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(54) **DISPLAY DEVICE AND ELECTRONIC APPARATUS**

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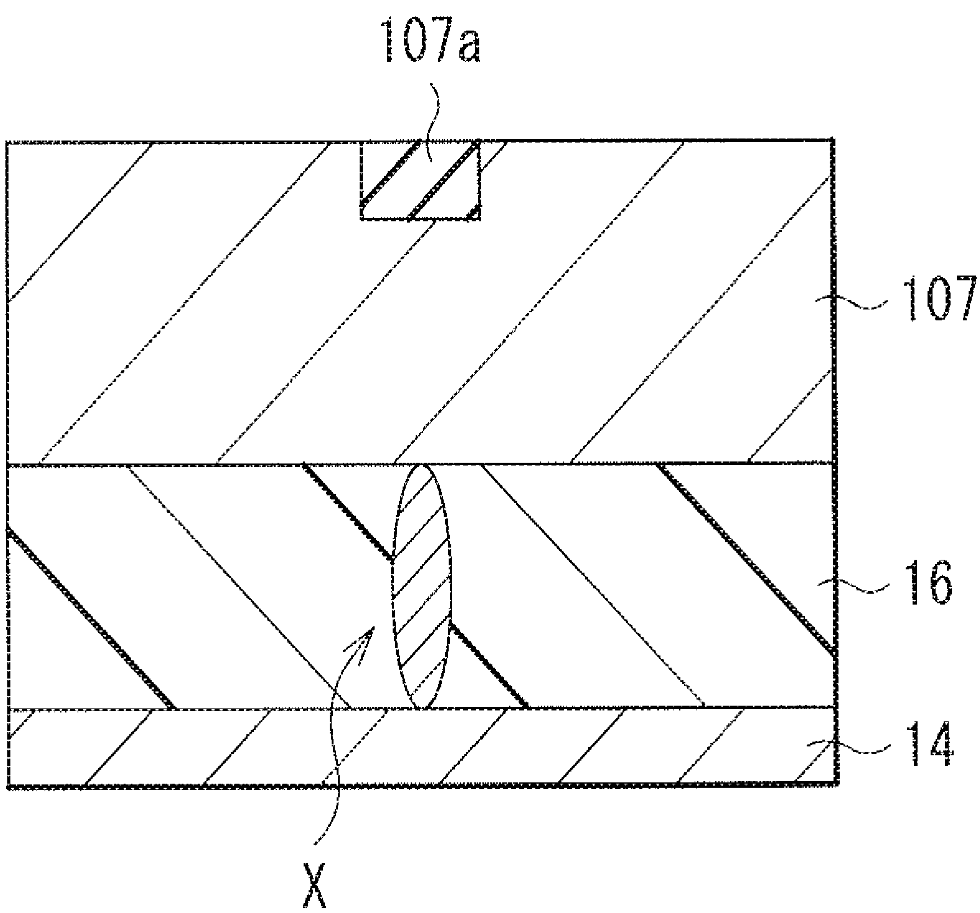
H01L 27/32 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 51/5234*** (2013.01); ***H01L 51/5218*** (2013.01); ***H01L 27/3244*** (2013.01)

(57) **ABSTRACT**

Provided is a display device, including: a first electrode; an organic layer that is provided on the first electrode and includes a light-emission layer; and a second electrode that includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer.



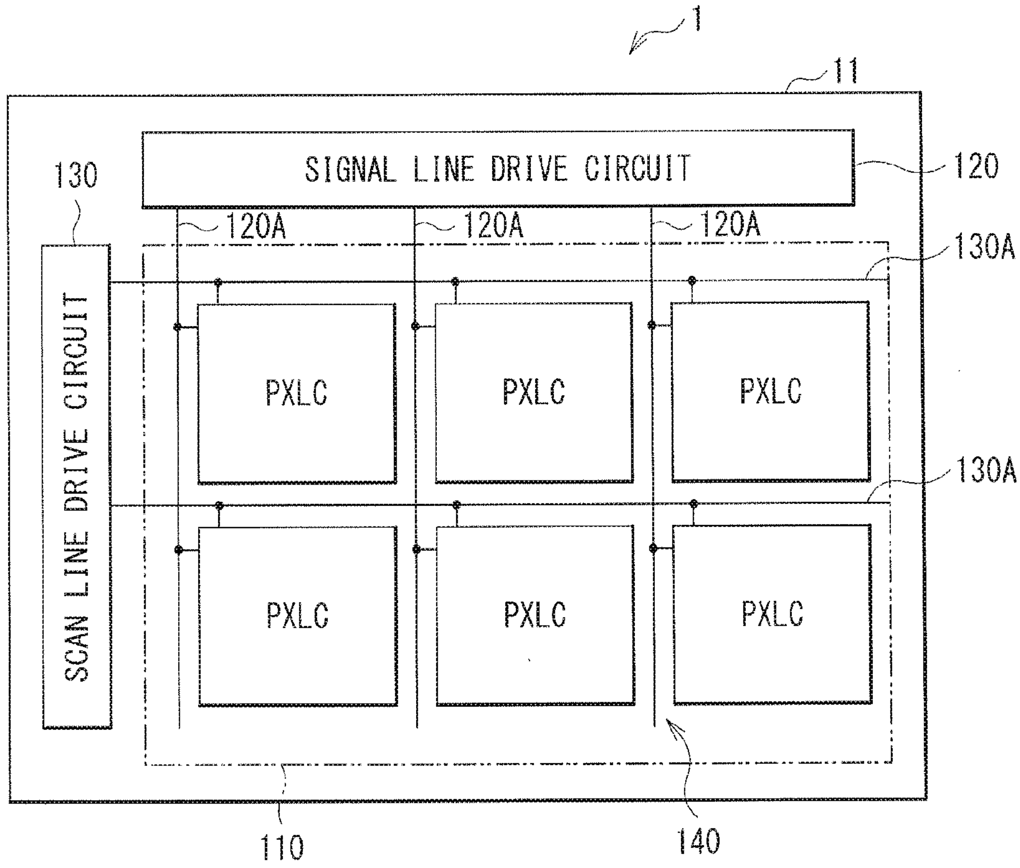

1
11
SIGNAL LINE DRIVE CIRCUIT
120
130
120A
120A
120A
130A
SCAN LINE DRIVE CIRCUIT
PXLC
PXLC
PXLC
130A
PXLC
PXLC
PXLC
110
140

FIG. 1

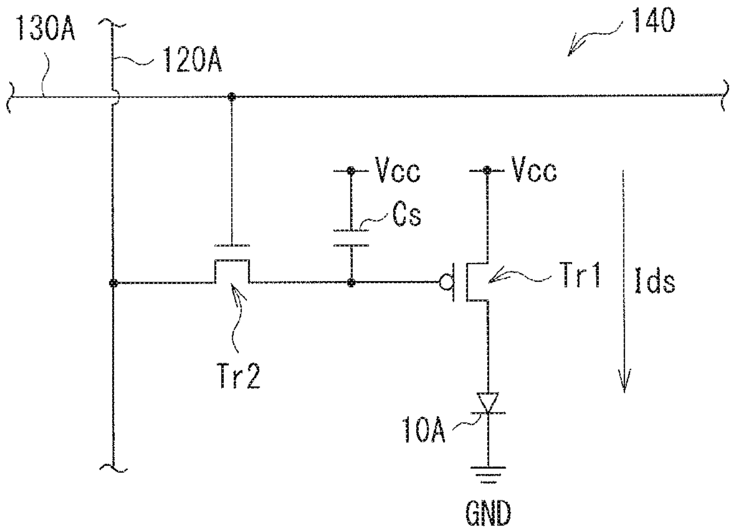

130A
120A
140
Vcc
Vcc
Cs
Tr1
Ids
Tr2
10A
GND

FIG. 2

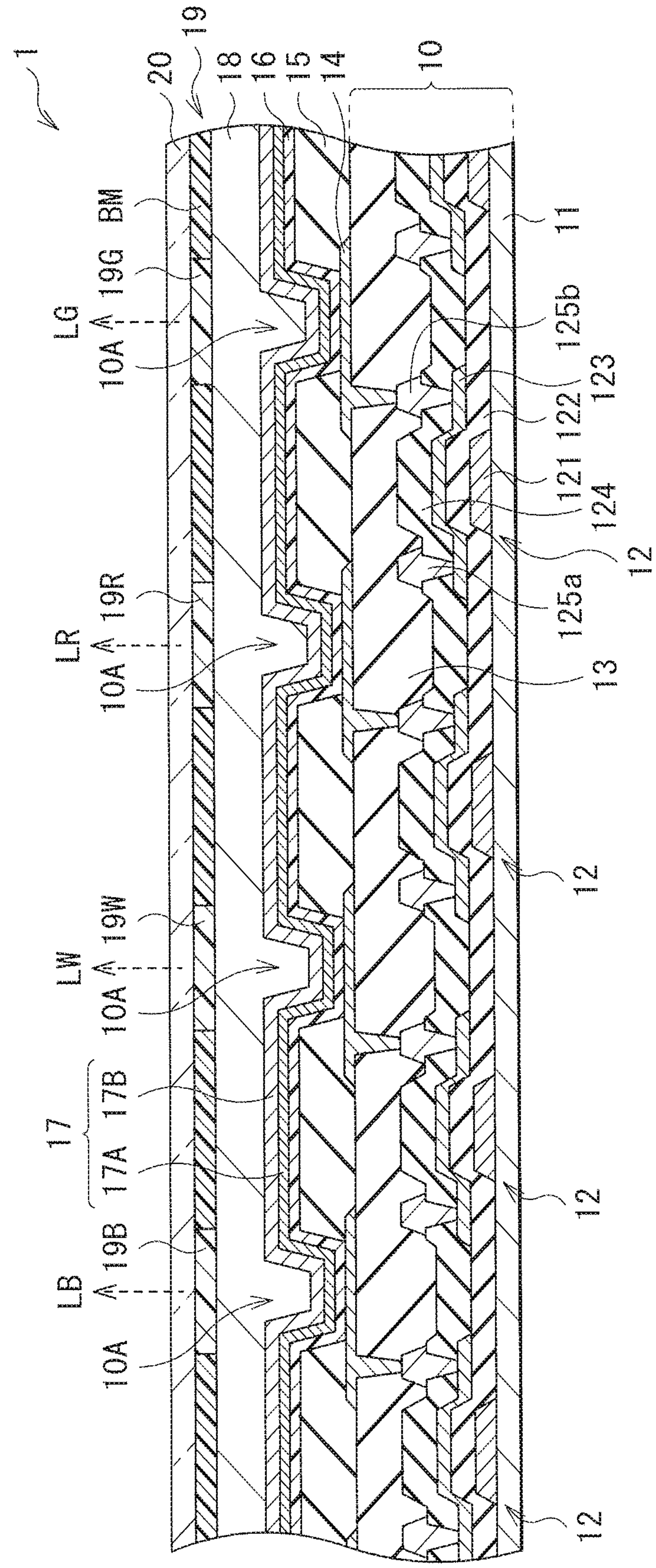

1
20
19
18
16
15
14
10
BM
19G
LG
10A
19R
LR
10A
19W
LW
10A
17
17A
17B
19B
LB
10A
11
125b
123
122
121
124
12
125a
13
12
12
12

