiency can be increased and introducing time can be shortened. With such a structure, separation can be easily performed.

[0213] Since it is necessary to introduce ions at a high dose, the surface of the semiconductor substrate **2101** is roughened in some cases. Therefore, a protective film against introducing of ions may be provided on a surface to which ions are introduced by using a silicon nitride film, a silicon nitride oxide film, or the like with a thickness of 50 to 200 nm.

[0214] Next, as shown in FIG. **15**B, a silicon oxide film is formed over a surface to which the base substrate is bonded as a bonding layer **2104**. As the silicon oxide film, a silicon oxide film formed by a chemical vapor deposition method using an organic silane gas as described above is preferably used. Alternatively, a silicon oxide film formed by a chemical vapor deposition method using a silane gas can be used. In film formation by a chemical vapor deposition method, film formation temperature at, for example, 350° C. or lower, at which degassing of the ion-doping layer **2103** formed in a single-crystal semiconductor substrate does not occur, is used. Heat treatment for separating an SOI layer from a single-crystal or polycrystalline semiconductor substrate is performed at a higher temperature than the film formation temperature.

[0215] FIG. **15**C shows a mode in which a surface of the base substrate **2100** and a surface of the semiconductor substrate **2101**, on which the bonding layer **2104** is formed are disposed in contact to be bonded to each other. The surfaces which are to be bonded are cleaned sufficiently. Then, when the base substrate **2100** and the bonding layer **2104** are disposed in contact, a bond is formed. This bond is formed by Van der Waals forces. When the base substrate **2100** and the semiconductor substrate **2101** are pressed against each other, a stronger bond can be formed by hydrogen bonding.

[0216] In order to form a favorable bond, the surfaces which are to form a bond may be activated. For example, the surfaces which are to form a bond are irradiated with an atomic beam or an ion beam. When an atomic beam or an ion beam is used, an inert gas neutral atom beam or inert gas ion beam of argon or the like can be used. Alternatively, plasma irradiation or radical treatment is performed. With such a surface treatment, a bond between different kinds of materials can be easily formed even at a temperature of 200 to 400° C.

[0217] After the base substrate **2100** and the semiconductor substrate **2101** are bonded to each other with the bonding layer **2104** interposed therebetween, heat treatment or pressure treatment is preferably performed. When heat treatment or pressure treatment is performed, bonding strength can be increased. Temperature of heat treatment is preferably lower than or equal to the upper temperature limit of the base substrate **2100** and temperature at which the elements included in the ion-doping layer **2103** by the above-described ion irradiation are removed. Pressure treatment is performed so that pressure is applied in a perpendicular direction to the bonded surface, in consideration of pressure resistance of the base substrate **2100** and the semiconductor substrate **2101**.

[0218] In FIG. **16**, after the base substrate **2100** and the semiconductor substrate **2101** are bonded to each other, heat treatment is performed to separate the semiconductor substrate **2101** from the base substrate **2100** with the ion-doping layer **2103** used as a cleavage plane. The heat treatment is preferably performed at a temperature ranging from the film formation temperature of the bonding layer **2104** to the upper temperature limit of the base substrate **2100**. When the heat treatment is performed at, for example, 400 to 600° C., the volume of fine voids formed in the ion-doping layer **2103** is changed, so that cleavage can be performed along the ion-doping layer **2103**. Since the bonding layer **2104** is bonded to the base substrate **2100**, the SOI layer **2102** having the same crystallinity as the semiconductor substrate **2101** remains over the base substrate **2100**.

[0219] FIGS. **17**A to **17**C show steps of forming an SOI layer with a bonding layer provided on the base substrate **2100** side. FIG. **17**A shows a step in which ions which are accelerated by an electric field are introduced into the semiconductor substrate **2101** which is provided with the silicon oxide film **2121** at a predetermined depth to form the ion-doping layer **2103**. Introducing of ions of hydrogen, helium, or a halogen typified by fluorine is performed similarly to the case shown in FIG. **15**A. When the silicon oxide film **2121** is formed on the surface of the semiconductor substrate **2101**, the surface of the semiconductor substrate **2101** can be prevented from being damaged by ion doping and from losing its flatness.

[0220] FIG. **17**B shows a step in which a surface of the base substrate **2100** provided with the silicon nitride layer **2105** and the bonding layer **2104** and the surface of the semiconductor substrate **2101**, on which the silicon oxide film **2121** is formed are disposed in contact to be bonded. A bond is formed when the bonding layer **2104** over the base substrate **2100** is disposed in contact with the silicon oxide film **2121** formed on the semiconductor substrate **2101**.

[0221] After that, as shown in FIG. **17**C, the semiconductor substrate **2101** is separated. Heat treatment for separating the semiconductor substrate **2101** is performed similarly to the case shown in FIG. **16**. In this manner, the SOI substrate shown in FIG. **14**B can be obtained.

[0222] In this manner, in accordance with this mode, even if a substrate with an upper temperature limit of 700° C. or lower, such as a glass substrate, is used as the base substrate **2100**, the SOI layer **2102** having strong adhesiveness of a bonded portion can be obtained. As the base substrate **2100**, any of various glass substrates which are used in the electronics industry and are referred to as non-alkali glass substrates, such as aluminosilicate glass substrates, aluminoborosilicate glass substrates, and barium borosilicate glass substrates can be used. That is, a single-crystal semiconductor layer can be formed over a substrate which is longer than one meter on a side. When such a large-area substrate is used, not only a display device such as a liquid crystal display but also a semiconductor integrated circuit can be manufactured.

[0223] FIGS. **22**A to **23**B show steps of forming an SOI layer with a BOX layer **2122** provided on the semiconductor substrate **2101**. FIG. **22**A shows a step in which ions which are accelerated by an electric field are introduced into the semiconductor substrate **2101** which is provided with the BOX layer **2122** to reach a predetermined depth to form the ion-doping layer **2103**. Introducing of ions of hydrogen, helium, or a halogen typified by fluorine is performed similarly to the case shown in FIG. **20**A. Here, a peak position in ion distribution is set to be in the BOX layer **2122**. That is, the ion-doping layer **2103** is provided in the BOX layer **2122**.

[0224] FIG. **22**B shows a step of forming a silicon oxide film over a surface to which the base substrate is bonded as a bonding layer **2104**. As the silicon oxide film, a silicon oxide film formed by a chemical vapor deposition method using an organic silane gas as described above is preferably used. Alternatively, a silicon oxide film formed by a chemical vapor deposition method using a silane gas can be used. In film formation by a chemical vapor deposition method, film formation temperature at, for example, 350° C. or lower, at which degassing of the ion-doping layer **2103** formed in a single-crystal semiconductor substrate does not occur, is used. Heat treatment for separating an SOI layer from a single-crystal or polycrystalline semiconductor substrate is performed at a higher temperature than the film formation temperature.

[0225] FIG. 22C shows a step in which a surface of the base substrate 2100 and a surface of the semiconductor substrate 2101, on which the bonding layer 2104 is formed are disposed in contact to be bonded to each other. The surfaces which are to be bonded are cleaned sufficiently. Then, when the base substrate 2100 and the bonding layer 2104 are disposed in contact, a bond is formed. This bond is formed by Van der Waals forces. When the base substrate 2100 and the semiconductor substrate 2101 are pressed against each other, a stronger bond can be formed by hydrogen bonding.

[0226] In order to form a favorable bond, the surfaces which are to form a bond may be activated. For example, the surfaces which are to form a bond are irradiated with an atomic beam or an ion beam. When an atomic beam or an ion beam is used, an inert gas neutral atom beam or inert gas ion beam of argon or the like can be used. Alternatively, plasma irradiation or radical treatment is performed. With such a surface treatment, a bond between different kinds of materials can be easily formed even at a temperature of 200 to 400° C.