FIG. 3

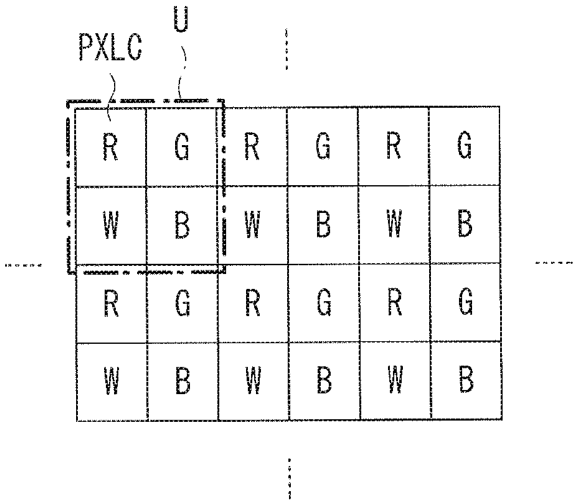


FIG. 4

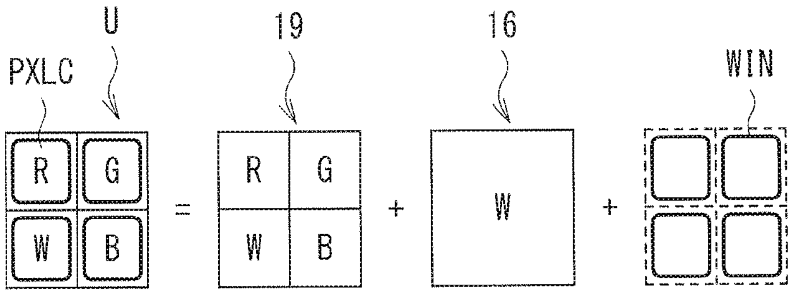


FIG. 5

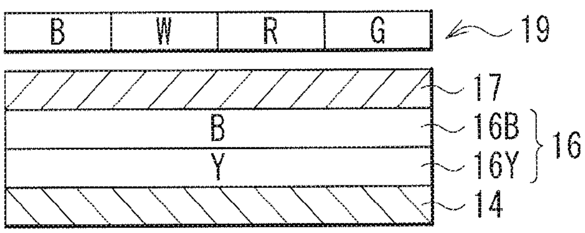


FIG. 6A

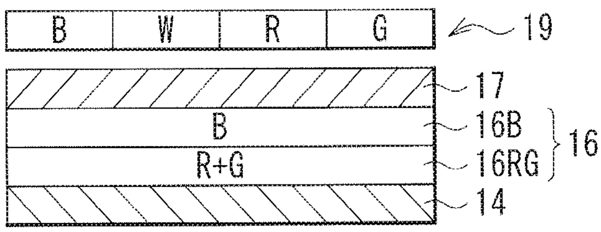


FIG. 6B

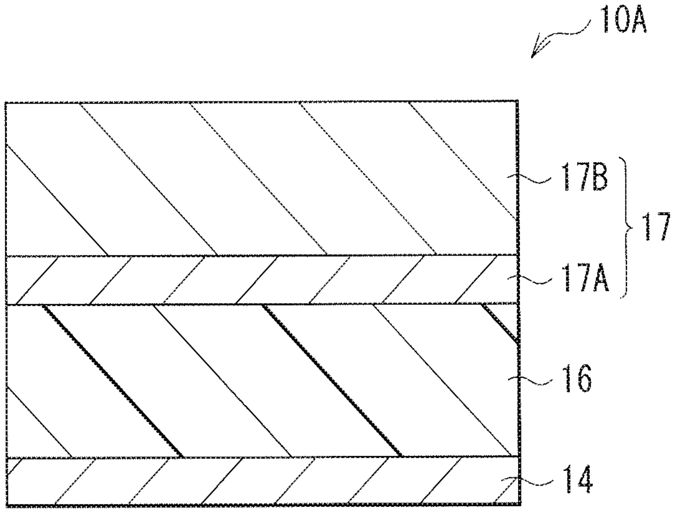


FIG. 7A

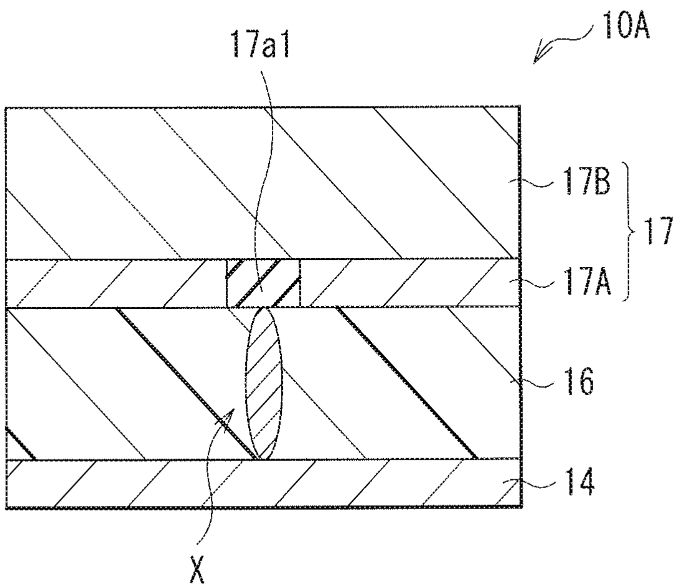


FIG. 7B

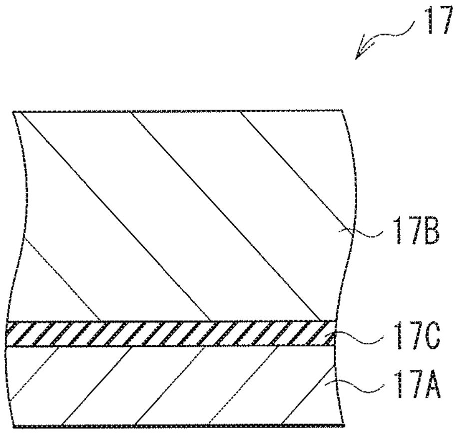


FIG. 8A

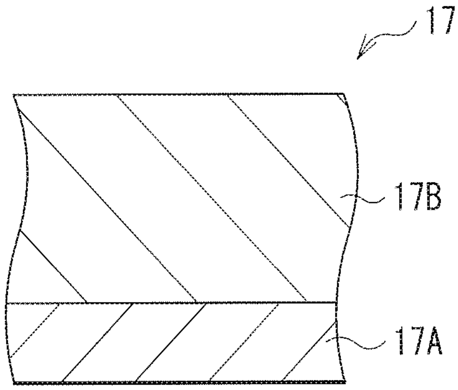


FIG. 8B

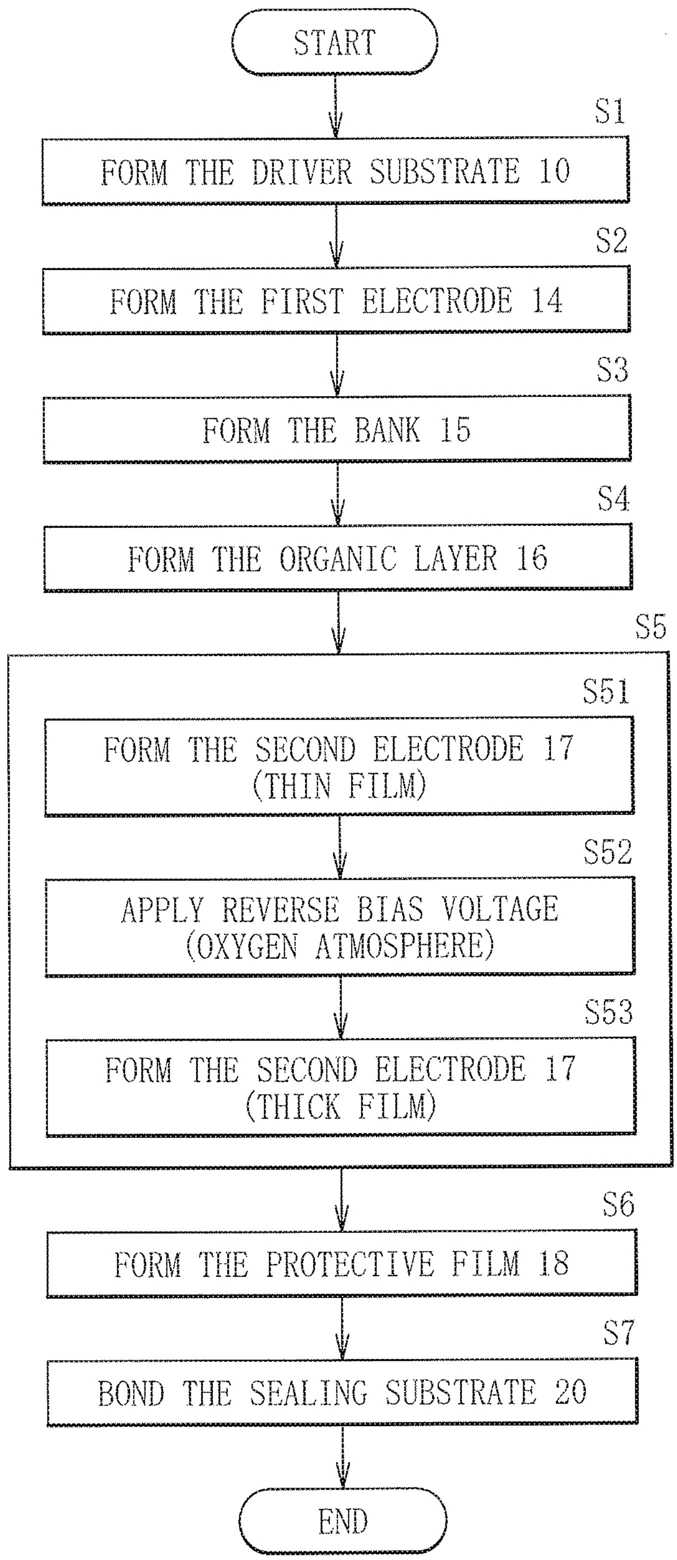

START
S1
FORM THE DRIVER SUBSTRATE 10
S2
FORM THE FIRST ELECTRODE 14
S3
FORM THE BANK 15
S4
FORM THE ORGANIC LAYER 16
S5
S51
FORM THE SECOND ELECTRODE 17 (THIN FILM)
S52
APPLY REVERSE BIAS VOLTAGE (OXYGEN ATMOSPHERE)
S53
FORM THE SECOND ELECTRODE 17 (THICK FILM)
S6
FORM THE PROTECTIVE FILM 18
S7
BOND THE SEALING SUBSTRATE 20
END

FIG. 9

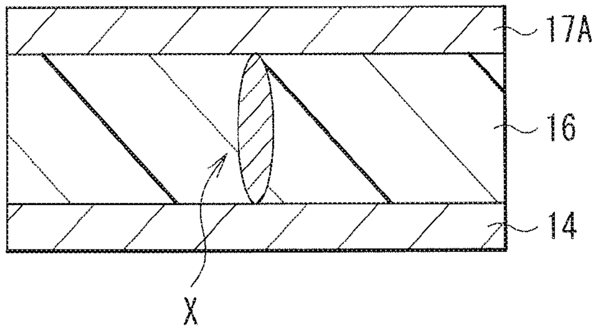


FIG. 10A

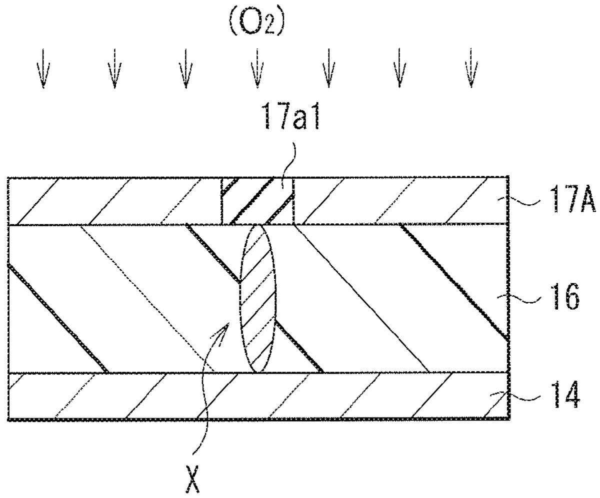


FIG. 10B

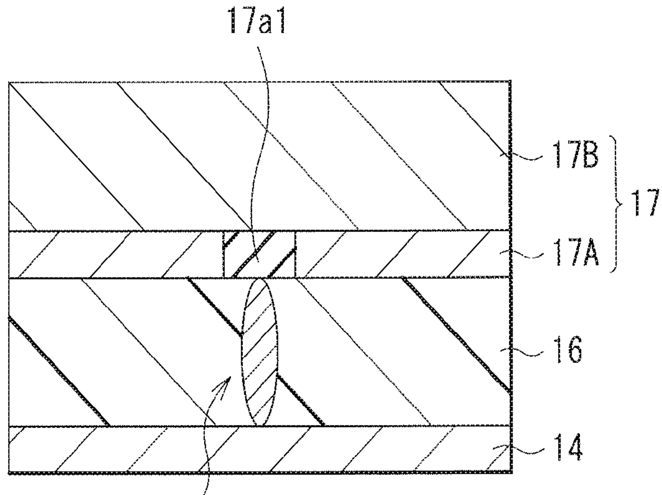


FIG. 10C

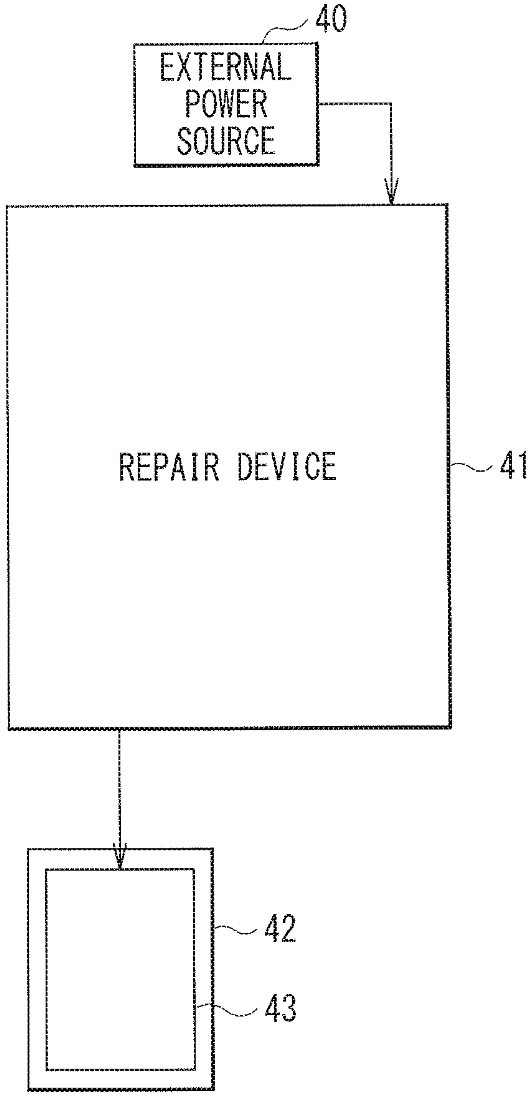


FIG. 11

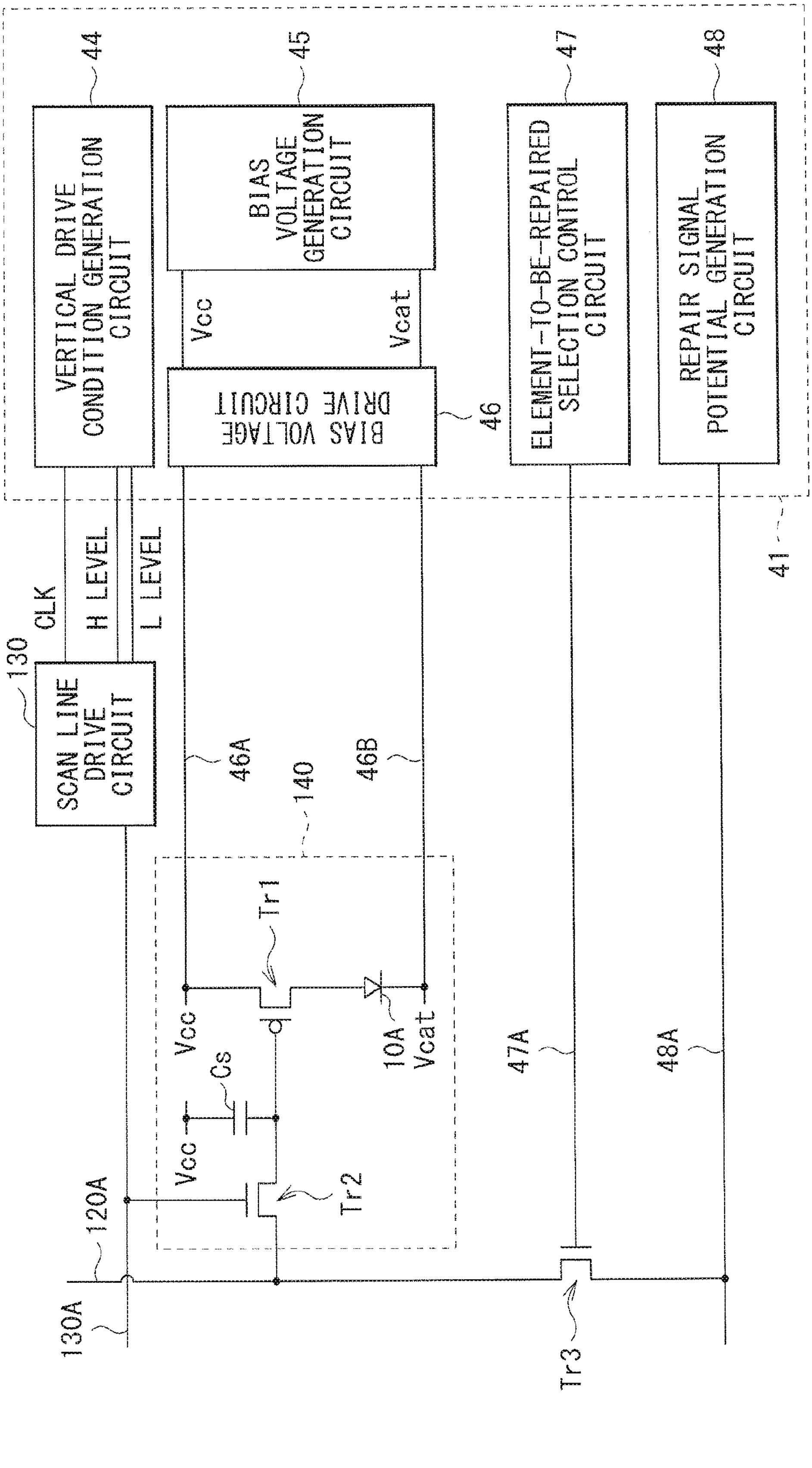

VERTICAL DRIVE CONDITION GENERATION CIRCUIT
44
BIAS VOLTAGE GENERATION CIRCUIT
45
Vcc
Vcat
BIAS VOLTAGE DRIVE CIRCUIT
46
ELEMENT-TO-BE-REPAIRED SELECTION CONTROL CIRCUIT
47
REPAIR SIGNAL POTENTIAL GENERATION CIRCUIT
48
41
CLK
H LEVEL
L LEVEL
SCAN LINE DRIVE CIRCUIT
130
46A
46B
140
Tr1
Vcc
10A
Vcat
Cs
Vcc
Tr2
120A
130A
47A
48A
Tr3