[0227] After the base substrate 2100 and the semiconductor substrate 2101 are bonded to each other with the bonding layer 2104 interposed therebetween, heat treatment or pressure treatment is preferably performed. When heat treatment or pressure treatment is performed, bonding strength can be increased. Temperature of heat treatment is preferably lower than or equal to the upper temperature limit of the base substrate 2100. Pressure treatment is performed so that pressure is applied in a perpendicular direction to the bonded surface, in consideration of pressure resistance of the base substrate 2100 and the semiconductor substrate 2101.

[0228] In FIG. 23A, after the base substrate 2100 and the semiconductor substrate 2101 are bonded to each other, heat treatment is performed to separate the semiconductor substrate 2101 from the base substrate 2100 with the ion-doping layer 2103 used as a cleavage plane. The heat treatment is preferably performed at a temperature ranging from the film formation temperature of the bonding layer 2104 to the upper temperature limit of the base substrate 2100. When the heat treatment is performed at, for example, 400 to 600° C., the volume of fine voids formed in the ion-doping layer 2103 is changed, so that cleavage can be performed along the ion-doping layer 2103. Since the bonding layer 2104 is bonded to the base substrate 2100, the SOI layer 2102 having the same crystallinity as the semiconductor substrate 2101 remains over the base substrate 2100.

[0229] FIG. 23B shows a step of removing the BOX layer 2122 which remains over the semiconductor substrate 2101 by wet etching using dilute hydrofluoric acid.

[0230] In the steps shown in FIGS. 22A to 23B, a dangling bond, a crystal defect, or the like of a separated surface are generated in the BOX layer 2122. That is, a dangling bond, a crystal defect, or the like are not generated in a semiconductor layer included in the semiconductor substrate 2101. In addition, when the BOX layer 2122 is removed, the semiconductor layer can be prevented from losing uniformity of the film thickness.

[0231] Subsequently, a semiconductor device using an SOI substrate is described with reference to FIGS. 18A to 18E and FIGS. 19A and 19B. In FIG. 18A, the SOI layer is provided over the base substrate 2100 with the bonding layer 2104 interposed therebetween. Over the SOI layer 2102, the silicon nitride layer 2105 and a silicon oxide layer 2106 are formed in accordance with an element formation region. The silicon oxide layer 2106 is used as a hard mask when the SOI layer 2102 is etched for element isolation. The silicon nitride layer 2105 functions as an etching stopper.

[0232] The thickness of the SOI layer 2102 is 5 to 500 nm, preferably 10 to 200 nm. The thickness of the SOI layer 2102 can be set as appropriate by controlling the depth of the weakened layer 2103 shown in FIGS. 15A to 15C. In order to control the threshold voltage, a p-type impurity such as boron, aluminum, or gallium is added to the SOI layer 2102. For example, boron may be added as a p-type impurity at a concentration of 5×10^{16} to 1×10^{18} cm^{-3}.

[0233] FIG. 18B shows a step of etching the SOI layer 2102 and the bonding layer 2104 by using the silicon oxide layer 2106 as a mask. Exposed end surfaces of the SOI layer 2102 and the bonding layer 2104 are nitrided by plasma treatment. By this nitridation treatment, a silicon nitride layer 2107 is formed at least at a peripheral end portion of the SOI layer 2102. The silicon nitride layer 2107 has insulating properties and has an effect of preventing leakage current from flowing through an end surface of the SOI layer 2102. In addition, since the silicon nitride layer 2107 has resistance to oxidation, it can prevent an oxide film from growing from the end surface into a bird's beak between the SOI layer 2102 and the bonding layer 2104.

[0234] FIG. 18C shows a step of depositing an element isolation insulating layer 2108. As the element isolation insulating layer 2108, a silicon oxide film is deposited by a chemical vapor deposition method by using TEOS. The element isolation insulating layer 2108 is deposited thickly so that the SOT layer 2102 is buried.

[0235] FIG. 18D shows a step of removing the element isolation insulating layer 2108 to expose the silicon nitride layer 2105. This removing step can be performed by dry etching, or may be performed by chemical mechanical polishing. The silicon nitride layer 2105 functions as an etching stopper. The element isolation insulating layer 2108 remains so as to be embedded between the SOI layers 2102. After that, the silicon nitride layer 2105 is removed.

[0236] In FIG. 18E, after the SOI layer 2102 is exposed, a gate insulating layer 2109, a gate electrode 2110, and a sidewall insulating layer 2111 are formed, and a first impurity region 2112 and a second impurity region 2113 are formed. An insulating layer 2114 is formed using silicon nitride and is used as a hard mask when the gate electrode 2110 is etched.

[0237] In FIG. 19A, an interlayer insulating layer 2115 is formed. As the interlayer insulating layer 2115, a borophosphosilicate glass (BPSG) film is formed and then planarized by reflow. Alternatively, a silicon oxide film may be formed using TEOS and then planarized by chemical mechanical polishing. In planarization treatment, the insulating layer 2114 over the gate electrode 2110 functions as an etching stopper. A contact hole 2116 is formed in the interlayer insulating layer 2115. The contact hole 2116 is formed in a self-aligned manner by utilizing the sidewall insulating layer 2111.

[0238] After that, as shown in FIG. 19B, a contact plug 2117 is formed by CVD by using tungsten hexafluoride. Further, an insulating layer 2118 is formed; an opening is formed in accordance with the contact plug 2117; and a wiring 2119 is provided. The wiring 2119 is formed using aluminum or an aluminum alloy and is provided with upper and lower metal films of molybdenum, chromium, titanium, or the like as barrier metal films.

[0239] In this manner, a field effect transistor can be manufactured using the SOI layer 2102 which is bonded to the base substrate 2100. Since the SOI layer 2102 in accordance with this mode is a single-crystal semiconductor with uniform crystal orientation, high-performance field-effect transistors which are uniform can be obtained. That is, variation in values of important transistor characteristics, such as the threshold voltage and mobility can be suppressed, so that high performance such as high mobility can be achieved.

[0240] Note that although this embodiment mode is described with reference to various drawings, the contents (or may be part of the contents) described in each drawing can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in another drawing. Further, even more drawings can be formed by combining each part with another part in the above-described drawings.

[0241] Similarly, the contents (or may be part of the contents) described in each drawing of this embodiment mode can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in a drawing in another embodiment mode. Further, even more drawings can be formed by combining each part with part of another embodiment mode in the drawings of this embodiment mode.

[0242] Note that this embodiment mode shows an example of an embodied case of the contents (or may be part of the contents) described in other embodiment modes, an example of slight transformation thereof, an example of partial modification thereof, an example of improvement thereof, an example of detailed description thereof, an application example thereof, an example of related part thereof, or the like. Therefore, the contents described in other embodiment modes can be freely applied to, combined with, or replaced with this embodiment mode.

Embodiment Mode 5

[0243] A method for manufacturing an SOI substrate, which is different from that of Embodiment Mode **4**, is described with reference to FIGS. **20**A to **20**C and FIGS. **21**A and **21**B. In FIG. **20**A, a silicon oxynitride film **2305** is formed over a single-crystal silicon substrate **2301** from which a natural oxide film has been removed with a thickness of 100 nm by plasma CVD by using an SiH_4 gas and an N_2O gas. In addition, a silicon nitride oxide film **2306** is formed with a thickness of 50 nm by using an SiH_4 gas and an N_2O gas.

[0244] Then, as shown in FIG. **20**B, hydrogen ions are introduced from the surface of the silicon nitride oxide film **2306** by using an ion doping apparatus. The ion doping apparatus is an apparatus used to introduce an ionized gas which is accelerated by an electric field into a substrate without mass separation. When this apparatus is used, ion doping can be performed with high efficiency and at high dose even in the case of a large-area substrate. In this example, hydrogen is ionized to form a ion-doping layer **2303** in the single-crystal silicon substrate **2301**. Ion doping is performed with accelerated voltage of 80 kV and dose of $2\times10^{16}/cm^2$.