FIG. 12

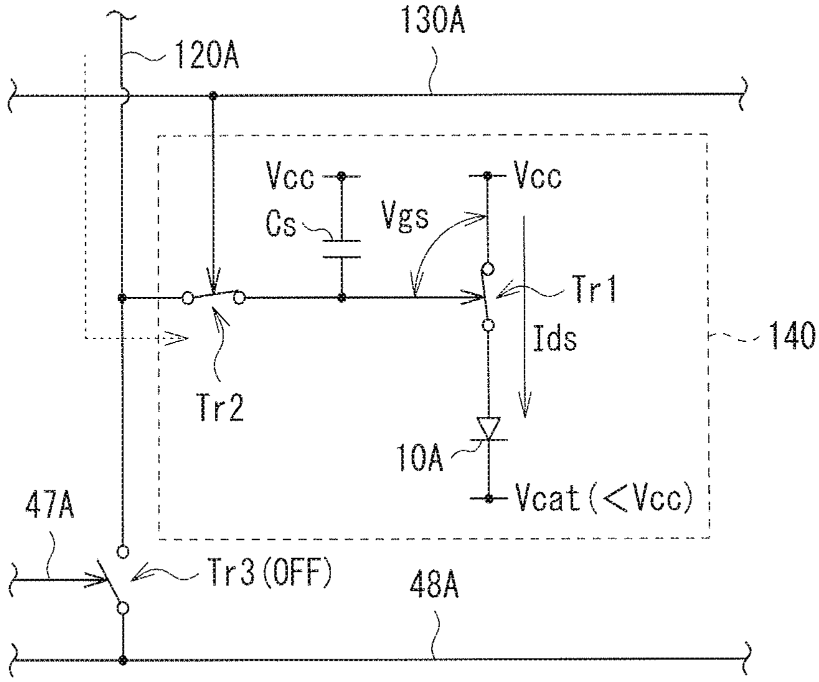


FIG. 13A

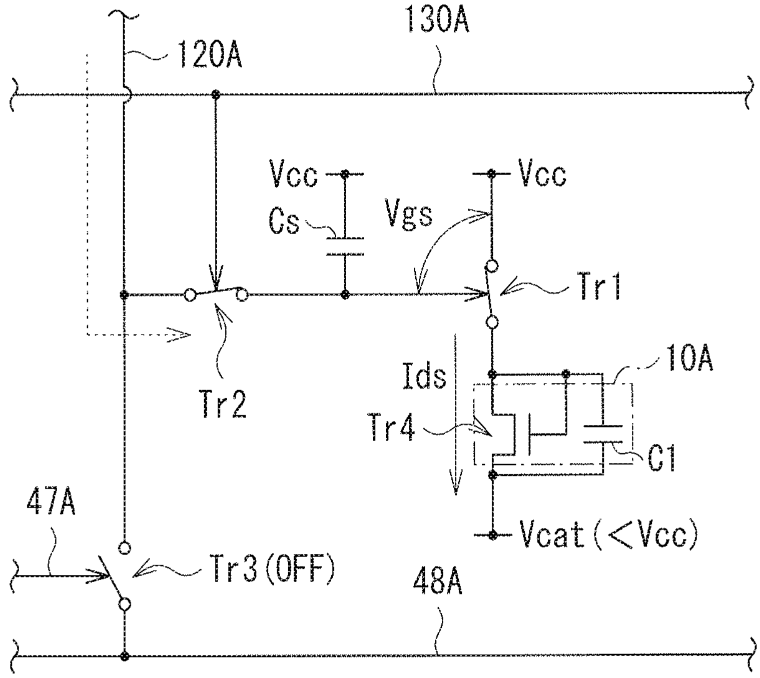


FIG. 13B

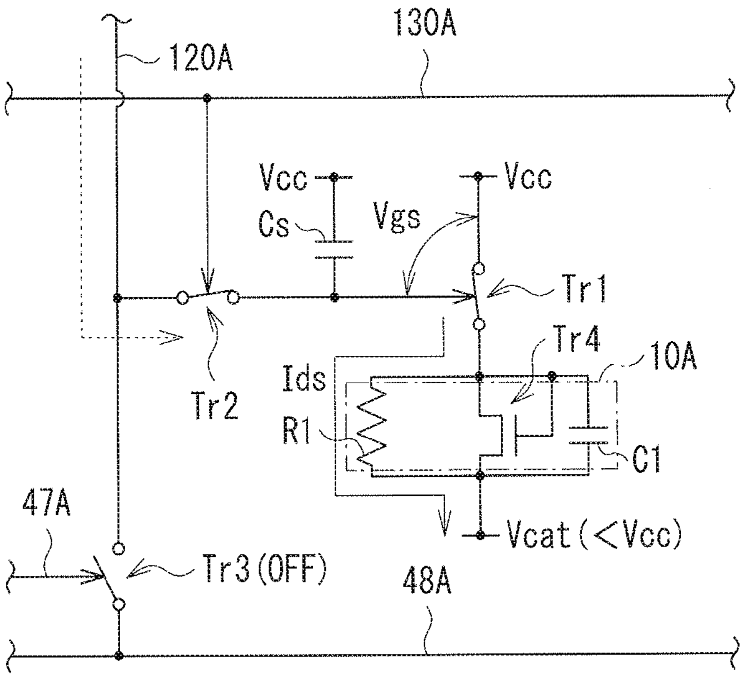


FIG. 13C

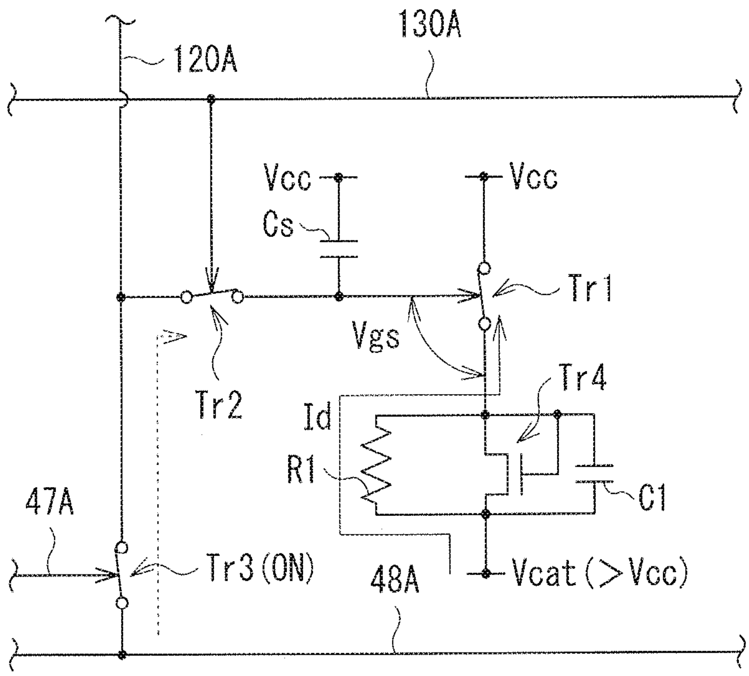


FIG. 13D

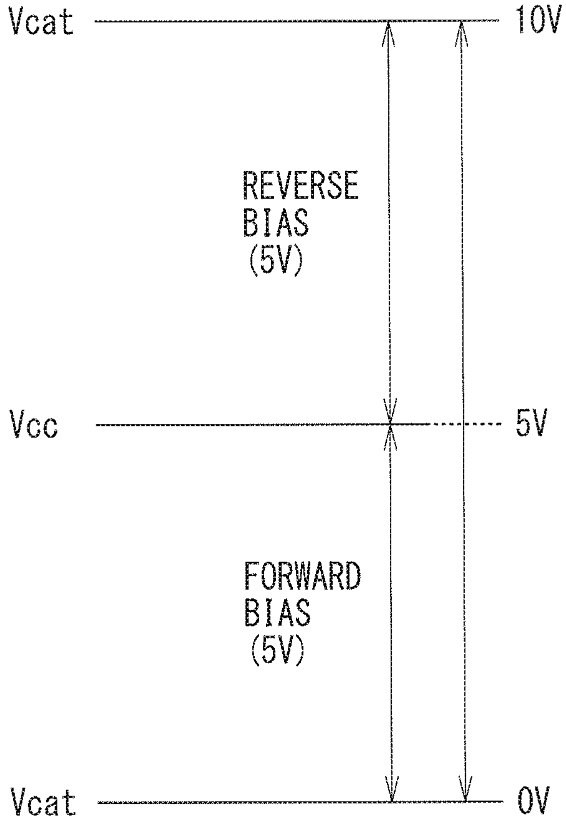


FIG. 14

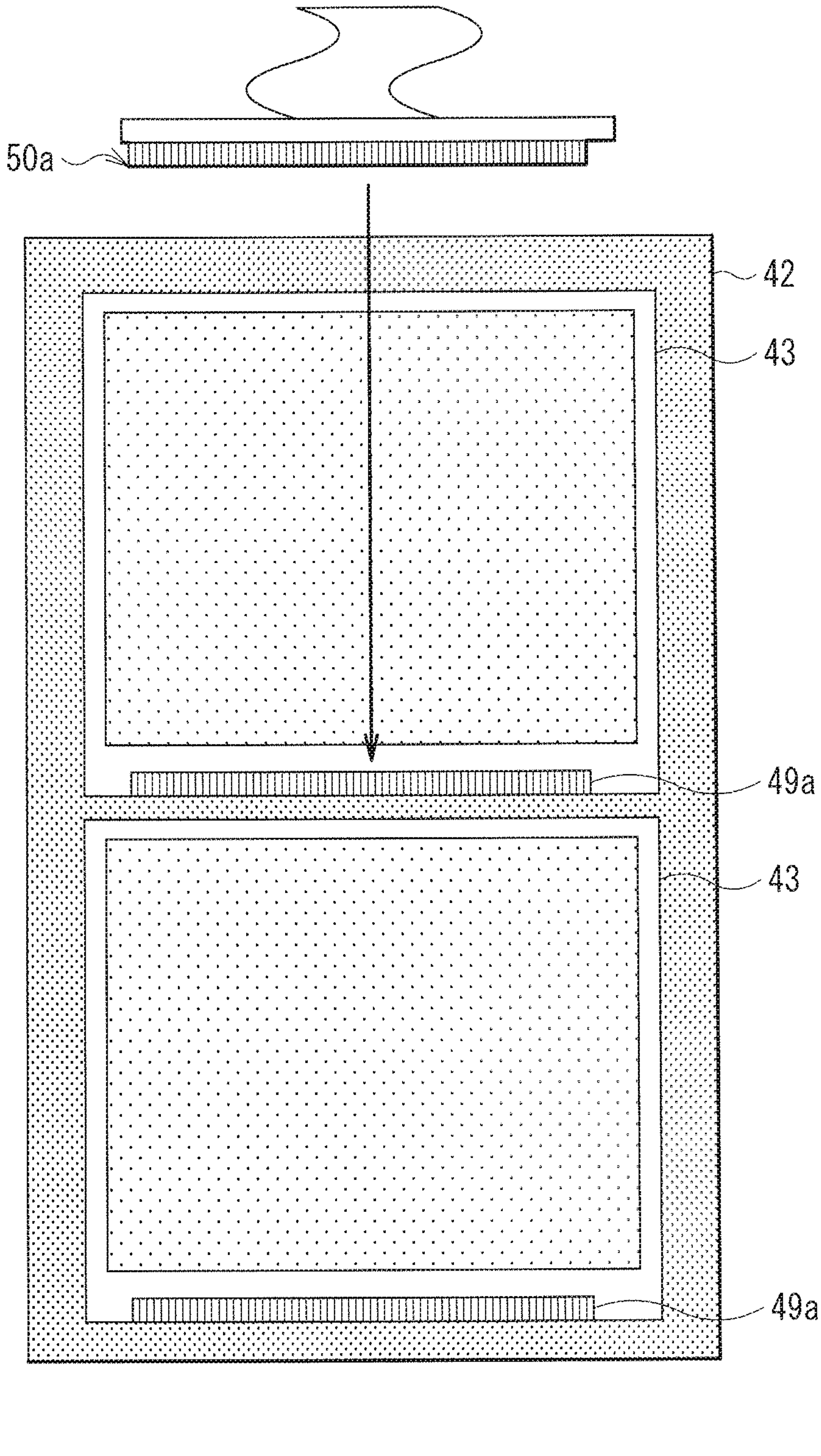


FIG. 15A

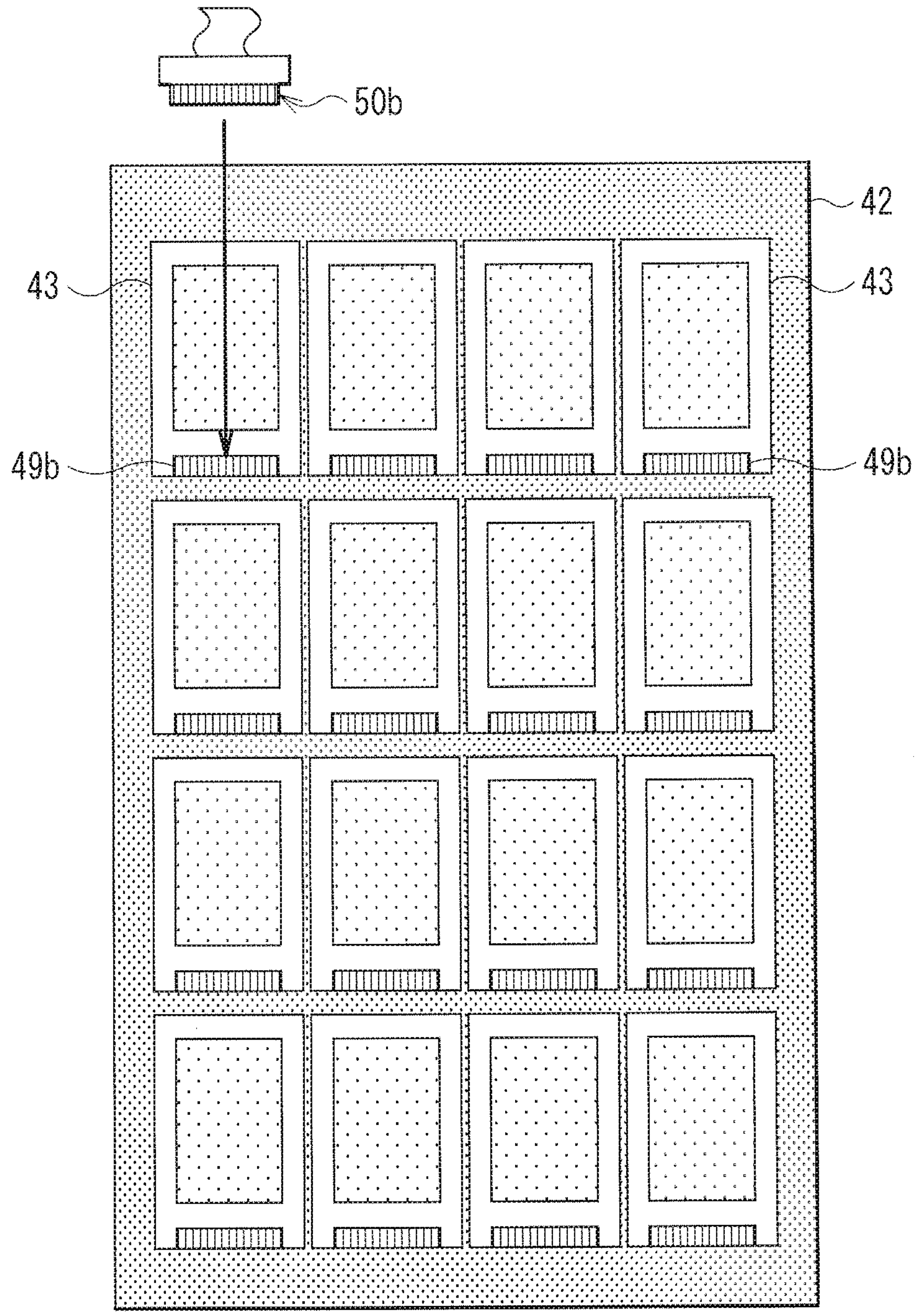


FIG. 15B

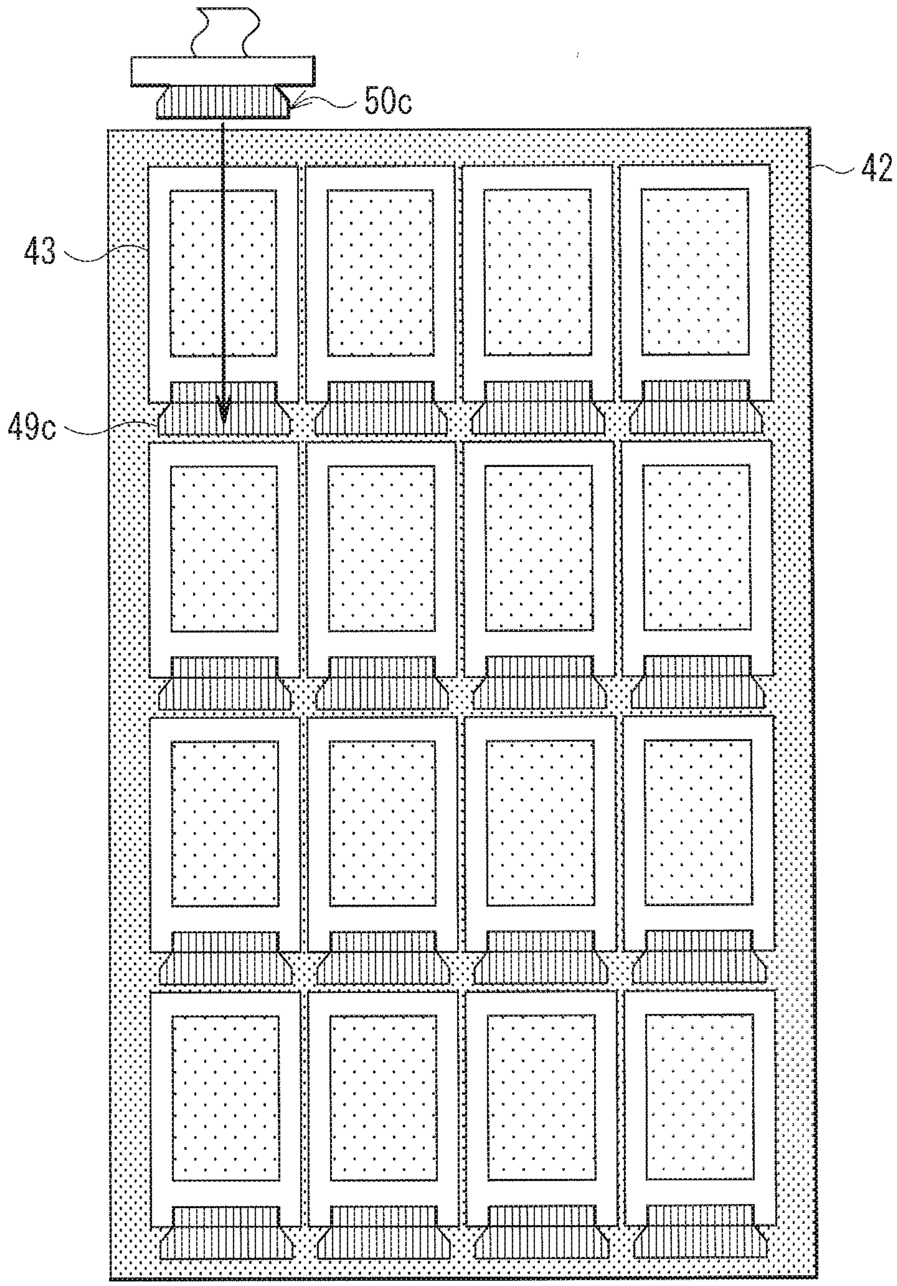


FIG. 15C

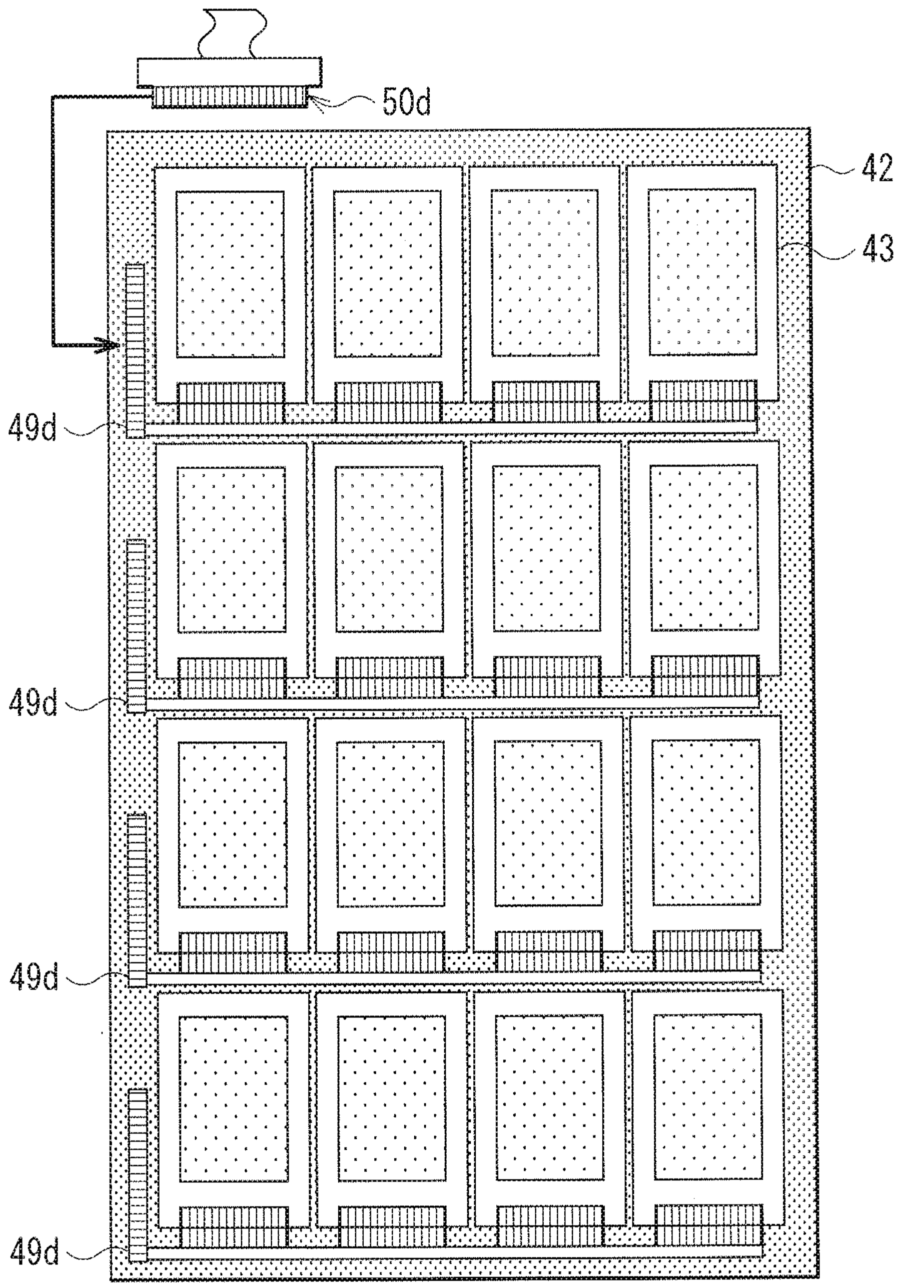


FIG. 15D

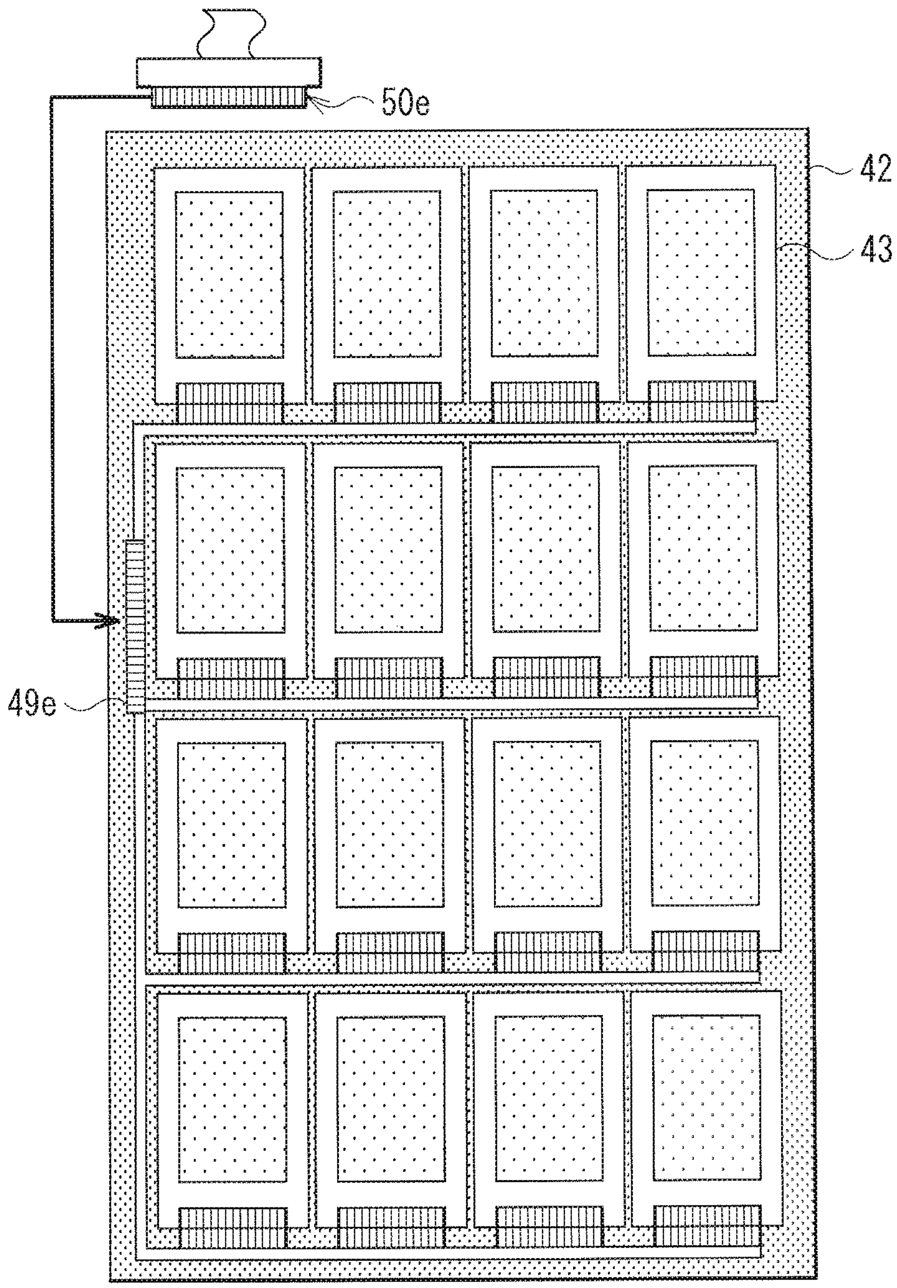


FIG. 15E

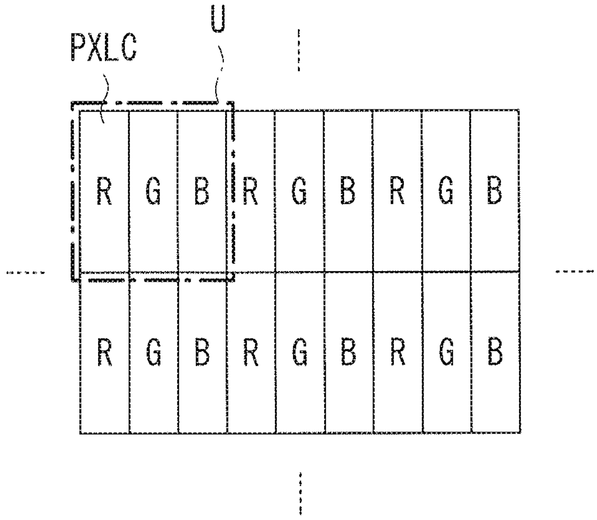


FIG. 16

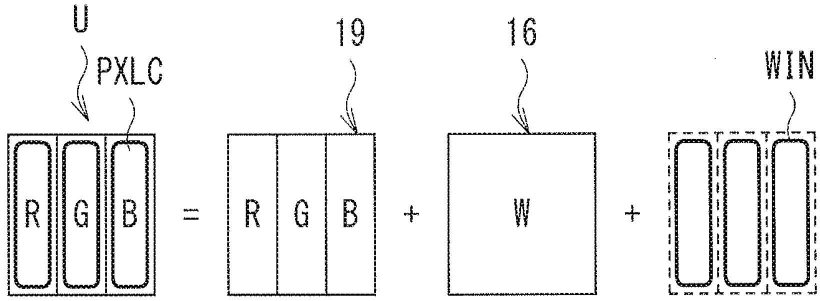


FIG. 17

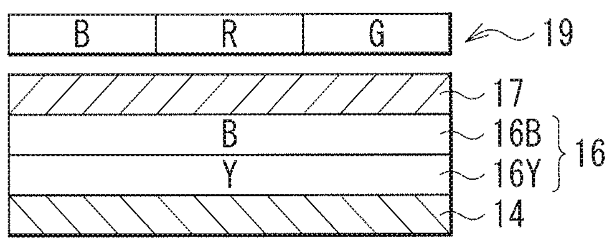


FIG. 18

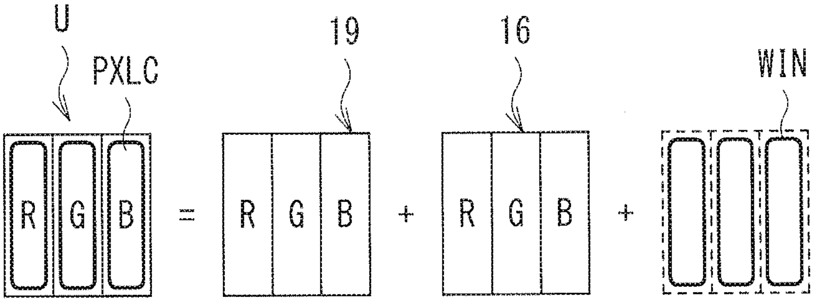


FIG. 19

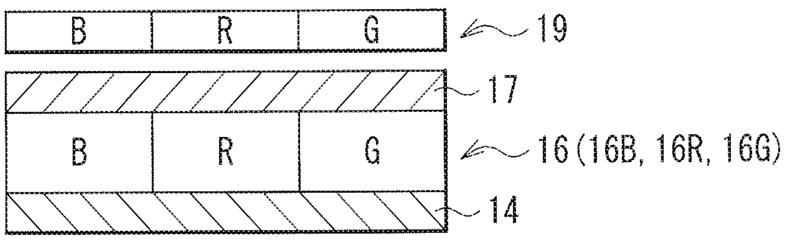


FIG. 20

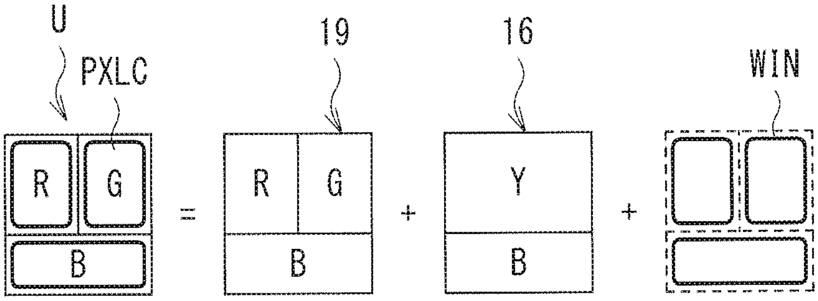


FIG. 21

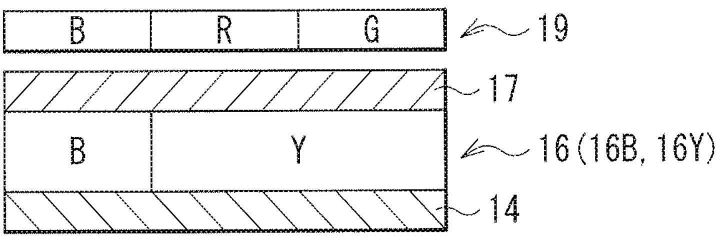


FIG. 22

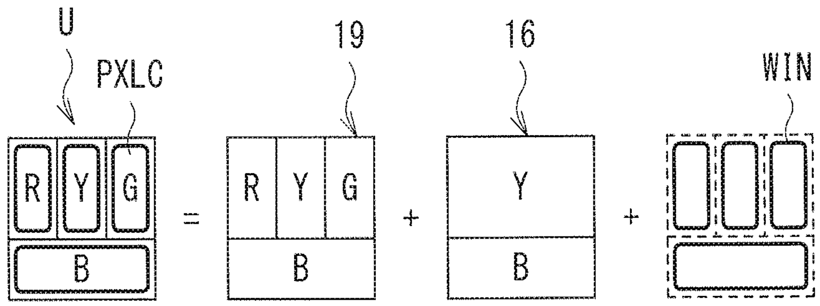


FIG. 23

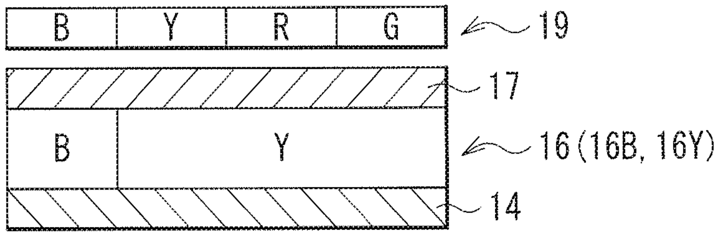


FIG. 24

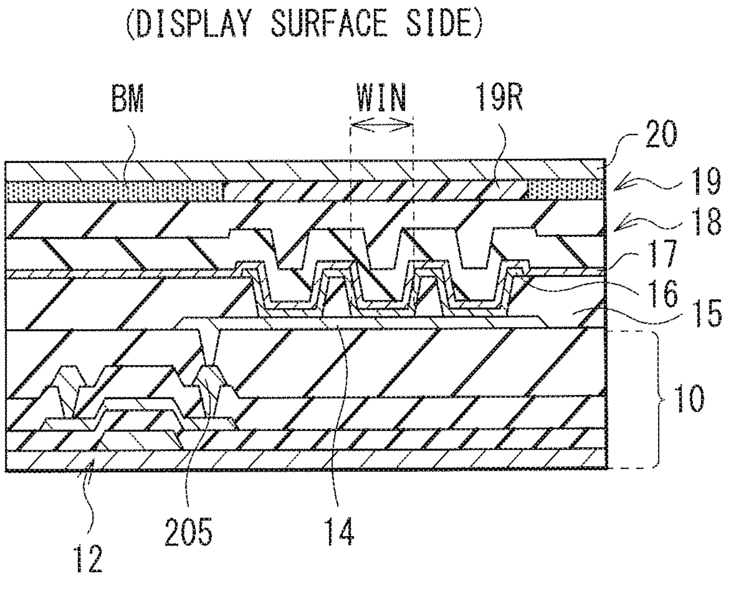


FIG. 25

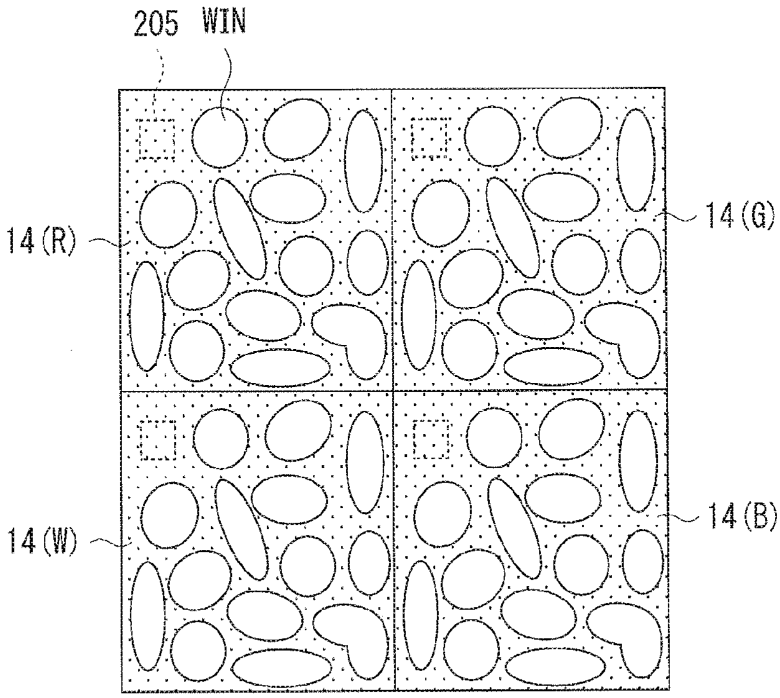

205
WIN
14(R)
14(G)
14(W)
14(B)

FIG. 26

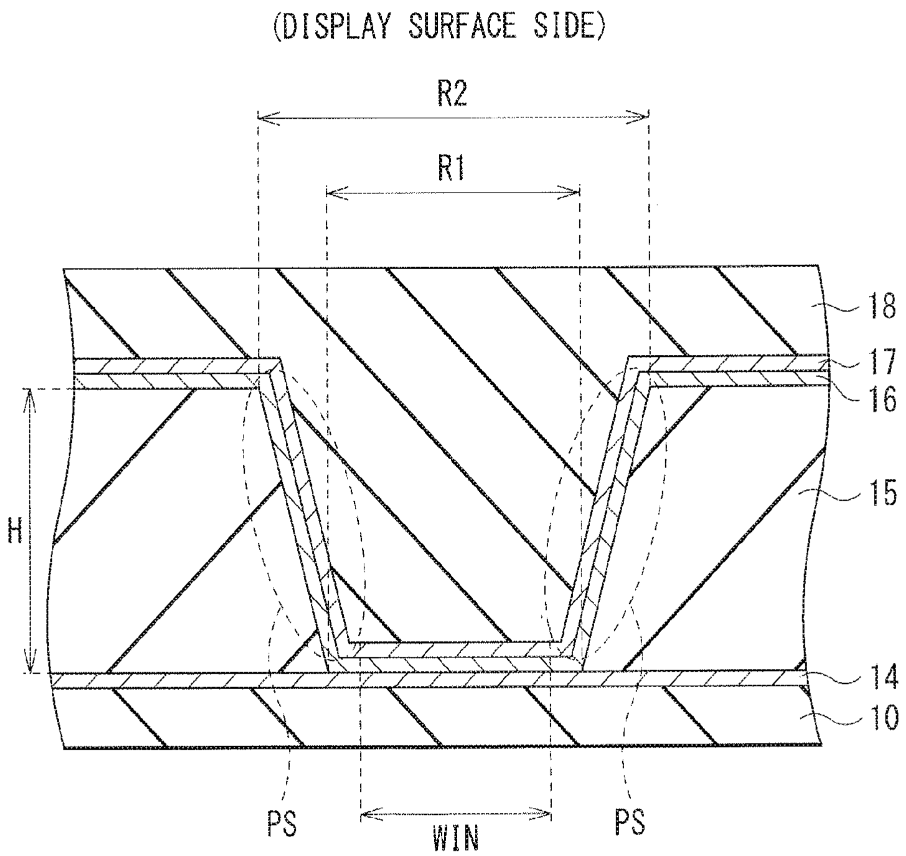

(DISPLAY SURFACE SIDE)
R2
R1
18
17
16
H
15
14
10
PS
WIN
PS

FIG. 27

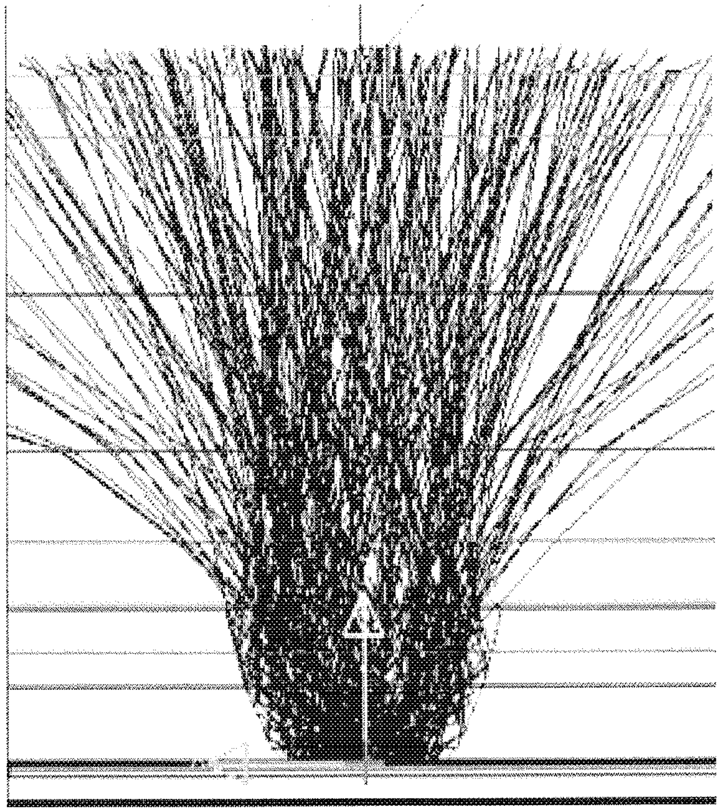


FIG. 28

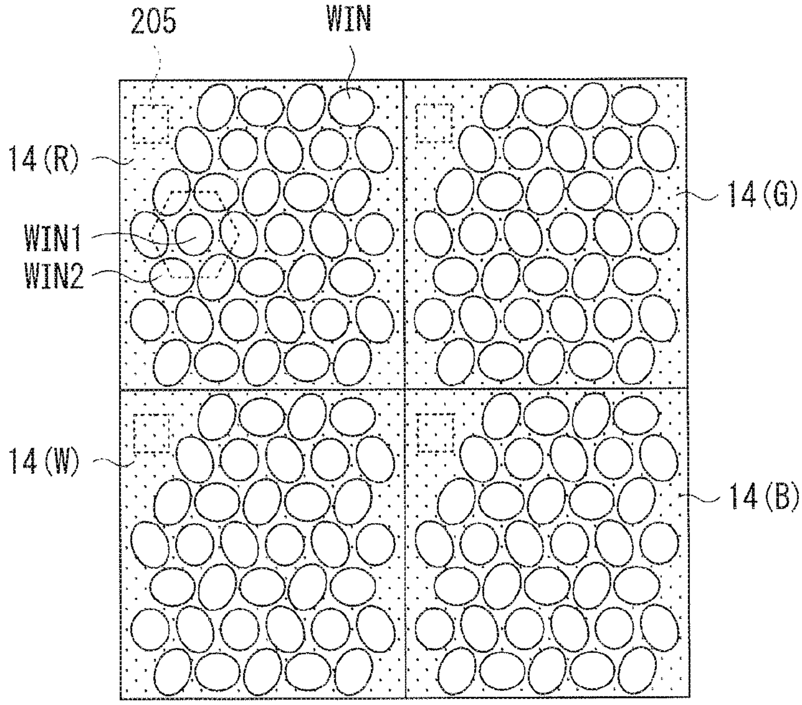


FIG. 29

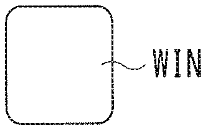


FIG. 30A

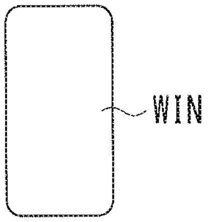


FIG. 30B

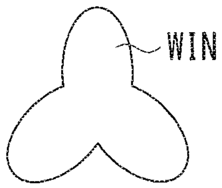


FIG. 30C

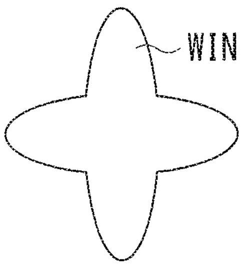


FIG. 30D

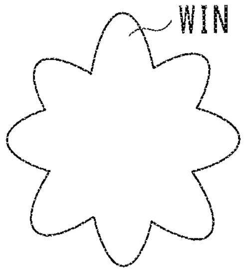


FIG. 30E

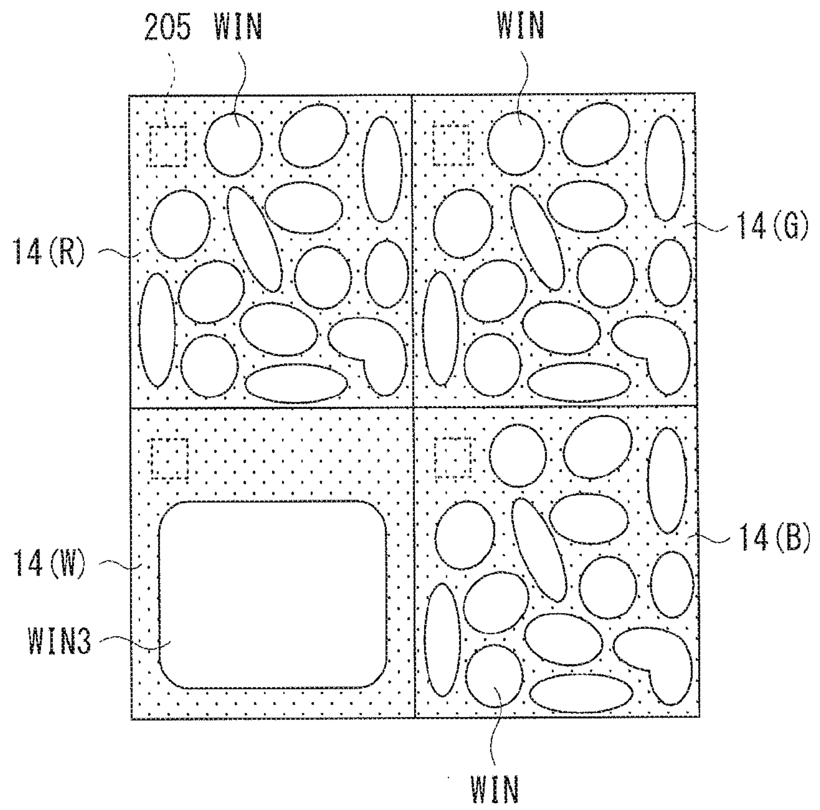

205 WIN
WIN
14(R)
14(G)
14(W)
WIN3
14(B)
WIN

FIG. 31

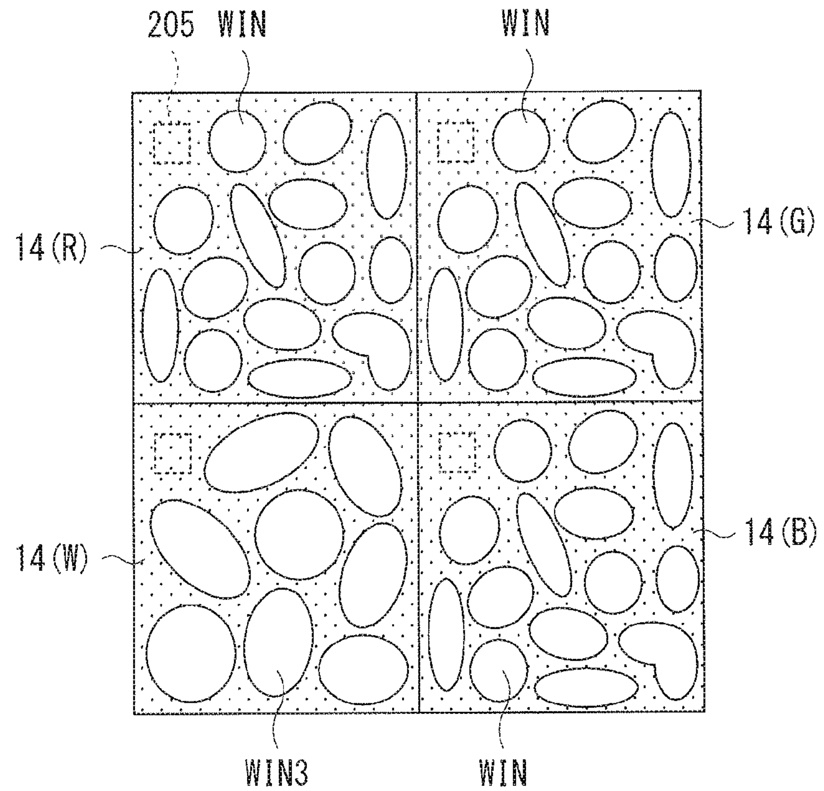

205 WIN
WIN
14(R)
14(G)
14(W)
14(B)
WIN3
WIN

FIG. 32

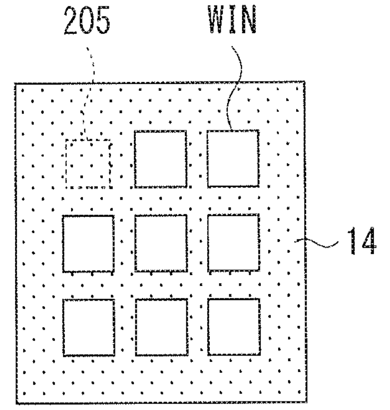


FIG. 33A

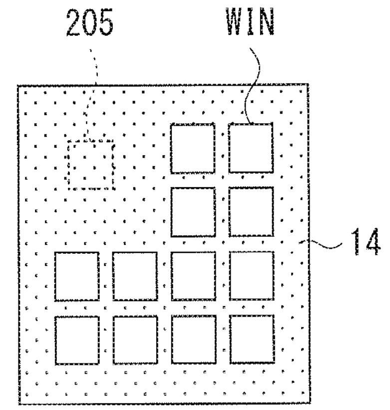


FIG. 33B

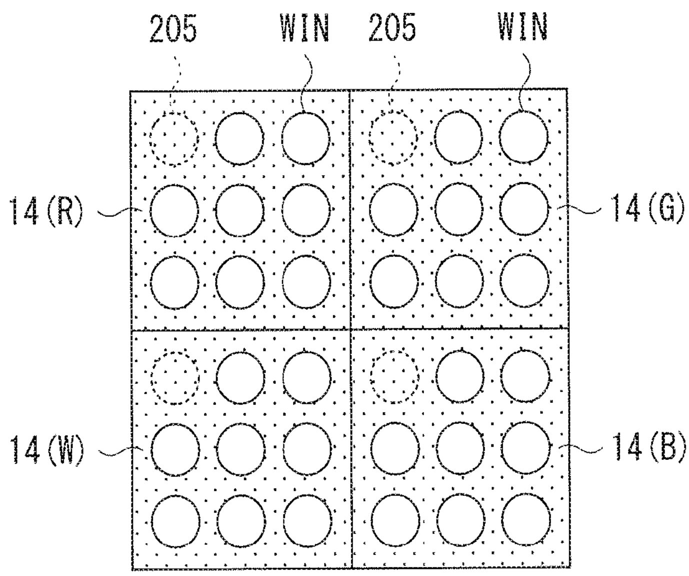


FIG. 34

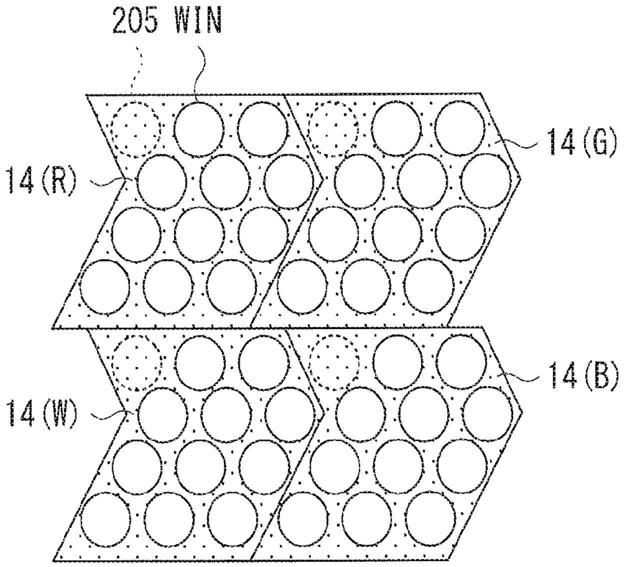


FIG. 35

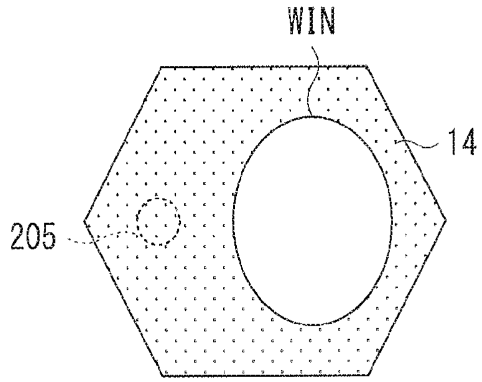


FIG. 36A

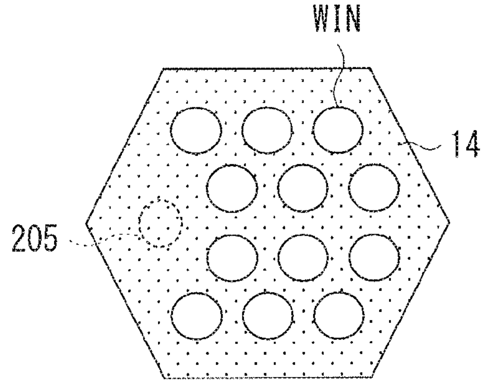


FIG. 36B

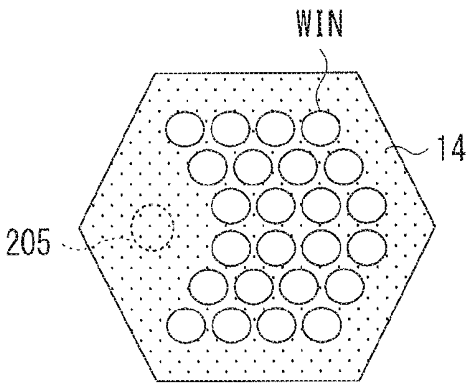


FIG. 36C

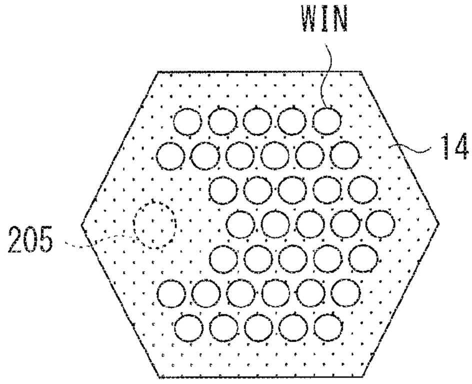


FIG. 36D

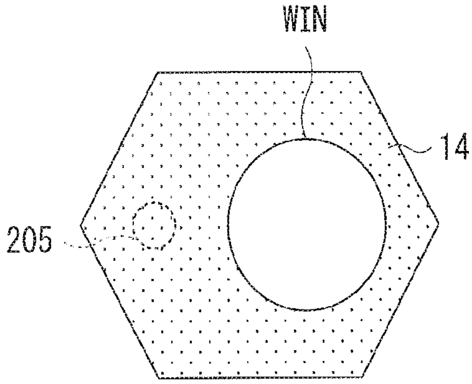


FIG. 37A

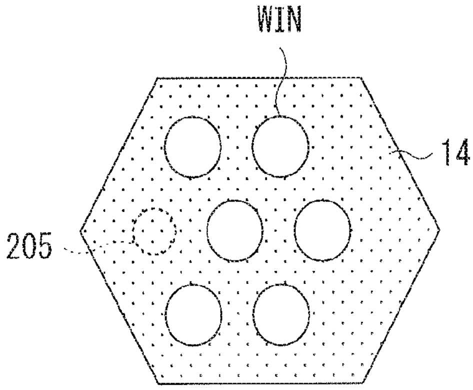


FIG. 37B

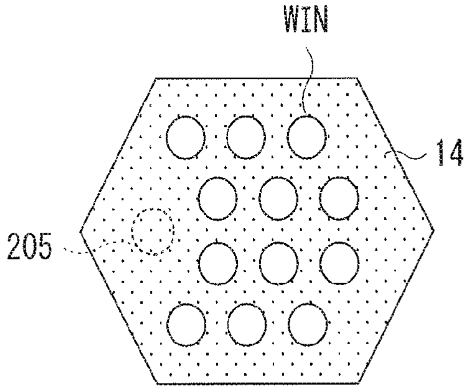


FIG. 37C

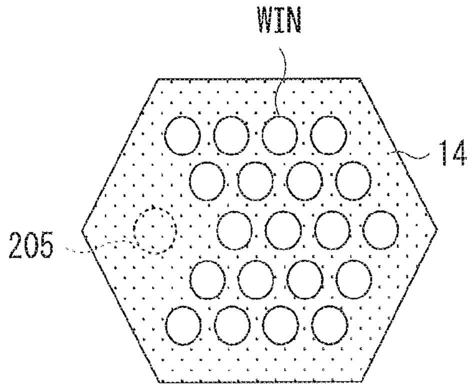


FIG. 37D

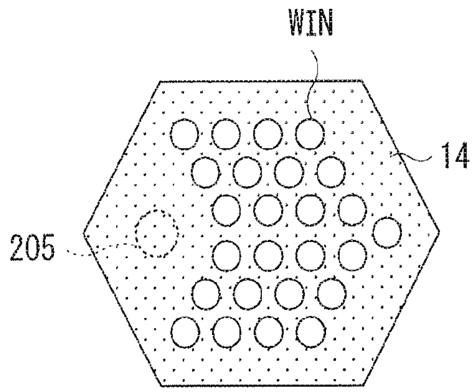