[0245] In this case, it is preferable to introduce one kind of ions or plural kinds of ions of different mass numbers consisting of a single kind of atoms. In the case of introducing hydrogen ions, the hydrogen ions preferably include H^+, H_2^+, and H_3^+ ions with a high proportion of H_3^+ ions of about 80%. When a large number of higher-order ions with small mass numbers as described above are contained in the single-crystal silicon substrate **2301**, cleavage of the ion-doping layer **2303** can be easily performed in a heat treatment step. In this case, when the silicon nitride oxide film **2306** and the silicon oxynitride film **2305** are provided on the ion-doping surface of the single-crystal silicon substrate **2301**, the surface of the single-crystal silicon substrate **2301** can be prevented from being roughened by ion doping.

[0246] Next, as shown in FIG. **20**C, a silicon oxide film **2304** is formed over the silicon nitride oxide film **2306**. The silicon oxide film **2304** is formed with a thickness of 50 nm by plasma CVD by using tetraethoxysilane (TEOS) (chemical formula: $Si(OC_2H_5)_4$) and an oxygen gas. The film formation temperature is set to be 350° C. or lower so that hydrogen is not removed from the ion-doping layer **2303**.

[0247] FIG. **20**A shows a step of superposing a glass substrate **2300** which is subjected to ultrasonic cleaning by using ozone-containing water and the single-crystal silicon substrate **2301** on each other with the silicon oxide film **2304** interposed therebetween, and pressing the substrates against each other to bond the substrates. After that, heat treatment is performed at 400° C. for 10 minutes in a nitrogen atmosphere and then at 500° C. for two hours, and the temperature is held constant at 400° C. for several hours and then gradually lowered to room temperature. Accordingly, a crack can be formed in the ion-doping layer **2303** to separate the single-crystal silicon substrate **2301**, and the silicon oxide film **2304** and the glass substrate **2300** can be bonded firmly.

[0248] In this manner, a single-crystal silicon layer **2302** can be formed over the glass substrate **2300** at a temperature at which the glass substrate **2300** is not distorted. The single-crystal silicon layer **2302** manufactured in this example is firmly bonded to the glass substrate **2300**, so that there is no separation of the silicon layer even when a tape peel test is performed. That is, a single-crystal silicon layer can be provided over any of various glass substrates which are used in the electronics industry and are referred to as non-alkali glass substrates, such as aluminosilicate glass substrates, aluminoborosilicate glass substrates, and barium borosilicate glass substrates can be used, and various integrated circuits and display devices can be manufactured by using a substrate which is longer than one meter on a side.

[0249] Note that although this embodiment mode is described with reference to various drawings, the contents (or may be part of the contents) described in each drawing can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in another drawing. Further, even more drawings can be formed by combining each part with another part in the above-described drawings.

[0250] Similarly, the contents (or may be part of the contents) described in each drawing of this embodiment mode can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in a drawing in another embodiment mode. Further, even more drawings can be formed by combining each part with part of another embodiment mode in the drawings of this embodiment mode.

[0251] Note that this embodiment mode shows an example of an embodied case of the contents (or may be part of the contents) described in other embodiment modes, an example of slight transformation thereof, an example of partial modification thereof, an example of improvement thereof, an example of detailed description thereof, an application example thereof, an example of related part thereof, or the like. Therefore, the contents described in other embodiment modes can be freely applied to, combined with, or replaced with this embodiment mode.

Embodiment Mode 6

[0252] In this embodiment mode, a pixel structure of a display device is described. In particular, a pixel structure of a display device using an organic EL element is described.

[0253] FIG. **40**A is an example of a top view (a layout diagram) of a pixel which includes two transistors. FIG. **40**B is an example of a cross-sectional view taken along X-X' in FIG. **40**A.

[0254] FIGS. **40**A and **40**B shows a first transistor **60105**, a first wiring **60106**, a second wiring **60107**, a second transistor **60108**, a third wiring **60111**, a counter electrode **60112**, a capacitor **60113**, a pixel electrode **60115**, a partition wall **60116**, an organic conductive film **60117**, an organic thin film **60118**, and a substrate **60119**. Note that it is preferable that the first transistor **60105**, the first wiring **60106**, the second wiring **60107**, the second transistor **60108**, and the third wiring **60111** are used as a switching transistor, a gate signal line, a source signal line, a driving transistor, and a current supply line, respectively.

[0255] A gate electrode of the first transistor **60105** is electrically connected to the first wiring **60106**. One of a source electrode and a drain electrode of the first transistor **60105** is electrically connected to the second wiring **60107**. The other of the source electrode and the drain electrode of the first transistor **60105** is electrically connected to a gate electrode of the second transistor **60108** and one of electrodes of the capacitor **60113**. Note that the gate electrode of the first transistor **60105** includes a plurality of gate electrodes. Thus, leakage current in an off state of the first transistor **60105** can be reduced.

[0256] One of a source electrode and a drain electrode of the second transistor **60108** is electrically connected to the third wiring **60111**. The other of the source electrode and the drain electrode of the second transistor **60108** is electrically connected to the pixel electrode **60115**. Thus, current flowing through the pixel electrode **60115** can be controlled by the second transistor **60108**.

[0257] The organic conductive film **60117** is provided over the pixel electrode **60115**, and the organic thin film **60118** (an organic compound layer) is provided thereover. The counter electrode **60112** is provided over the organic thin film **60118** (the organic compound layer). Note that the counter electrode **60112** may be formed over the entire surface so as to be connected to all the pixels in common, or may be patterned using a shadow mask or the like.

[0258] Light emitted from the organic thin film **60118** (the organic compound layer) is transmitted through either the pixel electrode **60115** or the counter electrode **60112**.

[0259] In FIG. **40**B, the case where light is emitted on the pixel electrode side, i.e., a side over which the transistor and the like are formed is referred to as bottom emission, and the case where light is emitted on the counter electrode side is referred to as top emission.

[0260] In the case of bottom emission, it is preferable to form the pixel electrode **60115** using a light-transmitting conductive film. On the other hand, in the case of top emission, it is preferable to form the counter electrode **60112** using a light-transmitting conductive film.

[0261] In a light-emitting device for color display, EL elements having respective light emission colors of R, G, and B may be separately formed, or an EL element having a single color may be formed over the entire surface and light emission of R, G, and B is obtained by using a color filter.

[0262] Note that the structures shown in FIGS. **40**A and **40**B are just examples, and various structures can be employed for a pixel layout, a cross-sectional structure, a stacking order of electrodes of an EL element, and the like, as well as the structures shown in FIGS. **40**A and **40**B. Further, as a light-emitting layer, various elements such as a crystalline element like an LED, and an element formed using an inorganic thin film can be used as well as the element formed using the organic thin film shown in the drawing.

[0263] Note that although this embodiment mode is described with reference to various drawings, the contents (or may be part of the contents) described in each drawing can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in another drawing. Further, even more drawings can be formed by combining each part with another part in the above-described drawings.

[0264] Similarly, the contents (or may be part of the contents) described in each drawing of this embodiment mode can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in a drawing in another embodiment mode. Further, even more drawings can be formed by combining each part with part of another embodiment mode in the drawings of this embodiment mode.

[0265] Note that this embodiment mode shows an example of an embodied case of the contents (or may be part of the contents) described in other embodiment modes, an example of slight transformation thereof, an example of partial modification thereof, an example of improvement thereof, an example of detailed description thereof, an application example thereof, an example of related part thereof, or the like. Therefore, the contents described in other embodiment modes can be freely applied to, combined with, or replaced with this embodiment mode.

Embodiment Mode 7

[0266] In this embodiment mode, examples of electronic devices are described.

[0267] FIG. **24** shows a display panel module in which a display panel **900101** and a circuit board **900111** are combined. The display panel **900101** includes a pixel portion **900102**, a scan line driver circuit **900103**, and a signal line driver circuit **900104**. The circuit board **900111** is provided with a control circuit **900112**, a signal dividing circuit **900113**, and the like, for example. The display panel **900101** and the circuit board **900111** are connected by a connection wiring **900114**. As the connection wiring **900114**, an FPC or the like can be used.

[0268] In the display panel **900101**, the pixel portion **900102** and part of peripheral driver circuits (a driver circuit having low operation frequency among a plurality of driver circuits) may be formed over the same substrate by using transistors, and another part of the peripheral driver circuits (a driver circuit having high operation frequency among the plurality of driver circuits) may be formed over an IC chip. The IC chip may be mounted on the display panel **900101** by COG (chip on glass) or the like. Thus, the area of the circuit board **900111** can be reduced, so that a small display device can be obtained. Alternatively, the IC chip may be mounted on the display panel **900101** by using TAB (tape automated bonding) or a printed circuit board. Thus, the area of the circuit board **900111** can be reduced, so that a display device with a narrower frame can be obtained.

[0269] For example, in order to reduce power consumption, a pixel portion may be formed over a glass substrate by using transistors, and all peripheral circuits may be formed over an IC chip. The IC chip may be mounted on a display panel by COG or TAB.

[0270] A television receiver can be completed with the display panel module shown in FIG. **24**. FIG. **25** is a block diagram showing a main structure of a television receiver. A tuner **900201** receives a video signal and an audio signal. The video signal is processed by a video signal amplifier circuit **900202**, a video signal processing circuit **900203** for converting a signal output from the video signal amplifier circuit

900202 into a color signal corresponding to each color of red, green, and blue, and a control circuit **900212** for converting the video signal into a signal which meets input specifications of a driver circuit. The control circuit **900212** outputs signals to a scan line drive circuit **900214** and a signal line drive circuit **900215**. In the case of digital driving, a structure may be used in which a signal dividing circuit **900213** is provided on the signal line side and an input digital signal is divided into m (m is a positive integer) pieces to be supplied. The scanning lines drive circuit **900214** and the signal line drive circuit **900215** are electrically connected to a display panel **900216**.

[0271] Among the signals received by the tuner **900201**, the audio signal is transmitted to an audio signal amplifier circuit **900205**, and output thereof is supplied to a speaker **900207** through an audio signal processing circuit **900206**. A control circuit **900208** receives control information on a receiving station (reception frequency) and sound volume from an input portion **900209**, and transmits a signal to the tuner **900201** or the audio signal processing circuit **900206**.

[0272] FIG. **26**A shows a television receiver incorporated with a display panel module which is different from that of FIG. **25**. In FIG. **26**A, a display screen **900302** stored in a housing **900301** is formed using the display panel module. Note that speakers **900303**, operation switches **900304**, an input means **900305**, a sensor **900306** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **900307**, or the like may be provided as appropriate.

[0273] FIG. **26**B shows a television receiver, only a display of which can be carried wirelessly. A battery and a signal receiver are incorporated in a housing **900312**. The battery drives a display portion **900313**, speaker portions **900317**, a sensor **900319** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), and a microphone **900320**. Electricity can be repeatedly stored in the battery by a charger **900310**. The charger **900310** can transmit and receive a video signal and can transmit the video signal to the signal receiver of the display. The device shown in FIG. **26**B is controlled by operation keys **900316**. Alternatively, the device shown in FIG. **26**B can transmit a signal to the charger **900310** by operating the operation keys **900316**. That is, the device may be an image audio two-way communication device. Further alternatively, the device shown in FIG. **26**B can transmit a signal to the charger **900310** by operating the operation keys **900316**, and can control communication of another electronic device when the electronic device is made to receive a signal which can be transmitted from the charger **900310**. That is, the device may be a general-purpose remote control device. Note that an input means **900318** or the like may be provided as appropriate. Note that the contents (or may be part of the contents) described in each drawing of this embodiment mode can be applied to the display portion **900313**.

[0274] FIG. **27**A shows a module in which a display panel **900401** and a printed wiring board **900402** are combined. The display panel **900401** may be provided with a pixel portion **900403** including a plurality of pixels, a first scan line driver circuit **900404**, a second scan line driver circuit **900405**, and a signal line driver circuit **900406** which supplies a video signal to a selected pixel.

[0275] The printed wiring board **900402** is provided with a timing controller **900407**, a central processing unit (CPU) **900408**, a memory **900409**, a power supply circuit **900410**, an audio processing circuit **900411**, a transmitting/receiving circuit **900412**, and the like. The printed wiring board **900402** and the display panel **900401** are connected by a flexible printed circuit (FPC) **900413**. The flexible printed circuit (FPC) **900413** may be provided with a storage capacitor, a buffer circuit, or the like so as to prevent noise on power supply voltage or a signal, and increase in rise time of a signal. Note that the timing controller **900407**, the audio processing circuit **900411**, the memory **900409**, the central processing unit (CPU) **900408**, the power supply circuit **900410**, and the like can be mounted on the display panel **900401** by using a COG (chip on glass) method. When a COG method is used, the size of the printed wiring board **900402** can be reduced.

[0276] Various control signals are input and output through an interface (I/F) portion **900414** provided for the printed wiring board **900402**. In addition, an antenna port **900415** for transmitting and receiving a signal to/from an antenna is provided for the printed wiring board **900402**.

[0277] FIG. **27**B is a block diagram of the module shown in FIG. **27**A. The module includes a VRAM **900416**, a DRAM **900417**, a flash memory **900418**, and the like as the memory **900409**. The VRAM **900416** stores data on an image displayed on the panel. The DRAM **900417** stores video data or audio data. The flash memory **900418** stores various programs.

[0278] The power supply circuit **900410** supplies electric power for operating the display panel **900401**, the timing controller **900407**, the central processing unit (CPU) **900408**, the audio processing circuit **900411**, the memory **900409**, and the transmitting/receiving circuit **900412**. Note that depending on panel specifications, the power supply circuit **900410** is provided with a current source in some cases.

[0279] The central processing unit (CPU) **900408** includes a control signal generation circuit **900420**, a decoder **900421**, a register **900422**, an arithmetic circuit **900423**, a RAM **900424**, an interface (I/F) portion **900419** for the central processing unit (CPU) **900408**, and the like. Various signals which are input to the central processing unit (CPU) **900408** through the interface (I/F) portion **900414** are once stored in the register **900422**, and then input to the arithmetic circuit **900423**, the decoder **900421**, and the like. The arithmetic circuit **900423** performs operation based on the input signal so as to designate a location to which various instructions are sent. On the other hand, the signal input to the decoder **900421** is decoded and input to the control signal generation circuit **900420**. The control signal generation circuit **900420** generates a signal including various instructions based on the input signal, and transmits the signal to locations designated by the arithmetic circuit **900423**, specifically the memory **900409**, the transmitting/receiving circuit **900412**, the audio processing circuit **900411**, the timing controller **900407**, and the like.

[0280] The memory **900409**, the transmitting/receiving circuit **900412**, the audio processing circuit **900411**, and the timing controller **900407** operate in accordance with respective instructions. Operations thereof are briefly described below.

[0281] A signal input from an input means **900425** is transmitted to the central processing unit (CPU) **900408** mounted on the printed wiring board **900402** through the interface (I/F) portion **900414**. The control signal generation circuit **900420**

converts image data stored in the VRAM **900416** into a predetermined format based on the signal transmitted from the input means **900425** such as a pointing device or a keyboard, and transmits the converted data to the timing controller **900407**.

[0282] The timing controller **900407** performs data processing of the signal including the image data transmitted from the central processing unit (CPU) **900408** in accordance with the panel specifications, and supplies the signal to the display panel **900401**. The timing controller **900407** generates an Hsync signal, a Vsync signal, a clock signal (CLK), alternating voltage (AC Cont), and a switching signal L/R based on power supply voltage input from the power supply circuit **900410** or various signals input from the central processing unit (CPU) **900408**, and supplies the signals to the display panel **900401**.