FIG. 37E

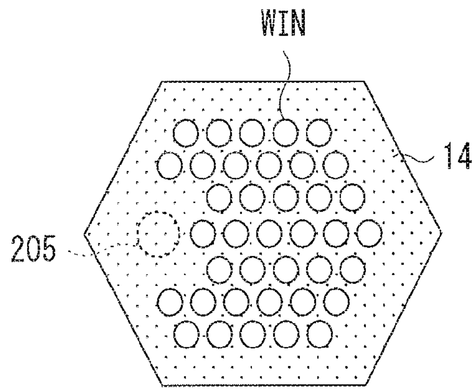


FIG. 37F

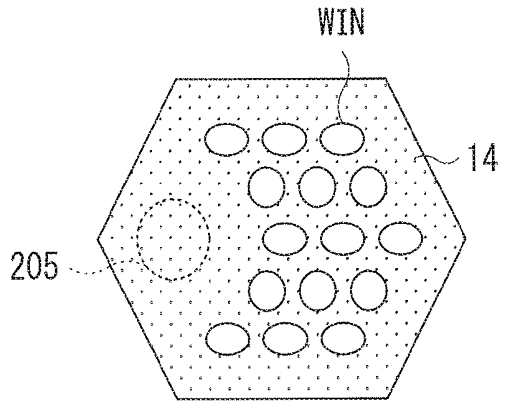


FIG. 38A

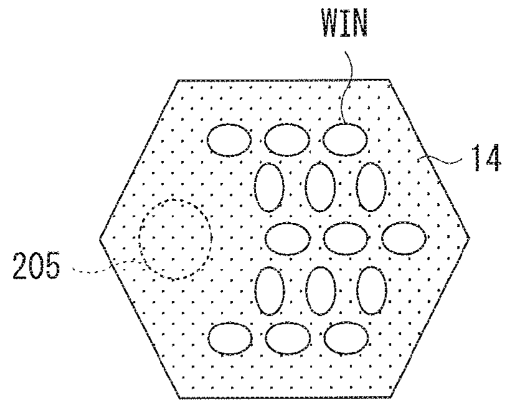


FIG. 38B

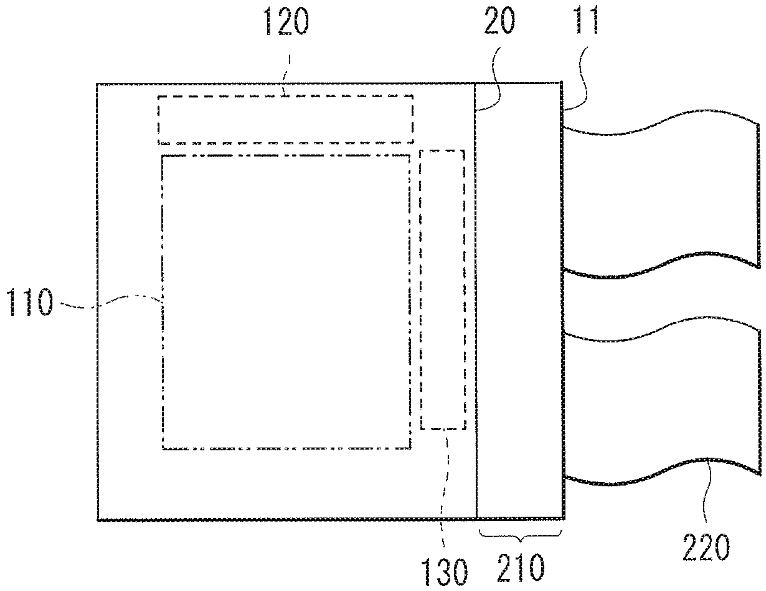


FIG. 39

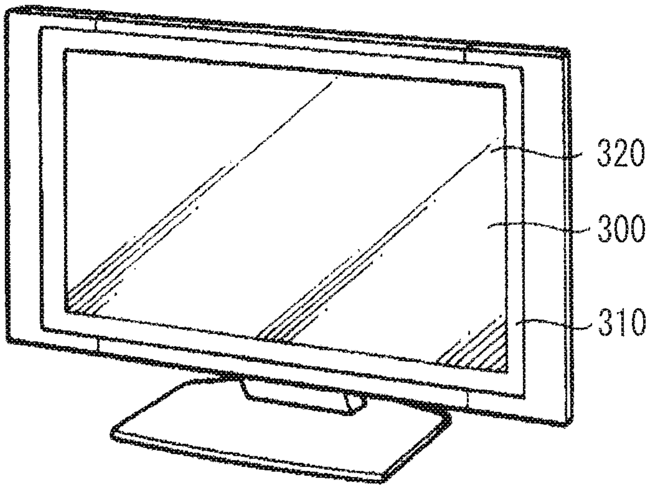


FIG. 40

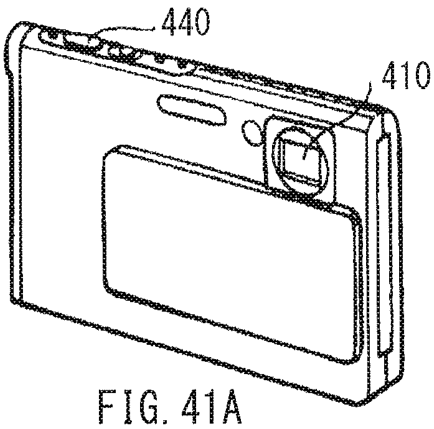


FIG. 41A

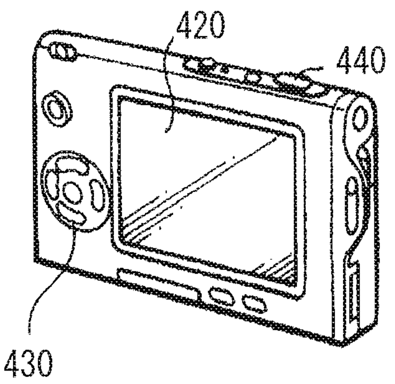


FIG. 41B

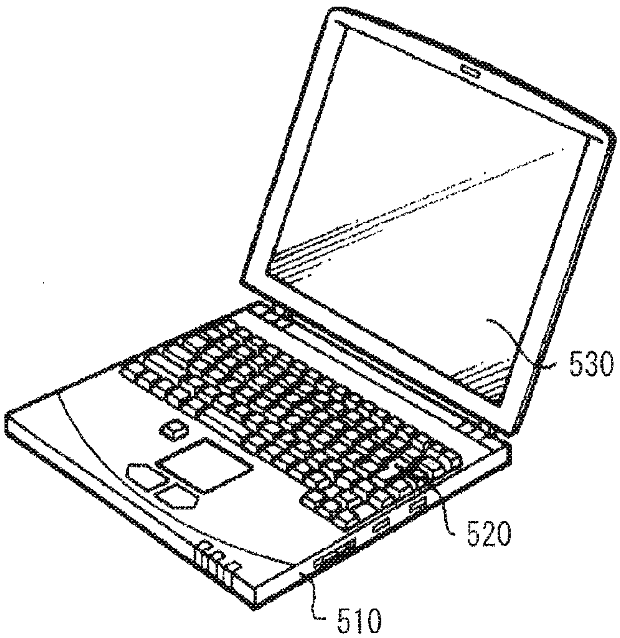


FIG. 42

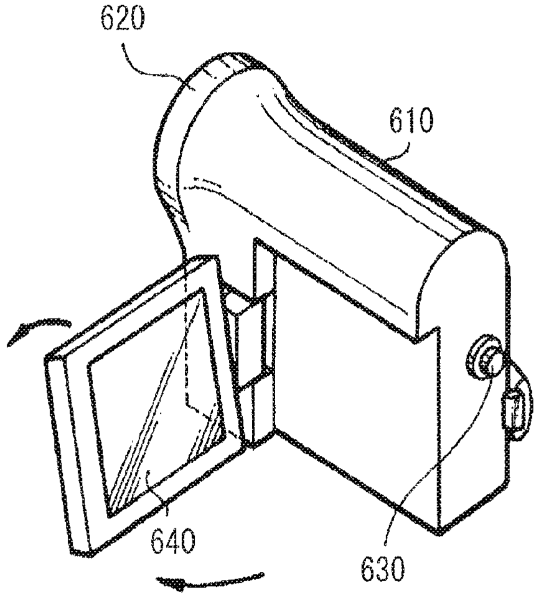


FIG. 43

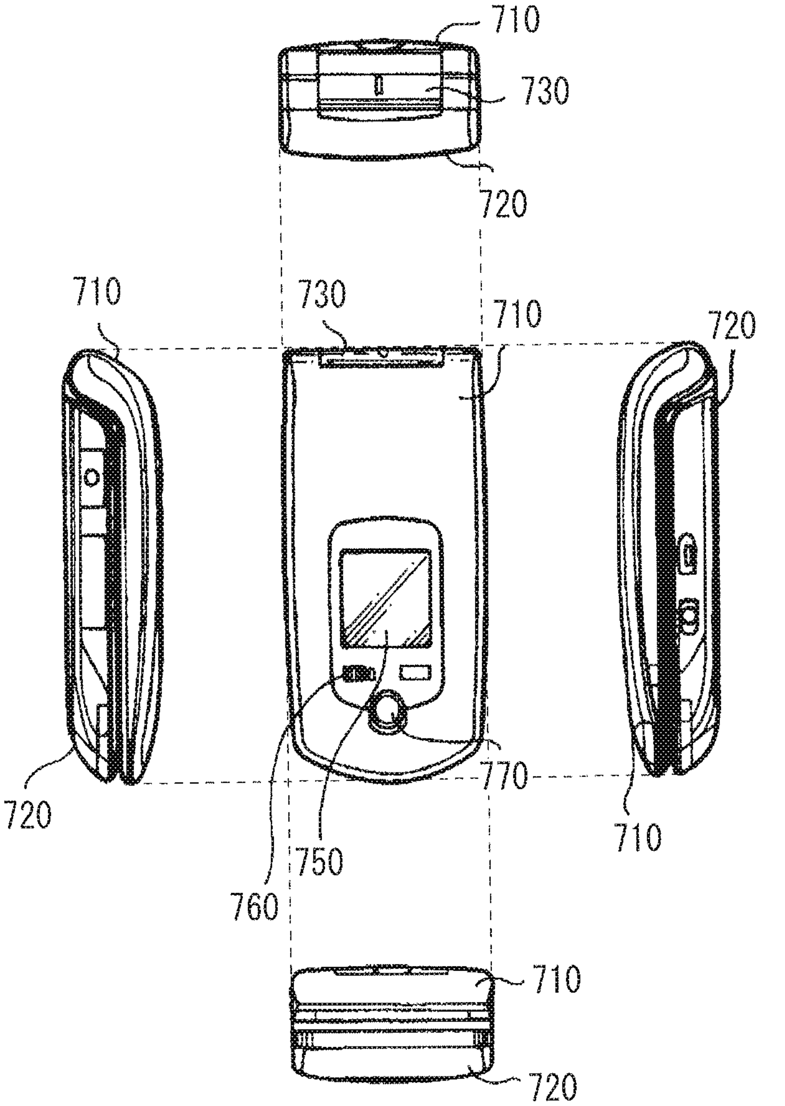


FIG. 44A

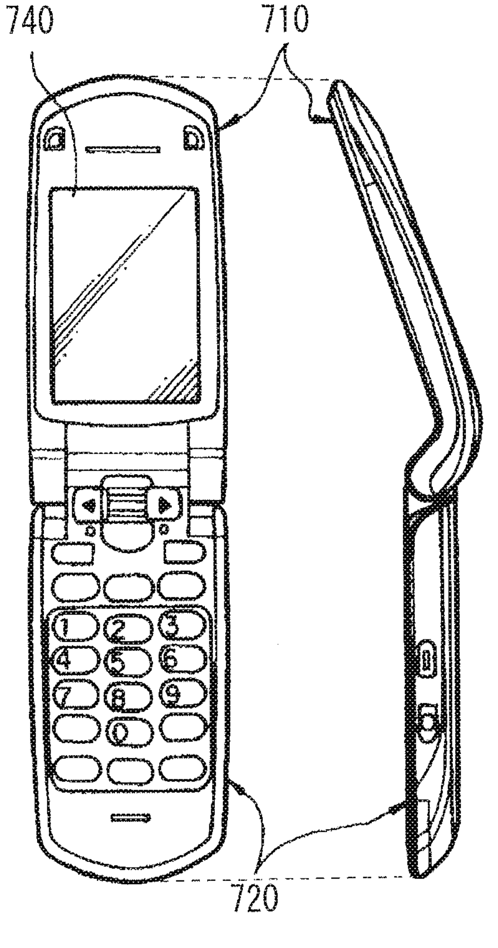


FIG. 44B

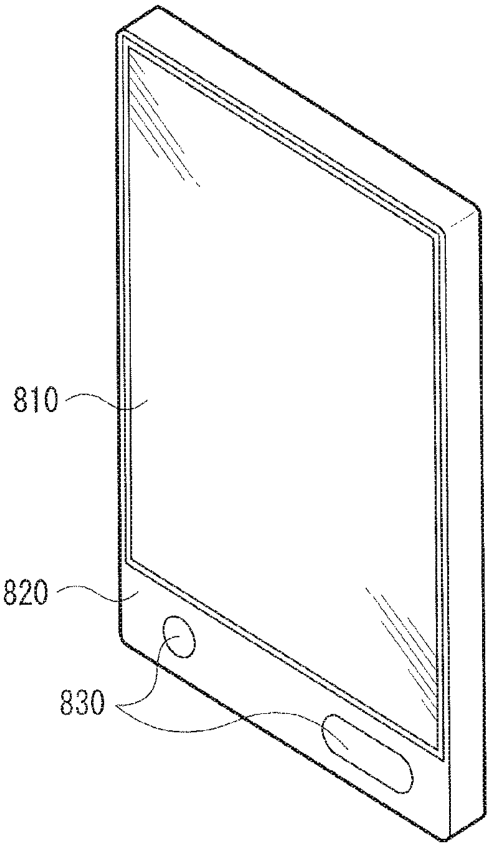


FIG. 45A

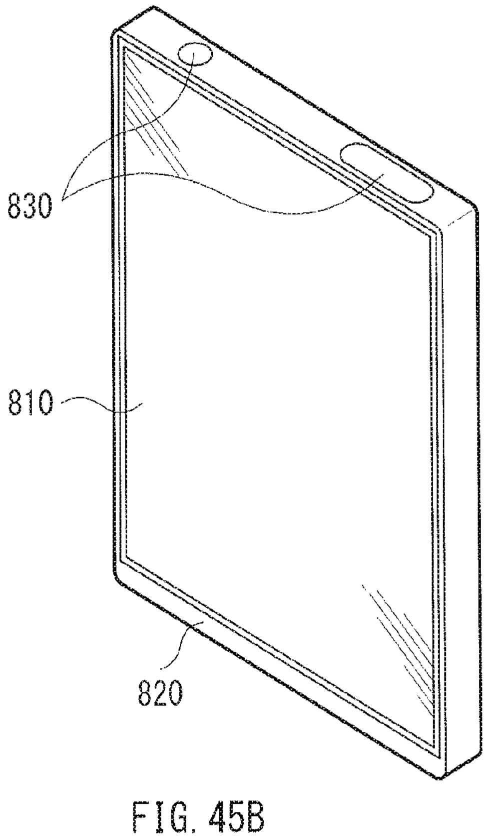


FIG. 45B

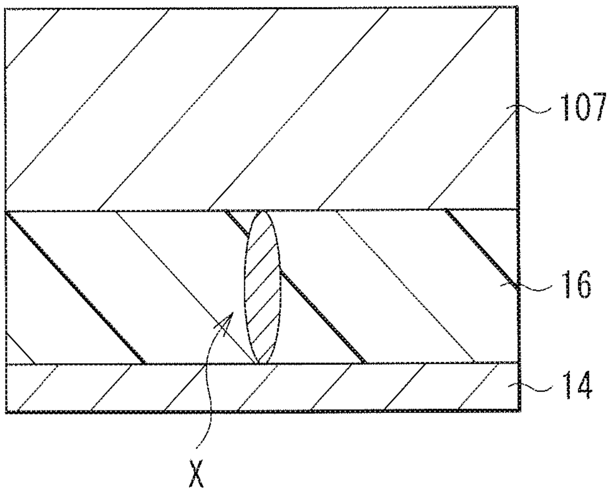


FIG. 46A

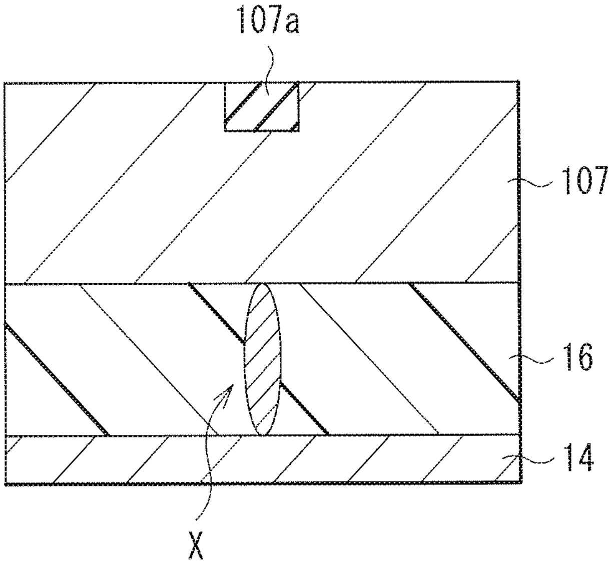


FIG. 46B

DISPLAY DEVICE AND ELECTRONIC APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Japanese Priority Patent Application JP 2013-225533 filed on Oct. 30, 2013, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] The present disclosure relates to a display device such as an organic EL (electroluminescence) display device, and to an electronic apparatus that includes the display device.

[0003] In recent years, in a field of display devices that perform image display, there has been developed and commercialized a display device (an organic EL display device) that uses, as a light-emission element, a current-driven optical element in which light-emission luminance is varied in response to a value of a flowing current, e.g., an organic EL element. Unlike a liquid crystal element, the light-emission element is a spontaneous light-emission element, and therefore an additional light source (a backlight) may be eliminated. Accordingly, the organic EL display device enjoys features such as high image visibility, low power consumption, and high response speed of the elements, compared to a liquid crystal display device accompanied with a light source.

[0004] Since such a display device has a configuration in which a light-emission layer (an organic electroluminescent layer) is interposed between electrodes (an anode and a cathode), an intrusion of a foreign matter into the organic layer during a manufacturing process may cause occurrence of a short-circuited path between the electrodes, which may lead to degradation in image quality. Thus, a repair technique of disconnecting the short-circuited path is proposed (for example, Japanese Unexamined Patent Application Publication No. 2005-340149).