[0283] The transmitting/receiving circuit **900412** processes a signal which is transmitted and received as a radio wave by an antenna **900428**. Specifically, the transmitting/receiving circuit **900412** may include a high-frequency circuit such as an isolator, a band pass filter, a VCO (voltage controlled oscillator), an LPF (low pass filter), a coupler, or a balun. Among signals transmitted and received by the transmitting/receiving circuit **900412**, a signal including audio information is transmitted to the audio processing circuit **900411** in accordance with an instruction from the central processing unit (CPU) **900408**.

[0284] The signal including the audio information, which is transmitted in accordance with the instruction from the central processing unit (CPU) **900408**, is demodulated into an audio signal by the audio processing circuit **900411** and is transmitted to a speaker **900427**. An audio signal transmitted from a microphone **900426** is modulated by the audio processing circuit **900411** and is transmitted to the transmitting/receiving circuit **900412** in accordance with an instruction from the central processing unit (CPU) **900408**.

[0285] The timing controller **900407**, the central processing unit (CPU) **900408**, the power supply circuit **900410**, the audio processing circuit **900411**, and the memory **900409** can be mounted as a package of this embodiment mode.

[0286] Needless to say, the present invention is not limited to the television receiver, and can be applied to various uses particularly as a large display medium such as an information display board at a train station, an airport, or the like, or an advertisement display board on the street, as well as a monitor of a personal computer.

[0287] Next, a structural example of a mobile phone is described with reference to FIG. **28**.

[0288] A display panel **900501** is incorporated in a housing **900530** so as to be detachable. The shape and the size of the housing **900530** can be changed as appropriate in accordance with the size of the display panel **900501**. The housing **900530** to which the display panel **900501** is fixed is fitted into a printed circuit board **900531** and is assembled as a module.

[0289] The display panel **900501** is connected to the printed wiring board **900531** through an FPC **900513**. The printed wiring board **900531** is provided with a speaker **900532**, a microphone **900533**, a transmitting/receiving circuit **900534**, a signal processing circuit **900535** including a CPU, a timing controller, and the like, and a sensor **900541** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray). Such a module, an input means **900536**, and a battery **900537** are combined and stored in a housing **900539**. An antenna **900540** is provided with the housing **900539**. A pixel portion of the display panel **900501** is provided so as to be seen from an opening window formed in the housing **900539**.

[0290] In the display panel **900501**, the pixel portion and part of peripheral driver circuits (a driver circuit having low operation frequency among a plurality of driver circuits) may be formed over the same substrate by using transistors, and another part of the peripheral driver circuits (a driver circuit having high operation frequency among the plurality of driver circuits) may be formed over an IC chip. The IC chip may be mounted on the display panel **900501** by COG (chip on glass). Alternatively, the IC chip may be connected to a glass substrate by using TAB (tape automated bonding) or a printed circuit board. With such a structure, power consumption of the mobile phone can be reduced, so that operation time of the mobile phone per charge can be extended. In addition, cost of the mobile phone can be reduced.

[0291] The mobile phone shown in FIG. **28** has various functions such as a function of displaying a variety of information (e.g., a still image, a moving image, and a text image); a function of displaying a calendar, a date, time, or the like on a display portion; a function of operating or editing the information displayed on the display portion; a function of controlling processing by a variety of software (programs); a wireless communication function; a function of communicating with another mobile phone, a fixed phone, or an audio communication device by using the wireless communication function; a function of connecting with a variety of computer networks by using the wireless communication function; a function of transmitting or receiving a variety of data by using the wireless communication function; a function of operating a vibrator in accordance with incoming call, reception of data, or an alarm; and a function of generating a sound in accordance with incoming call, reception of data, or an alarm. Note that functions of the mobile phone shown in FIG. **28** are not limited to them, and the mobile phone can have various functions.

[0292] In a mobile phone shown in FIG. **29**, a main body (A) **900601** which is provided with an operation switch **900604**, a microphone **900605**, an input means **900612** and the like is connected to a main body (B) **900602** which is provided with a display panel (A) **900608**, a display panel (B) **900609**, a speaker **900606**, a sensor **900611** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), and the like by using a hinge **900610** so that the mobile phone can be opened and closed. The display panel (A) **900608** and the display panel (B) **900609** are stored in a housing **900603** of the main body (B) **900602** together with a circuit board **900607**. Each of pixel portions of the display panel (A) **900608** and the display panel (B) **900609** is provided so as to be seen from an opening window formed in the housing **900603**.

[0293] Specifications of the display panel (A) **900608** and the display panel (B) **900609**, such as the number of pixels, can be set as appropriate in accordance with functions of a mobile phone **900600**. For example, the display panel (A) **900608** can be used as a main screen and the display panel (B) **900609** can be used as a sub screen.

[0294] Each of the mobile phones of this embodiment mode can be changed in various modes depending on functions or applications thereof. For example, it may be a camera-equipped mobile phone by incorporating an imaging element in a portion of the hinge **900610**. When the operation switch **900604**, the display panel (A) **900608**, and the display panel (B) **900609** are stored in one housing, the above-described advantageous effects can be obtained. Further, similar advantageous effects can be obtained when the structure of this embodiment mode is applied to an information display terminal provided with a plurality of display portions.

[0295] The mobile phone shown in FIG. **29** has various functions such as a function of displaying a variety of information (e.g., a still image, a moving image, and a text image); a function of displaying a calendar, a date, time, or the like on a display portion; a function of operating or editing the information displayed on the display portion; a function of controlling processing by a variety of software (programs); a wireless communication function; a function of communicating with another mobile phone, a fixed phone, or an audio communication device by using the wireless communication function; a function of connecting with a variety of computer networks by using the wireless communication function; a function of transmitting or receiving a variety of data by using the wireless communication function; a function of operating a vibrator in accordance with incoming call, reception of data, or an alarm; and a function of generating a sound in accordance with incoming call, reception of data, or an alarm. Note that functions of the mobile phone shown in FIG. **29** are not limited to them, and the mobile phone can have various functions.

[0296] The contents (or may be part of the contents) described in each drawing of this embodiment mode can be applied to various electronic devices. Specifically, the contents (or may be part of the contents) described in each drawing of this embodiment mode can be applied to display portions of electronic devices. Examples of such electronic devices are cameras such as a video camera and a digital camera, a goggle-type display, a navigation system, an audio reproducing device (e.g., a car audio component or an audio component), a computer, a game machine, a portable information terminal (e.g., a mobile computer, a mobile phone, a mobile game machine, or an electronic book), an image reproducing device provided with a recording medium (specifically, a device which reproduces a recording medium such as a digital versatile disc (DVD) and has a display for displaying a reproduced image), and the like.

[0297] FIG. **30**A shows a display, which includes a housing **900711**, a support base **900712**, a display portion **900713**, an input means **900714**, a sensor **900715** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **900716**, a speaker **900717**, operation keys **900718**, an LED lamp **900719**, and the like. The display shown in FIG. **30**A has a function of displaying a variety of information (e.g., a still image, a moving image, and a text image) on the display portion. Note that the display shown in FIG. **35**A is not limited to having this function, and can have various functions.

[0298] FIG. **30**B shows a camera, which includes a main body **900731**, a display portion **900732**, an image receiving portion **900733**, operation keys **900734**, an external connection port **900735**, a shutter button **900736**, an input means **900737**, a sensor **900738** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **900739**, a speaker **900740**, an LED lamp **900741**, and the like. The camera shown in FIG. **30**B has a function of photographing a still image and a moving image; a function of automatically correcting the photographed image (the still image or the moving image); a function of storing the photographed image in a recording medium (provided outside or incorporated in the camera); and a function of displaying the photographed image on the display portion. Note that the camera shown in FIG. **30**B is not limited to having these functions, and can have various functions.

[0299] FIG. **30**C shows a computer, which includes a main body **900751**, a housing **900752**, a display portion **900753**, a keyboard **900754**, an external connection port **900755**, a pointing device **900756**, an input means **900757**, a sensor **900758** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **900759**, a speaker **900760**, an LED lamp **900761**, a reader/writer **900762**, and the like. The computer shown in FIG. **30**C has a function of displaying a variety of information (e.g., a still image, a moving image, and a text image) on the display portion; a function of controlling processing by a variety of software (programs); a communication function such as wireless communication or wire communication; a function of connecting to various computer networks by using the communication function; and a function of transmitting or receiving a variety of data by using the communication function. Note that the computer shown in FIG. **30**C is not limited to having these functions, and can have various functions.

[0300] FIG. **37**A shows a mobile computer, which includes a main body **901411**, a display portion **901412**, a switch **901413**, operation keys, **901414**, an infrared port **901415**, an input means **901416**, a sensor **901417** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **901418**, a speaker **901419**, an LED lamp **901420**, and the like. The mobile computer shown in FIG. **37**A has a function of displaying a variety of information (e.g., a still image, a moving image, and a text image) on the display portion; a touch panel function on the display portion; a function of displaying a calendar, a date, the time, and the like on the display portion; a function of controlling processing by a variety of software (programs); a wireless communication function; a function of connecting to various computer networks by using the wireless communication function; and a function of transmitting or receiving a variety of data by using the wireless communication function. Note that the mobile computer shown in FIG. **37**A is not limited to having these functions, and can have various functions.

[0301] FIG. **37**B shows a portable image reproducing device provided with a recording medium (e.g., a DVD reproducing device), which includes a main body **901431**, a housing **901432**, a display portion A **901433**, a display portion B **901434**, a recording medium (e.g., DVD) reading portion **901435**, operation keys **901436**, a speaker portion **901437**, an input means **901438**, a sensor **901439** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **901440**, an LED lamp **901441**, and the like. The display portion A **901433** can mainly display image information, and the display portion B **901434** can mainly display text information.

[0302] FIG. **37**C shows a goggle-type display, which includes a main body **901451**, a display portion **901452**, an earphone **901453**, a support portion **901454**, an input means **901455**, a sensor **901456** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **901457**, a speaker **901458**, a LED lamp **901459** and the like. The goggle-type display shown in FIG. **37**C has a function of displaying an image (e.g., a still image, a moving image, or a text image) which is externally obtained on the display portion. Note that the goggle-type display shown in FIG. **37**C is not limited to having these functions, and can have various functions.

[0303] FIG. **38**A shows a portable game machine, which includes a housing **901511**, a display portion **901512**, speaker portions **901513**, operation keys **901514**, a recording medium insert portion **901515**, an input means **901516**, a sensor **901517** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **901518**, an LED lamp **901519**, and the like. The portable game machine shown in FIG. **28**A has a function of reading a program or data stored in the recording medium to display on the display portion, and a function of sharing information with another portable game machine by wireless communication. Note that the portable game machine shown in FIG. **38**A is not limited to having these functions, and can have various functions.

[0304] FIG. **38**B shows a digital camera having a television reception function, which includes a main body **901531**, a display portion **901532**, operation keys **901533**, a speaker **901534**, a shutter button **901535**, an image receiving portion **901536**, an antenna **901537**, an input means **901538**, a sensor **901539** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **901540**, an LED lamp **901541**, and the like. The digital camera having the television reception function shown in FIG. **38**B has a function of photographing a still image and a moving image; a function of automatically correcting the photographed image; a function of obtaining a variety of information from the antenna; a function of storing the photographed image or the information obtained from the antenna; and a function of displaying the photographed image or the information obtained from the antenna on the display portion. Note that the digital camera having the television reception function shown in FIG. **38**B is not limited to having these functions, and can have various functions.

[0305] FIG. **39** shows a portable game machine, which includes a housing **901611**, a first display portion **901612**, a second display portion **901613**, speaker portions **901614**, operation keys **901615**, a recording medium insert portion **901616**, an input means **901617**, a sensor **901618** (having a function of measuring force, displacement, position, speed, acceleration, angular velocity, rotation number, distance, light, liquid, magnetism, temperature, chemical reaction, sound, time, hardness, electric field, current, voltage, electric power, radial ray, flow rate, humidity, gradient, vibration, smell, or infrared ray), a microphone **901619**, an LED lamp **901620**, and the like. The portable game machine shown in FIG. **39** has a function of reading a program or data stored in the recording medium to display on the display portion, and a function of sharing information with another portable game machine by wireless communication. Note that the portable game machine shown in FIG. **39** is not limited to having these functions, and can have various functions.

[0306] As shown in FIGS. **30**A to **30**C, FIGS. **37**A to **37**C, and FIGS. **38**A to **38**B, an electronic device includes a display portion for displaying some information. When the electronic device includes two display panels, one of display panels (i.e., a peripheral portion of a display region of the one of the display panels) is provided with circuits which are necessary for operating the display panels or circuits which are necessary for the electronic device in which the display panels are incorporated. Thus, the electronic device can be made smaller. Further, since the number of electronic components which are mounted on display portions can be reduced, the electronic device can be made thinner.

[0307] Next, an application of a semiconductor device is described.

[0308] FIG. **31** shows an example in which the semiconductor device is incorporated in a structure. FIG. **31** shows a housing **900810**, a display panel **900811**, a remote controller **900812** which is an operation portion, a speaker portion **900813**, and the like. The semiconductor device is incorporated in the structure as a wall-hanging type, so that the semiconductor device can be provided without requiring a wide space.

[0309] FIG. **32** shows another example in which the semiconductor device is incorporated in a structure. A display panel **900901** is incorporated in a prefabricated bath unit **900902**, so that a bather can view the display panel **900901**. The display panel **900901** has a function of displaying information by an operation of the bather. The display panel **900901** can be utilized for advertisement or an amusement means.

[0310] Note that the semiconductor device can be provided in various places as well as on a sidewall of the prefabricated bath unit **900902** shown in FIG. **32**. For example, the semiconductor device may be incorporated in part of a mirror or the bathtub itself. At this time, the shape of the display panel **900901** may be a shape in accordance with the mirror or the bathtub.

[0311] FIG. **33** shows another example in which the semiconductor device is incorporated in a structure. Display panels **901002** are curved in accordance with curved surfaces of columnar objects **901001**. Note that here, the columnar objects **901001** are described as telephone poles.

[0312] The display panels **901002** shown in FIG. **33** are provided in positions higher than a human eye level. When the display panels **901002** are provided for structures standing outside to each other in large numbers, such as telephone poles, advertisement can be performed to an unspecified number of viewers. Here, since the display panels **901002** can easily display the same images by control from outside and can easily switch images instantly, extremely effective information display and advertising effects can be expected. When self-luminous display elements are provided in the display panels **901002**, the display panels **901002** are effectively used as highly visible display media even at night. When the display panels **901002** are provided for the telephone poles, power supply means of the display panels **901002** can be easily secured. In an emergency such as a disaster, the display panels **901002** can be means for quickly transmitting precise information to victims.

[0313] Note that as each of the display panels **901002**, a display panel in which a display element is driven by providing a switching element such as an organic transistor over a film-shaped substrate so that an image is displayed can be used.

[0314] Note that although this embodiment describes the wall, the prefabricated bath unit, and the columnar object as examples of the structure, this embodiment mode is not limited to this, and the semiconductor device can be provided for various structures.

[0315] Next, an example is described in which the semiconductor device is incorporated in a moving object.

[0316] FIG. **34** shows an example in which the semiconductor device is incorporated in a car. A display panel **901102** is incorporated in a car body **901101** of the car and can display information on an operation of the car or information input from inside or outside of the car on an on-demand basis. Note that the display panel **901102** may have a navigation function.

[0317] Note that the semiconductor device can be provided in various positions as well as the car body **901101** shown in FIG. **34**. For example, the semiconductor device may be incorporated in a glass window, a door, a steering wheel, a shift lever, a seat, a room mirror, or the like. At this time, the shape of the display panel **901102** may be a shape in accordance with a shape of an object in which the display panel **901102** is provided.

[0318] FIGS. **35**A and **35**B each show an example in which the semiconductor device is incorporated in a train car.