SUMMARY

[0005] The method proposed in Japanese Unexamined Patent Application Publication No. 2005-340149 involves applying a reverse bias voltage between the electrodes to destroy or insulate the short-circuited portion. However, depending on a material or a thickness of the electrodes, the repair may be difficult in some cases. Hence, there has been a desire for an element structure capable of reducing an electrical influence due to an intrusion of a foreign matter and improving image quality.

[0006] It is desired to provide a display device that makes it possible to improve display image quality, and an electronic apparatus.

[0007] According to an embodiment (1) of the present disclosure, there is provided a display device including: a first electrode; an organic layer that is provided on the first electrode and includes a light-emission layer; and a second electrode that includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer.

[0008] According to an embodiment of the present disclosure, there is provided an electronic apparatus provided with a display device. The display device includes: a first electrode; an organic layer that is provided on the first electrode and includes a light-emission layer; and a second electrode that includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer.

[0009] In the display device according to the above-described embodiment (1) of the present disclosure and the electronic apparatus according to the above-described embodiment of the present disclosure, the second electrode includes the first conductive film and the second conductive film that are laminated in order on the organic layer. Thereby, during a manufacturing process, in a case of occurrence of a short-circuited path between the first electrode and the second electrode due to a foreign matter, the short-circuited path is allowed to be readily electrically-disconnected, and resistance of the second electrode is allowed to be easily lowered.

[0010] According to an embodiment (2) of the present disclosure, there is provided a display device including: a first electrode; an organic layer that is provided on the first electrode and includes a light-emission layer; and a second electrode that is provided on the organic layer and includes a local portion having higher resistance than that of another portion.