[0319] FIG. **35**A shows an example in which display panels **901202** are provided for glasses of a door **901201** of the train car. The display panels **901202** have an advantage over conventional paper-based advertisement that labor cost which is necessary for switching advertisement is not needed. Since the display panels **901202** can instantly switch images displayed on display portions by external signals, images on the display panels can be switched as the type of train passenger changes in accordance with different time periods, for example, so that a more effective advertising effect can be expected.

[0320] FIG. **35**B shows an example in which display panels **901202** are provided for glass windows **901203** and a ceiling **901204** as well as the glasses of the doors **901201** of the train car. Since the semiconductor device can be easily provided in a position in which the semiconductor device is conventionally difficult to be provided in this manner, an effective advertisement effect can be obtained. Since the semiconductor device can instantly switch images displayed on the display portion by external signals, cost and time generated in advertisement switching can be reduced, so that more flexible advertisement operation and information transmission can be performed.

[0321] Note that the semiconductor device can be provided in various positions as well as the doors **901201**, the glass windows **901203**, and the ceiling **901204** which are shown in FIGS. **35**A and **35**B. For example, the semiconductor device may be incorporated in a hand strap, a seat, a handrail, a floor, or the like. At this time, the shape of the display panel **901202** may be a shape in accordance with a shape of an object in which the display panel **901202** is provided.

[0322] FIGS. **36**A and **36**B each show an example in which the semiconductor device is incorporated in a passenger airplane.

[0323] FIG. **36**A shows a shape in use when a display panel **901302** is provided for a ceiling **901301** above a seat of the passenger airplane. The display panel **901302** is incorporated in the ceiling **901301** through a hinge portion **901303**, and a passenger can view the display panel **901302** by a telescopic motion of the hinge portion **901303**. The display panel **901302** has a function of displaying information by an operation of the passenger. The display panel **901302** can be utilized for advertisement or an amusement means. When the display panel **901302** is stored on the ceiling **901301** by folding the hinge portion **901303** as shown in FIG. **36**B, safety during takeoff and landing can be secured. Note that the display panel **901302** can also be utilized as a medium and a guide light by lighting display elements of the display panel **901302** in an emergency.

[0324] Note that the semiconductor device can be incorporated in various positions as well as the ceiling **901301** shown in FIGS. **36**A and **36**B. For example, the semiconductor device may be incorporated in a seat, a table, an armrest, a window, or the like. A large display panel which can be viewed simultaneously by a plurality of people may be provided on a wall of an airframe. At this time, the shape of the display panel **901302** may be a shape in accordance with a shape of an object in which the display panel **901302** is provided.

[0325] Note that although this embodiment mode describes the train car body, the car body, and the airplane body as examples of moving objects, the present invention is not limited to them, and the semiconductor device can be provided in various objects such as a motorbike, a four-wheeled vehicle (including a car, a bus, and the like), a train (including a monorail, a railroad, and the like), and a vessel. Since display on display panels in a moving object can be switched instantly by external signals, the semiconductor device can be used for an advertisement display board for an unspecified number of customers, an information display board in an emergency, or the like by providing the semiconductor device in the moving object.

[0326] Note that although the case where one display panel is included and the case where a plurality of display panels are included are described at the same time in the structures shown in this embodiment mode, a structure where a first display panel and a second display panel are included may be used, as described in the above embodiment modes. Note that in the case where the first display panel and the second display panel are included, a compact display module can be formed by using a structure where the second display panel is included to be back on to the first display panel. Thus, the electronic device can be made smaller.

[0327] Note that although this embodiment mode is described with reference to various drawings, the contents (or may be part of the contents) described in each drawing can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in another drawing. Further, even more drawings can be formed by combining each part with another part in the above-described drawings.

[0328] Similarly, the contents (or may be part of the contents) described in each drawing of this embodiment mode can be freely applied to, combined with, or replaced with the contents (or may be part of the contents) described in a drawing in another embodiment mode. Further, even more drawings can be formed by combining each part with part of another embodiment mode in the drawings of this embodiment mode.

[0329] Note that this embodiment mode shows an example of an embodied case of the contents (or may be part of the contents) described in other embodiment modes, an example of slight transformation thereof, an example of partial modification thereof, an example of improvement thereof, an example of detailed description thereof, an application example thereof, an example of related part thereof, or the like. Therefore, the contents described in other embodiment modes can be freely applied to, combined with, or replaced with this embodiment mode.

[0330] This application is based on Japanese Patent Application serial no. 2007-132898 filed with Japan Patent Office on May 18, 2007, the entire contents of which are hereby incorporated by reference.

What is claimed is:

1. A liquid crystal display device comprising:

a first display panel including a first terminal and a first display screen having a first liquid crystal element;

a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; and

a substrate including a wiring,

wherein the circuit group is electrically connected to the first terminal through the second terminal and the wiring, and

wherein the second display panel comprises a transistor including a semiconductor layer formed of a single-crystal semiconductor.

2. The liquid crystal display device according to claim **1**, wherein a diagonal measurement of the first display screen is larger than a diagonal measurement of the second display screen.

3. The liquid crystal display device according to claim **1**, wherein the number of pixels of the first display screen is larger than the number of pixels of the second display screen.

4. The liquid crystal display device according to claim **1**, wherein the circuit group includes a timing controller.

5. The liquid crystal display device according to claim **1**, wherein the circuit group includes a power supply circuit.

6. The liquid crystal display device according to claim **1**, wherein the circuit group is shared between the first display panel and the second display panel.

7. The liquid crystal display device according to claim **1**, wherein the first display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

8. The liquid crystal display device according to claim **1**, wherein the first display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

9. The liquid crystal display device according to claim **1**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

10. The liquid crystal display device according to claim **1**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

11. An electronic device comprising the liquid crystal display device according to claim **1**.

12. A liquid crystal display device comprising:

a first display panel including a first terminal and a first display screen having a first liquid crystal element;

a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element;

a substrate including a wiring; and

an integrated circuit,

wherein the circuit group is electrically connected to the first terminal through the second terminal and the wiring,

wherein the integrated circuit is electrically connected to the second terminal through the wiring, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

13. The liquid crystal display device according to claim **12**, wherein a diagonal measurement of the first display screen is larger than a diagonal measurement of the second display screen.

14. The liquid crystal display device according to claim **12**, wherein the number of pixels of the first display screen is larger than the number of pixels of the second display screen.

15. The liquid crystal display device according to claim **12**, wherein the circuit group includes a timing controller.

16. The liquid crystal display device according to claim **12**, wherein the circuit group includes a power supply circuit.

17. The liquid crystal display device according to claim **12**, wherein the circuit group is shared between the first display panel and the second display panel.

18. The liquid crystal display device according to claim **12**, wherein the first display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

19. The liquid crystal display device according to claim **12**, wherein the first display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

20. The liquid crystal display device according to claim **12**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

21. The liquid crystal display device according to claim **12**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

22. An electronic device comprising the liquid crystal display device according to claim **12**.

23. A liquid crystal display device comprising:

a first display panel including a first terminal and a first display screen having a first liquid crystal element;

a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element;

a substrate including a wiring; and

a sensor,

wherein the circuit group is electrically connected to the first terminal through the second terminal and the wiring, and

wherein the sensor is electrically connected to the second terminal through the wiring.

24. The liquid crystal display device according to claim **23**, wherein a diagonal measurement of the first display screen is larger than a diagonal measurement of the second display screen.

25. The liquid crystal display device according to claim **23**, wherein the number of pixels of the first display screen is larger than the number of pixels of the second display screen.

26. The liquid crystal display device according to claim **23**, wherein the circuit group includes a timing controller.

27. The liquid crystal display device according to claim **23**, wherein the circuit group includes a power supply circuit.

28. The liquid crystal display device according to claim **23**, wherein the circuit group is shared between the first display panel and the second display panel.

29. The liquid crystal display device according to claim **23**, wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

30. The liquid crystal display device according to claim **23**, wherein the first display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

31. The liquid crystal display device according to claim **23**, wherein the first display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

32. The liquid crystal display device according to claim **23**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

33. The liquid crystal display device according to claim **23**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

34. An electronic device comprising the liquid crystal display device according to claim **23**.

35. A liquid crystal display device comprising:

a first display panel including a first terminal and a first display screen having a first liquid crystal element;

a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element;

a substrate including a wiring;

an integrated circuit; and

a sensor,

wherein the circuit group is electrically connected to the first display panel through the wiring,

wherein the integrated circuit is electrically connected to the first display panel and the second display panel through the wiring,

wherein the circuit group is electrically connected to the first terminal through the second terminal and the wiring,

wherein the integrated circuit is electrically connected to the second terminal through the wiring, and

wherein the sensor is electrically connected to the second terminal through the wiring.

36. The liquid crystal display device according to claim **35**, wherein a diagonal measurement of the first display screen is larger than a diagonal measurement of the second display screen.

37. The liquid crystal display device according to claim **35**, wherein the number of pixels of the first display screen is larger than the number of pixels of the second display screen.

38. The liquid crystal display device according to claim **35**, wherein the circuit group includes a timing controller.

39. The liquid crystal display device according to claim **35**, wherein the circuit group includes a power supply circuit.

40. The liquid crystal display device according to claim **35**, wherein the circuit group is shared between the first display panel and the second display panel.

41. The liquid crystal display device according to claim **35**, wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

42. The liquid crystal display device according to claim **35**, wherein the first display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

43. The liquid crystal display device according to claim **35**, wherein the first display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

44. The liquid crystal display device according to claim **35**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

45. The liquid crystal display device according to claim **35**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

46. An electronic device comprising the liquid crystal display device according to claim **35**.

47. A liquid crystal display device comprising:

a first display panel including a first terminal, a level shifter, a driver circuit, and a first display screen having a first liquid crystal element;

a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element; and

a substrate including a wiring,

wherein the circuit group is electrically connected to the first terminal through the second terminal and the wiring.

48. The liquid crystal display device according to claim **47**, wherein a diagonal measurement of the first display screen is larger than a diagonal measurement of the second display screen.

49. The liquid crystal display device according to claim **47**, wherein the number of pixels of the first display screen is larger than the number of pixels of the second display screen.

50. The liquid crystal display device according to claim **47**, wherein the circuit group includes a timing controller.

51. The liquid crystal display device according to claim **47**, wherein the circuit group includes a power supply circuit.

52. The liquid crystal display device according to claim **47**, wherein the circuit group is shared between the first display panel and the second display panel.

53. The liquid crystal display device according to claim **47**, wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

54. The liquid crystal display device according to claim **47**, wherein the first display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

55. The liquid crystal display device according to claim **47**, wherein the first display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

56. The liquid crystal display device according to claim **47**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

57. The liquid crystal display device according to claim **47**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

58. An electronic device comprising the liquid crystal display device according to claim **47**.

59. A liquid crystal display device comprising:

a first display panel including a first terminal, a level shifter, a driver circuit, and a first display screen having a first liquid crystal element;

a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element;

a substrate including a wiring; and

an integrated circuit,

wherein the circuit group is electrically connected to the first terminal through the second terminal and the wiring, and

wherein the integrated circuit is electrically connected to the second terminal through the wiring.

60. The liquid crystal display device according to claim **59**, wherein a diagonal measurement of the first display screen is larger than a diagonal measurement of the second display screen.

61. The liquid crystal display device according to claim **59**, wherein the number of pixels of the first display screen is larger than the number of pixels of the second display screen.

62. The liquid crystal display device according to claim **59**, wherein the circuit group includes a timing controller.

63. The liquid crystal display device according to claim **59**, wherein the circuit group includes a power supply circuit.

64. The liquid crystal display device according to claim **59**, wherein the circuit group is shared between the first display panel and the second display panel.

65. The liquid crystal display device according to claim **59**, wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

66. The liquid crystal display device according to claim **59**, wherein the first display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

67. The liquid crystal display device according to claim **59**, wherein the first display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

68. The liquid crystal display device according to claim **59**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

69. The liquid crystal display device according to claim **59**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

70. An electronic device comprising the liquid crystal display device according to claim **59**.

71. A liquid crystal display device comprising:

a first display panel including a first terminal, a level shifter, a driver circuit, and a first display screen having a first liquid crystal element;

a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element;

a substrate including a wiring; and

a sensor,

wherein the circuit group is electrically connected to the first terminal through the second terminal and the wiring, and

wherein the sensor is electrically connected to the second terminal through the wiring.

72. The liquid crystal display device according to claim **71**, wherein a diagonal measurement of the first display screen is larger than a diagonal measurement of the second display screen.

73. The liquid crystal display device according to claim **71**, wherein the number of pixels of the first display screen is larger than the number of pixels of the second display screen.

74. The liquid crystal display device according to claim **71**, wherein the circuit group includes a timing controller.

75. The liquid crystal display device according to claim **71**, wherein the circuit group includes a power supply circuit.

76. The liquid crystal display device according to claim **71**, wherein the circuit group is shared between the first display panel and the second display panel.

77. The liquid crystal display device according to claim **71**, wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

78. The liquid crystal display device according to claim **71**, wherein the first display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

79. The liquid crystal display device according to claim **71**, wherein the first display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

80. The liquid crystal display device according to claim **71**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

81. The liquid crystal display device according to claim **71**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

82. An electronic device comprising the liquid crystal display device according to claim **71**.

83. A liquid crystal display device comprising:

a first display panel including a first terminal, a level shifter, a driver circuit, and a first display screen having a first liquid crystal element;

a second display panel including a second terminal, a circuit group, and a second display screen having a second liquid crystal element;

a substrate including a wiring;

an integrated circuit; and

a sensor,

wherein the circuit group is electrically connected to the first display panel through the wiring,

wherein the integrated circuit is electrically connected to the first display panel through the wiring,

wherein the circuit group is electrically connected to the first terminal through the second terminal and the wiring,

wherein the integrated circuit is electrically connected to the second terminal through the wiring, and

wherein the sensor is electrically connected to the second terminal through the wiring.

84. The liquid crystal display device according to claim **83**, wherein a diagonal measurement of the first display screen is larger than a diagonal measurement of the second display screen.

85. The liquid crystal display device according to claim **83**, wherein the number of pixels of the first display screen is larger than the number of pixels of the second display screen.

86. The liquid crystal display device according to claim **83**, wherein the circuit group includes a timing controller.

87. The liquid crystal display device according to claim **83**, wherein the circuit group includes a power supply circuit.

88. The liquid crystal display device according to claim **83**, wherein the circuit group is shared between the first display panel and the second display panel.

89. The liquid crystal display device according to claim **83**, wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

90. The liquid crystal display device according to claim **83**,wherein the first display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

91. The liquid crystal display device according to claim **83**,wherein the first display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a single-crystal semiconductor.

92. The liquid crystal display device according to claim **83**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a polycrystalline semiconductor.

93. The liquid crystal display device according to claim **83**, wherein the circuit group includes a transistor including a semiconductor layer formed of a single-crystal semiconductor, and

wherein the second display panel includes a transistor including a semiconductor layer formed of a non-crystal semiconductor.

94. An electronic device comprising the liquid crystal display device according to claim **83**.

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当前申请(专利权)人(译)	半导体能源研究所有限公司.		
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摘要(译)

为了减少诸如IC芯片的部件的数量，从而实现显示模块和安装有显示模块的电子设备的尺寸和厚度的减小。此外，为了减少诸如IC芯片的部件的数量，从而提供廉价的显示模块和安装有显示模块的电子设备。电子设备或显示模块包括两个显示面板。显示面板之一（即，显示面板之一的显示区域的外围部分）设置有操作显示面板或电路所必需的电路，其中显示面板或电路是显示面板所在的电子设备所必需的。中。然后，显示面板或其中包含显示面板的电子设备由结合在显示面板中的电路驱动。