[0011] In the display device according to the above-described embodiment (2) of the present disclosure, the second electrode includes the local portion having higher resistance than that of another portion. Thus, during a manufacturing process, the short-circuited path between the first electrode and the second electrode due to a foreign matter is allowed to be readily electrically-disconnected, and resistance of the second electrode is allowed to be easily lowered.

[0012] According to the display device in the above-described embodiment (1) of the present disclosure and the electronic apparatus in the above-described embodiment of the present disclosure, the second electrode includes the first conductive film and the second conductive film that are laminated in order on the organic layer. It is therefore possible to reduce an electrical influence of a foreign matter and to allow resistance of the second electrode to be easily lowered. This makes it possible to improve image quality.

[0013] According to the display device in the above-described embodiment (2) of the present disclosure, the second electrode includes the local portion having higher resistance than that of another portion. It is therefore possible to reduce an electrical influence of a foreign matter and to allow resistance of the second electrode to be easily lowered. This makes it possible to improve image quality.

[0014] It is to be noted that the contents above are an example of the present disclosure. Effects of the present disclosure are not limited to those described above, and may be other different effects, or may further include other effects.

[0015] It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the technology as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments and, together with the specification, serve to explain the principles of the technology.

[0017] FIG. **1** illustrates a configuration of a display device according to an embodiment of the present disclosure.

[0018] FIG. **2** is a circuit diagram illustrating one example of a pixel drive circuit illustrated in FIG. **1**.

[0019] FIG. **3** is a cross-sectional view illustrating a configuration of the display device illustrated in FIG. **1**.

[0020] FIG. **4** schematically illustrates a subpixel layout illustrated in FIG. **1**.

[0021] FIG. **5** schematically illustrates layouts of a color filter layer, an organic layer (a light-emission layer), and bank apertures that constitute the pixel layout illustrated in FIG. **4**.

[0022] FIG. **6**A is a schematic cross-sectional view illustrating an example of a tandem configuration of an organic layer illustrated in FIG. **3**.

[0023] FIG. **6**B is a schematic cross-sectional view illustrating an example of a tandem configuration of the organic layer illustrated in FIG. **3**.

[0024] FIG. **7**A is a cross-sectional view illustrating a configuration of an organic EL element (without a foreign matter) illustrated in FIG. **3**.

[0025] FIG. **7**B is a cross-sectional view illustrating a configuration of an organic EL element (in a vicinity of a region where a foreign matter intrudes) illustrated in FIG. **3**.

[0026] FIG. **8**A is an enlarged cross-sectional view illustrating an example of a second electrode illustrated in FIG. **3**.

[0027] FIG. **8**B is an enlarged cross-sectional view illustrating an example of a second electrode illustrated in FIG. **3**.

[0028] FIG. **9** is a flowchart illustrating a flow of a manufacturing process of the display device illustrated in FIG. **3**.

[0029] FIG. **10**A is a cross-sectional view illustrating a process of forming the second electrode in the manufacturing process of the display device illustrated in FIG. **9**.

[0030] FIG. **10**B is a cross-sectional view illustrating a process following FIG. **10**A.

[0031] FIG. **10**C is a cross-sectional view illustrating a process following FIG. **10**B.

[0032] FIG. **11** is a functional block diagram illustrating an example of a system configuration including a repair device used in the manufacturing process illustrated in FIG. **9**.

[0033] FIG. **12** is a functional block diagram illustrating a configuration of the repair device illustrated in FIG. **11**, together with the pixel drive circuit.

[0034] FIG. **13**A is a circuit diagram illustrating a state of the pixel drive circuit and so on in display operation.

[0035] FIG. **13**B is a circuit diagram illustrating a state of the pixel drive circuit and so on in normal light-emission.

[0036] FIG. **13**C is a circuit diagram illustrating a state of the pixel drive circuit and so on in failure of normal light-emission (with an intrusion of a foreign matter).

[0037] FIG. **13**D is a circuit diagram illustrating a state of the pixel drive circuit and so on in repair operation.

[0038] FIG. **14** illustrates an example of a drive condition of a bias voltage in the repair operation.

[0039] FIG. **15**A schematically illustrates an example of a method of energizing a panel in the repair operation.

[0040] FIG. **15**B schematically illustrates an example of a method of energizing a panel in the repair operation.

[0041] FIG. **15**C schematically illustrates an example of a method of energizing a panel in the repair operation.

[0042] FIG. **15**D schematically illustrates an example of a method of energizing a panel in the repair operation.

[0043] FIG. **15**E schematically illustrates an example of a method of energizing a panel in the repair operation.

[0044] FIG. **16** schematically illustrates a subpixel layout according to a modification example 1-1.

[0045] FIG. **17** schematically illustrates layouts of the color filter layer, the organic layer (the light-emission layer), and the bank apertures that constitute the pixel layout illustrated in FIG. **16**.

[0046] FIG. **18** is a schematic cross-sectional view illustrating an example of the tandem configuration of the organic layer illustrated in FIG. **17**.

[0047] FIG. **19** schematically illustrates layouts of the color filter layer, the organic layer (the light-emission layer), and the bank apertures that constitute a pixel layout according to a modification example 1-2.

[0048] FIG. **20** is a schematic cross-sectional view illustrating an example configuration of separate forming of the organic layer illustrated in FIG. **19**.

[0049] FIG. **21** schematically illustrates layouts of the color filter layer, the organic layer (the light-emission layer), and the bank apertures that constitute a pixel layout according to a modification example 1-3.

[0050] FIG. **22** is a schematic cross-sectional view illustrating an example configuration of separate forming of the organic layer illustrated in FIG. **21**.

[0051] FIG. **23** schematically illustrates layouts of the color filter layer, the organic layer (the light-emission layer), and the bank apertures that constitute a pixel layout according to a modification example 1-4.

[0052] FIG. **24** is a schematic cross-sectional view illustrating an example configuration of separate forming of the organic layer illustrated in FIG. **23**.

[0053] FIG. **25** is a cross-sectional view illustrating an element configuration including an anode reflector according to a modification example 2.

[0054] FIG. **26** is a plan view illustrating an example of a layout of the apertures illustrated in FIG. **25**.

[0055] FIG. **27** is a cross-sectional view illustrating a configuration example of the aperture illustrated in FIG. **25**.

[0056] FIG. **28** illustrates rays in the aperture illustrated in FIG. **25**.

[0057] FIG. **29** is a plan view illustrating another example of a layout of the apertures illustrated in FIG. **25**.

[0058] FIG. **30**A is a plan view illustrating another example of the aperture illustrated in FIG. **25**.

[0059] FIG. **30**B is a plan view illustrating another example of the aperture illustrated in FIG. **25**.

[0060] FIG. **30**C is a plan view illustrating another example of the aperture illustrated in FIG. **25**.

[0061] FIG. **30**D is a plan view illustrating another example of the aperture illustrated in FIG. **25**.

[0062] FIG. **30**E is a plan view illustrating another example of the aperture illustrated in FIG. **25**.

[0063] FIG. **31** is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0064] FIG. **32** is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0065] FIG. **33**A is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0066] FIG. **33**B is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0067] FIG. **34** is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0068] FIG. **35** is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0069] FIG. **36**A is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0070] FIG. **36**B is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0071] FIG. **36**C is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0072] FIG. **36**D is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0073] FIG. **37**A is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0074] FIG. **37**B is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0075] FIG. **37**C is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0076] FIG. **37**D is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0077] FIG. **37**E is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0078] FIG. **37**F is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0079] FIG. **38**A is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0080] FIG. **38**B is a plan view illustrating another example of the layout of the apertures illustrated in FIG. **25**.

[0081] FIG. **39** is a plan view illustrating an overall configuration of a module including the display device illustrated in FIG. **1** and so on.

[0082] FIG. **40** is a perspective view illustrating a configuration of a television set.

[0083] FIG. **41**A is a perspective view illustrating a configuration of a digital still camera.

[0084] FIG. **41**B is a perspective view illustrating a configuration of a digital still camera.

[0085] FIG. **42** is a perspective view illustrating an appearance of a personal computer.

[0086] FIG. **43** is a perspective view illustrating an appearance of a video camera.

[0087] FIG. **44**A is a plan view illustrating a configuration of a mobile phone.

[0088] FIG. **44**B is a plan view illustrating a configuration of a mobile phone.

[0089] FIG. **45**A is a perspective view illustrating a configuration of a smart phone.

[0090] FIG. **45**B is a perspective view illustrating a configuration of a smart phone.

[0091] FIG. **46**A schematically illustrates a manufacturing process of an organic EL element according to a comparative example.

[0092] FIG. **46**B schematically illustrates the manufacturing process of the organic EL element according to the comparative example.

DETAILED DESCRIPTION

[0093] In the following, some embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. It is to be noted that description will be made in the following order.

[0094] 1. Embodiment (one example of a display device that includes a two-layered second electrode, the second electrode including an insulated (high-resistance) portion in a local region on a light-emission layer side)

[0095] Configuration

[0096] Manufacturing method (including a repair process)

[0097] 2. Modification Example 1-1 to 1-4 (other examples of a subpixel layout)

[0098] 3. Modification Example 2 (one example of an anode reflector)

[0099] 4. Application Example (examples of electronic apparatuses)

Embodiment

Configuration

[0100] FIG. **1** illustrates a configuration of a display device (a display device **1**) according to an embodiment of the present disclosure. The display device **1** is, for example, an organic EL display device, and includes a display region **110** on a substrate **11**, in which a plurality of pixels (subpixels) PXLC are arrayed, for example, in a matrix. Each of the pixels PXLC includes an organic EL element **10**A and is configured to produce, for example, red light LR (of a wavelength of 620 nm to 750 nm both inclusive), green light LG (of a wavelength of 495 nm to 570 nm both inclusive), blue light LB (of a wavelength of 450 nm to 495 nm both inclusive), or white light LW. Here, description is given on an example in which a unit of these four kinds of pixels PXLC (an R pixel, a G pixel, a B pixel, and a W pixel) constitutes one pixel. In a periphery of the display region **110**, provided are a signal line drive circuit **120** and a scan line drive circuit **130**.

[0101] In the display region **110**, provided is, for example, an active matrix drive circuit (a pixel drive circuit **140**). The pixel drive circuit **140** includes, as illustrated in FIG. **2**, a transistor Tr**1** for driving and a transistor Tr**2** for writing, with a capacitor Cs provided between the transistors Tr**1** and Tr**2**. Between a first power supply line (Vcc) and a second power supply line (GND), the organic EL element **10**A is connected in series to the transistor Tr**1**. The signal line drive circuit **120** is configured to supply image signals to source electrodes of the transistors Tr**2** through a plurality of signal lines **120**A arranged in a column direction. The scan line drive circuit **130** is configured to supply, in order, scan signals to gate electrodes of the transistors Tr**2** through a plurality of scan lines **130**A arranged in a row direction.

[0102] FIG. **3** illustrates in section a configuration of the display device illustrated in FIG. **1**. It is to be noted that FIG. **3** illustrates a region corresponding to the pixels PXLC of the above-mentioned four colors. The display device **1** is an organic EL display device of a so-called top-emission type (an upper-surface-light-emission type), in which, for example, light produced in the organic EL element **10**A is extracted upward of a sealing substrate **20**. The organic EL element **10**A has an element configuration in which white light is produced. White light produced in each of the organic EL elements **10**A passes through a color filter layer **19** (color filters **19**R, **19**G, **19**B, and **19**W) to allow the above-mentioned light LR, LG, LB, and LW to be emitted.

[0103] The organic EL element **10**A is provided between a driver substrate **10** and the sealing substrate **20**. The driver substrate **10** is provided, on the substrate **11**, with the pixel drive circuit **140** that is configured to drive each of the organic EL elements **10**A (FIG. **3** illustrates a TFT **12** that serves as the above-mentioned transistor Tr**1**). A surface of the driver substrate **10** is covered with a planarization layer **13**. On the planarization layer **13**, provided is a first electrode **14** as, for example, an anode. The first electrode **14** is electrically connected to the TFT **12** provided on the driver substrate **10**.

[0104] In the organic EL elements **10**A, the first electrode **14**, a bank (an inter-pixel insulating film) **15**, an organic layer **16** including a light-emission layer, and a second electrode **17**

as, for example, a cathode are laminated in the order from the driver substrate **10** side. Above the organic EL elements **10**A, the sealing substrate **20** is bonded with a protective layer **18** in between. The sealing substrate **20** is provided with a color filter layer **19** that includes the color filters **19**R, **19**G, **19**B, and **19**W, and a black matrix layer BM. In the color filter layer **19**, the black matrix layer BM is formed in a lattice shape, and the color filters **19**R, **19**G, **19**B and **19**W is formed in apertures in the lattice shape of the black matrix layer BM.

[0105] FIG. **4** illustrates an example of a layout of the pixels PXLC including the organic EL elements **10**A. As illustrated, for example, the four pixels PXLC of R, G, B, and W are arranged in an array of two rows and two columns (in a shape of a crossed square), and the four pixels PXLC constitute a display unit U (one pixel).

[0106] FIG. **5** illustrates an example of layouts of the color filter layer **19**, the organic layer **16** (specifically, the organic electroluminescent layer) and apertures WIN (apertures of the bank **15**) that constitute the above-mentioned four pixels PXLC. As illustrated, in the example embodiment, a color arrangement (R, G, B, W) of the color filter layer **19** corresponds to a layout of the pixels PXLC, and the organic layer **16** includes a white light-emission layer (W) that is common to the four pixels PXLC. The apertures WIN of the bank **15** are provided in one-to-one correspondence with the pixels PXLC.

[0107] In the following, description is given on a configuration of each portion of the display device **1**.

[0108] The substrate **11** is configured of, for example, glass, silicon (Si), a resin or a conductive substrate and so on. The conductive substrate may be used, for example, with its surface insulated by silicon oxide (SiO_2), a resin or the like.

[0109] The TFT **12** is a thin film transistor (TFT), for example, of a bottom gate type, and is configured of, for example, a metal oxide semiconductor field effect transistor (MOSFET). In the TFT **12**, on the substrate **11**, a gate electrode **121** that is patterned, for example, with an insulating film in between, a gate insulating film **122**, a semiconductor thin film **123** (for example, polisilicon) that constitutes a channel, an interlayer insulating film **124** are laminated in the order. A source electrode **125***a* and a drain electrode **125***b* are formed on the respective end side of the semiconductor layer **123**. To the drain electrode **125***b*, the first electrode **14** is electrically connected. It is to be noted that the transistor Tr**1** is not limited to that of a bottom gate type, but may be that of a top gate type. The semiconductor thin film **123** may be configured of crystalline silicon or amorphous silicon, or may be configured of oxide semiconductor.

[0110] The planarization film **13** is provided for planarization of the surface of the driver substrate **10**, and allows each layer of the organic EL element **10**A to be formed with a uniform thickness. The planarization film **13** is provided with a contact hole that electrically connects the first electrode **14** and the drain electrode **125***b* of the TFT **12**, and has a function of preventing them from coming into unintended contact. Examples of constituent materials of the planarization film **13** may include organic materials such as a polyimide resin, an acrylic resin, and a novolac resin, or inorganic materials such as silicon oxide (SiO_2), silicon nitride (SiNx) or silicon oxynitride (SiON).

[0111] The first electrode **14** is provided to be electrically insulated for each pixel, and has, for example, light-reflectivity. The first electrode **14** preferably has as high light-reflectivity as possible for improving light-emission efficiency. Since the first electrode **14** serves as an anode, a material with high hole-injection ability is preferable. Examples of constituent materials of the first electrode **14** may include a single substance or an alloy of metal elements such as chromium (Cr), gold (Au), platinum (Pt), nickel (Ni), copper (Cu), molybdenum (Mo), tungsten (W), titanium (Ti), tantalum (Ta), or silver (Ag) and so on. On a surface of the first electrode **14**, a transparent conductive film such as an oxide of indium and tin (ITO) may be provided. A thickness of the first electrode **14** may be appropriately set so as to balance wiring resistance against light-reflectivity (surface roughness).

[0112] Other than the above-described materials, a single substance or an alloy of aluminum may be used. Aluminum has high light-reflectivity, but a hole injection barrier may be formed due to a low work function. However, aluminum may be used as the first electrode **14** by providing an appropriate hole injection layer. The first electrode **14** may be a single-layer film or a layered film of a single substance or an alloy of the above-mentioned metals.

[0113] The bank **15** is configured to electrically separate the first electrode **14** for each pixel, and ensure insulation between the first electrode **14** and the second electrode **17**. The bank **15** has the apertures WIN in selective regions that each face the first electrode **14**, and defines a light-emission region of each of the organic EL elements **10**A. The bank **15** is configured of an insulating material such as, for example, silicon oxide, polyimide, or a photosensitive resin.

[0114] The organic layer **16** includes the light-emission layer (the organic electroluminescent layer). Here, the organic layer **16** is a white light-emission layer that is common to the organic EL elements **10**A. The organic layer **16** may include, for example, a hole transport layer (HTL), a hole injection layer (HIL), and an electron transport layer (ETL) and so on, as well as the light-emission layer. An electron injection layer (EIL) such as LiF may be provided between the organic layer **16** and the second electrode **17**.

[0115] Specifically, as illustrated in FIG. **6**A, the organic layer **16** (the light-emission layer) includes, for example, a yellow light-emission layer **16**Y and a blue light-emission layer **16**B that are laminated in the order from the first electrode **14** side. The yellow light-emission layer **16**Y includes a material that is configured to produce yellow (Y) light by recombination of paired electron-holes. The blue light-emission layer **16**B includes a material that is configured to produce blue (B) light by recombination of paired electron-holes. The light of respective colors from the yellow light-emission layer **16**Y and the blue light-emission layer **16**B is color-mixed to allow white light as a whole to be emitted from the organic layer **16**.

[0116] The lamination order of the yellow light-emission layer **16**Y and the blue light-emission layer **16**B in the organic layer **16** may be inverted from as described above. Specifically, the blue light-emission layer **16**B may be disposed on the first electrode **14** side, and the yellow light-emission layer **16**Y may be disposed on the second electrode **17** side. The constituent material of the yellow light-emission layer **16**Y is not limited to a material that configured to produce yellow (Y) light as described above, but may be other materials. For example, as the yellow light-emission layer **16**RG illustrated in FIG. **6**B, the yellow light-emission layer **16**Y may be configured of a material that is configured to produce red (R) light doped with a material that is configured to produce green

(G) light. Also in this example, the lamination order of the yellow light-emission layer **16**RG and the blue light-emission layer **16**B may be inverted.

[0117] The second electrode **17** has light-transmittance, and for example, provided over an entire surface of the display region, commonly to the organic EL elements **10**A. The second electrode **17** is configured of, for example, a transparent conductive film such as indium zinc oxide (IZO) or a translucent conductive film. Other examples of a constituent material of the transparent conductive film may include indium tin oxide (ITO), zinc oxide (ZnO), alumina-doped zinc oxide (AZO), gallium-oxide-doped zinc oxide (GZO), or indium titanium oxide (ITiO) and so on. The second electrode **17** may be formed, for example, by a sputtering method.

[0118] FIG. **7**A illustrates, in an enlarged manner, an element configuration of the organic EL element **10**A. In the example embodiment, the second electrode **17** has a multilayered structure including the transparent conductive film as described above. Specifically, in the second electrode **17**, a first conductive film **17**A and a second conductive film **17**B are laminated in the order from the organic layer **16** side. Among them, the first conductive layer **17**A is formed before a repair process, which is to be described later. The second conductive layer **17**B is formed after the repair process. For example, the first conductive layer **17**A and the second conductive layer **17**B are both configured of the transparent conductive films as described above. Here, the first conductive film **17**A and the second conductive film **17**B are configured of the same material (for example, IZO).

[0119] However, in the second electrode **17**, the first conductive film **17**A and the second conductive film **17**B may be configured of different materials from each other. For example, the first conductive film **17**A may include an alloy of magnesium and silver (Mg—Ag, magnesium-silver), and the second conductive film **17**B may include a transparent conductive film such as IZO. Since Mg—Ag is allowed to be translucent by thinning, Mg—Ag is used in a case of utilizing an optical resonance phenomenon by a micro cavity, which is to be described later. Alternatively, one of the first conductive film **17**A and the second conductive film **17**B may be a transparent conductive film, and another may be a metal film. For example, in a case of adopting an element configuration of a bottom-emission type and so on, the first conductive film **17**A may be a transparent conductive film, and the second conductive film **17**B may be a reflective metal film similarly to the first electrode **14**.

[0120] A thickness of the first conductive film **17**A may be smaller than a thickness of the second conductive film **17**B. Specifically, the first conductive film **17**A may have a thickness (of, for example, a few nanometers to several tens of nanometers both inclusive) with which the first conductive film **17**A is allowed to have sufficiently high resistance (or to be insulated) in the repair process (a dark spot eliminating process), which is to be described later. The second conductive layer **17**B may have a thickness (of, for example, several tens of nanometers to several hundreds of nanometers both inclusive) with which the second conductive film **17**B is allowed to have a desired resistance value. Thus, the first conductive film **17**A may be a thin film having a thickness that is equal to or smaller than, for example, about one tenth of the thickness of the second conductive film **17**B.

[0121] FIG. **7**B illustrates, in an enlarged manner, an element configuration of the organic EL element **10**A (in the vicinity of a foreign matter X). As illustrated, in a case that a foreign matter X intrudes into the organic layer **16**, the second electrode **17** includes an insulated (high-resistance) portion **17*a*1** (a local portion) in a region corresponding to the foreign matter X. The insulated portion **17*a*1** is formed in the repair process, which is to be described later, and has a function of electrically disconnecting a short-circuited path between the first electrode **14** and the second electrode **17** due to the foreign matter X. The insulated portion **17*a*1** is provided in a scattered state, within a surface of, for example, the second electrode **17**, at a plurality of spots corresponding to a plurality of foreign matters X. The insulated portion **17*a*1** is formed selectively in the first conductive layer **17**A out of the first conductive layer **17**A and the second conductive layer **17**B.

[0122] FIGS. **8**A and **8**B illustrate, in an enlarged manner, an interface in the second electrode **17**. As illustrated in FIG. **8**A, in the second electrode **17**, an oxide film **17**C may be formed between the first conductive film **17**A and the second conductive film **17**B. The oxide film **17**C may be a thin film (a coating film) generated by oxidation of a surface of the first conductive film **17**A, and may be generated along with formation of the above-mentioned insulated portion **17*a*1**. To allow the electrical resistance of the oxide film **17**C to be as low as possible, conditions in the repair process, which is to be described later, may be set appropriately.

[0123] Alternatively, as illustrated in FIG. **8**B, the first conductive film **17**A and the second conductive film **17**B may be adjacently laminated (with the oxide film **17**C removed). Thus, it is possible to eliminate resistance due to the oxide film **17**C, which is advantageous in reducing the resistance of the second electrode **17**.

[0124] The protective film **18** may be configured of, for example, silicon nitride, silicon oxide, a metal oxide, and so on. It is to be noted that an adhesive layer configured of, for example, a thermosetting resin or an ultraviolet curing resin may be provided between the protective film **18** and the sealing substrate **20**.

[0125] The sealing substrate **20** is configured of a material (specifically, glass) that is transparent to light passing through the color filters **19**R, **19**G, **19**B, and **19**W. The color filter layer **19** may be provided either on a light-incident side (an element side) or on a light-exit side of the sealing substrate **20**. For example, they are provided on the light-incident side. The color filters **19**R, **19**G, **19**B, and **19**W each are provided to face the organic EL element **10**A. The color filters **19**R, **19**G, and **19**B are configured to selectively allow red light, green light, and blue light to pass through. The color filter **19**W is provided for obtaining, for example, a desired whiteness, and is a filter that adjusts chromaticity or luminance. It is to be noted that the color filter **19**W may be omitted.

[Manufacturing Method]

[0126] FIG. **9** illustrates a flow of a manufacturing process of the display device **1** as described above (a manufacturing process of the organic EL element **10**A). As illustrated, first, the driver substrate **10** is formed (step S**1**). Specifically, on the substrate **11**, by, for example, a low-temperature polisilicon process, the pixel drive circuit **140** is formed that includes the transistors Tr**1** and Tr**2**, and the capacitor Cs and so on as described above. After this, the planarization film **13** is formed on an entire surface of the substrate **11**, and then, the planarization film **13** is patterned to form contact holes and so on.

[0127] After this, on the planarization film **13** of the driver substrate **10**, the first electrode **14** is formed (step S2). Specifically, for example, on the planarization film **13**, the first electrode **14** configured of the above-mentioned material is formed by, for example, sputtering method, and then, the first electrode **14** is patterned by, for example, etching with the use of photolithography.

[0128] Subsequently, the bank **15** is formed (step S**3**). Specifically, the above-described insulating material is formed and then patterned to form the apertures WIN in the regions that each face the first electrode **14**.

[0129] After this, the organic layer **16** is formed (step S4). Specifically, the white light-emission layer configured of the above-mentioned materials or the like is formed by, for example, a vacuum evaporation method. At this time, the hole injection layer, the hole transport layer, and the electron transport layer may be continuously formed by a vacuum consistent process.

[0130] Next, the second electrode **17** is formed (step S5). Specifically, first, as illustrated in FIG. **10**A, the first conductive film **17**A configured of the above-mentioned materials or the like is formed by, for example, a sputtering method or the like (step S**51**). After this, as illustrated in FIG. **10**B, a reverse bias voltage is applied (step S**52**) between the first conductive film **17**A thus formed and the first electrode **14** in a predetermined oxygen atmosphere. Thus, a short-circuited path due to the foreign matter is electrically disconnected to remove (to repair) a portion that is to become a dark spot (a dark spot pixel). Subsequently, as illustrated in FIG. **10**C, the second conductive film **17**B configured of the above-mentioned materials or the like is formed by, for example, a sputtering method or the like (step S**53**). It is to be noted that, in the process of forming the second electrode **17**, the repair process (step S**52**) is to be described later.

[0131] Subsequently, on the second electrode **17**, the protective film **18** is formed (step S6) by, for example, a chemical vapor deposition (CVD) method. Finally, the sealing substrate **20** on which the color filter layer **19** is formed is bonded (step S7). Thus, the display device **1** as illustrated in FIG. **3** is completed.

[Repair Process]

[0132] FIG. **11** illustrates a system configuration including a repair device (a repair device **41**) used in the process of applying the reverse bias voltage. The repair device **41** is connected to an external power source **40**, and is configured to energize a panel **43** mounted in a mounting section **42** based on power supplied from the external power source **40**. The mounting section **42** is provided for placing the panel **43** on a predetermined place, and may include, for example, a hotplate and so on. Here, the panel **43** as an object-to-be-repaired is in a semi-finished product state in the manufacturing process. Specifically, the panel **43** is an element substrate in a state that the first electrode **14**, the bank **15**, the organic layer **16**, and the first conductive film **17**A are formed on the driver substrate **10** on which the pixel drive circuit **140**, the scan line drive circuit **130**, and the signal line drive circuit **120** are formed (in a state before a signal line driver IC and so on are connected). FIG. **12** illustrates a functional configuration of the repair device **41** together with a configuration of the pixel drive circuit **140** and the scan line drive circuit **130**.

(1 Configuration of Repair Device)

[0133] The repair device **41** may include, for example, a vertical drive condition generation circuit **44**, a bias voltage generation circuit **45**, a bias voltage drive circuit **46**, an element-to-be-repaired selection control circuit **47**, and a repair signal potential generation circuit **48**. The repair device **41** is, for example, configured to perform a repair operation of a dark spot by supplying a repair signal to the pixel drive circuit **140** in a specific region, with the signal line drive circuit **120** in the panel **43** (the display device **1**) suspended, and by applying the reverse bias voltage to the organic EL element **10**A.

[0134] The vertical drive condition generation circuit **44** is configured to generate two kinds of selection signal potentials (H level and L level) that satisfy drive conditions desired in the repair, and a clock signal. The selection signal potential (H level) is a signal potential (a high level) used to control the pixel drive circuit **140** in a selected state, and may be, for example, 17 V. The selection signal potential (L level) is a signal potential (a low level) used to control the pixel drive circuit **140** in a non-selected state, and may be, for example, −3 V. The two kinds of selection signal potentials are configured to be applied to the scan lines **130**A through the scan line drive circuit **130**. The clock signal is configured to be generated for scanning operation of the scan line drive circuit **130**. The clock signal may be similar to that used in a normal display operation. It is to be noted that a clock signal dedicated to the repair operation may be generated to control a specific selected line in a selected state for a long time.

[0135] The bias voltage generation circuit **45** is configured to generate a power supply voltage Vcc and a cathode line voltage Vcat. The power supply voltage Vcc is configured to be supplied to the anode side of the organic EL element **10**A through a power supply line **46**A. The cathode line voltage Vcat is configured to be supplied to the cathode side of the organic EL element **10**A through a cathode voltage supply line **46**B. Thus, in the repair operation, the reverse bias voltage (where Vcc is smaller than Vcat ($Vcc<Vcat$)) is applied to the organic EL element **10**A, while, in a display operation, a forward bias voltage (where Vcc is larger than Vcat ($Vcc>Vcat$)) is applied to the organic EL element **10**A.

[0136] As an example, a potential of, for example, 5 V is generated as the power supply voltage Vcc, while two kinds of potentials of, for example, 0 V and 10 V are generated as the cathode line voltage Vcat. The two kinds of potentials are provided for alternate application of the reverse bias voltage (in the repair operation) and the forward bias voltage (in the display operation). However, the voltage applied is not limited to an alternative voltage, but may be a direct voltage. For example, in a case of direct application of the reverse bias voltage, for example 10 V may be generated as the cathode line voltage Vcat. By applying 5 V to the power supply line **46**A while applying 10 V to the cathode voltage supply line **46**B, the reverse bias voltage of 5 V is applied to the organic EL element **10**A.

[0137] The bias voltage drive circuit **46** is configured to alternately apply, for example, 0 V and 10 V to the cathode voltage supply line **46**B. In other words, the bias voltage drive circuit **46** is configured to alternately apply the forward bias voltage and the reverse bias voltage to the organic EL element **10**A. Alternately driving the cathode line voltage Vcat is for charging a capacitor component parasitic on the organic EL element **10**A to allow a current to easily flow into a short-circuit that causes a dark point.

[0138] The element-to-be-repaired selection control circuit **47** is used to control turning on or off a select transistor Tr**3**. In other words, the element-to-be-repaired selection control circuit **47** is used for application of the reverse bias voltage to a selective pixel or selective pixels. As to a control signal here, there may be generated as many control signals as the element-to-be-repaired selection lines **47**A.

[0139] The element-to-be-repaired selection control circuit **47** is configured, in the repair operation, to turn on the select transistor Tr3 of the signal line **120**A regarding the element-to-be-repaired (to turn the select transistor Tr**3** into a closed state), allowing the signal line **120**A to be connected to a signal line for repair **48**A. On the other hand, in the display operation, the element-to-be-repaired selection control circuit **47** is configured to turn off all the select transistors Tr**3** (to turn all the select transistors Tr**3** into an opened state), allowing the signal line **120**A and the signal line for repair **48**A to be in a disconnected state.

[0140] It is to be noted that the element-to-be-repaired selection line **47**A may be arranged in one-to-one correspondence with the signal line **120**A. Alternatively, one element-to-be-repaired selection line **47**A may be arranged for a plurality of signal lines **120**A. For example, an effective display region may be divided in two, i.e. the right region and the left region, and two element-to-be-repaired selection lines **47**A may be arranged to correspond to the respective regions thus divided. Further, for example, with a plurality of subpixels that constitute one pixel considered as a unit, the element-to-be-repaired selection line **47**A may be arranged for each unit. In these cases, it is possible to perform the repair in region unit or in pixel unit. That is, by appropriately setting a combination of the element-to-be-repaired selection control circuit **47**, the element-to-be-repaired selection line **47**A, and the select transistor Tr**3**, it is possible to apply a potential that satisfies a repair condition to a specific region.

[0141] The repair signal potential generation circuit **48** is configured to generate a signal potential for repair that is applied to the signal line **120**A selected by the element-to-be-repaired selection control circuit **47** and the select transistor Tr**3**. For example, 17 V is generated as black level (for non-repair), and 0 V is generated as white level (for repair). As to a signal potential here, there may be generated as many signal potentials as the signal lines for repair **48**A. In this connection, in the display operation, the signal line **120**A is supplied with a potential of, for example, 5 V as black level and 1.5 V as white level.

[0142] It is to be noted that the signal line for repair **48**A may be arranged in one-to-one correspondence with the signal line **120**A. Alternatively, one signal line for repair **48**A may be arranged for a plurality of signal lines **120**A. For example, with a plurality of subpixels that constitute one pixel considered as a unit, the signal line for repair **48**A may be arranged for each unit. Further, for example, the signal line for repair **48**A may be arranged for each color pixel, i.e. R, G, B, and W. In other words, the signal line for repair **48**A may be arranged for each color, commonly to the pixels in the same color.

[0143] A signal potential applied to the signal line for repair **48**A may be, for example, a direct voltage. In a case of application of a direct voltage, it is possible to apply a constant repair signal (voltage) to the whole display. Alternatively, the signal potential applied to the signal line for repair **48**A may be, for example, a pulsed repair signal (voltage) that is synchronized with the scan line drive circuit **130**. In this case, it is possible to apply a constant repair signal (voltage) to a specific scan line (one selected line).

[0144] It is to be noted that the repair device **41** may be also used for inspection of a portion-to-be-repaired. In this case, the repair device **41** is configured to generate a potential for the display operation. For example, the vertical drive condition generation circuit **44** generates, for example, 7 V as a high potential and −8 V as a low potential. The bias voltage generation circuit **45** generates fixedly, for example, 5 V as the power supply voltage Vcc and −8 V as the cathode line voltage Vcat.

[0145] Thus, by performing inspection by the display operation using the repair device **41** to identify a portion of a dark spot or a dark spot pixel, it is possible to allow a specific region to be repaired. In this way, it is possible to allow the reverse bias voltage not to be applied to a portion or a pixel without the foreign matter (a portion that is not to become a dark spot). This enables effective repair operation. Also, it is possible to reduce damage to the organic layer **16** due to unnecessary application of the reverse bias voltage.

(2 Repair Operation)

[0146] Prior to the repair operation, description is given on a case that the organic EL element **10**A is allowed to emit light (the display operation of the organic EL element **10**A). FIG. **13**A illustrates an operation state of the pixel drive circuit **140** in the display operation, together with the element-to-be-repaired selection line **47**A, the select transistor Tr**3**, and the signal line for repair **48**A. FIG. **13**B illustrates an operation state in a case of the normal light-emission in the display operation. It is to be noted that the transistors Tr**1** to Tr**3** are denoted by a circuit symbol for a switch, for indicating an ON/OFF state (an opened/closed state). In the display operation, in the pixel drive circuit **140**, by the scan line drive circuit **130**, an ON voltage is applied to the scan line **130**A, and the transistor Tr**2** is controlled into an ON state. Thus, signal data that is supplied from the signal line drive circuit **120** through the signal line **120**A is applied to a gate of the transistor Tr**1**. At this time, the signal data is stored in the storage capacitor Cs. The signal data is stored even after the transistor Tr**2** is switched to an OFF state. As a result, a drain current Ids corresponding to a gate-source voltage Vgs is allowed to continuously flow through the transistor Tr**1**. The drain current Ids is supplied to the organic EL element **10**A, allowing the organic EL element **10**A to continuously emit light.

[0147] In the display operation, the power supply voltage Vcc is, for example, 5 V, and the cathode line voltage Vcat is, for example, −8 V (Vcat is smaller than Vcc (Vcat<Vcc)). In other words, the forward bias voltage is applied to the organic EL element **10**A. In the normal light-emission, as illustrated in FIG. **13**B, the organic EL element **10**A may be denoted by a diode-connected transistor Tr**4** and a parasitic capacitor component C**1**.

[0148] By the way, in actuality, some of the organic EL elements **10**A do not emit light normally due to the intrusion of the foreign matter or the like. FIG. **13**C illustrates an example of an equivalent circuit in a case that the organic EL element **10**A does not emit light normally. In this case, the organic EL element **10**A may be denoted by the diode-connected transistor Tr**4**, the parasitic capacitor component C**1**, and a resistor component R**1**.

[0149] In a case like this, the drain current Ids flows through the resistor component R**1**, and does not flow (or rarely flows) through the transistor Tr**4**. Consequently, the organic layer **16** is not supplied with the drain current Ids, suppressing an organic electroluminescent phenomenon. This is a principle of occurrence of a dark spot (a dark spot pixel). The repair operation of such a dark spot may be carried out, for example, as follows.

(Repair Operation by Alternative Reverse Bias Drive)

[0150] FIG. **13**D illustrates an operation state of the pixel drive circuit **140** in the repair operation, together with the element-to-be-repaired selection line **47**A, the select transistor Tr**3**, and the signal line for repair **48**A. The organic EL element **10**A is denoted by the diode-connected transistor Tr**4**, the parasitic capacitor component C**1**, and the resistor component R**1**. In this equivalent circuit, application of the reverse bias voltage to the organic EL element **10**A allows a reverse current Id to flow through the resistor component R**1** by a diode characteristic of the organic EL element **10**A.

[0151] At this time, in the pixel drive circuit **140**, the ON voltage is applied to the scan line **130**A by the scan line drive circuit **130**, and the transistor Tr**2** is controlled into the ON state. On the other hand, the select transistor Tr**3** is controlled into an ON state based on a signal supplied through the element-to-be-repaired selection line **47**A. In the meanwhile, a low potential (for example, 0 V) is applied, through the signal line for repair **48**A, to the signal line **120**A that is connected to the pixel drive circuit **140** in a region (or a pixel) to be repaired. A high potential (for example, 17 V) is applied to the other signal lines **120**A. Consequently, the transistor Tr**1** in the region to be repaired is turned to the ON state. Thus, a bias voltage based on the cathode line voltage Vcat and the power supply voltage Vcc is applied to the organic EL element **10**A connected to the drain of the transistor Tr**1**.

[0152] FIG. **14** illustrates an example of a drive condition of the bias voltage. As illustrated, the power supply voltage Vcc is fixed to, for example, 5 V, while the cathode line voltage Vcat is alternately switched between, for example, 0 V and 10 V. In this way, when 0 V is applied for the cathode line voltage Vcat, the forward bias voltage of 5 V is applied to the organic EL element **10**A. On the other hand, when 10 V is applied for the cathode line voltage Vcat, the reverse bias voltage of 5 V is applied to the organic EL element **10**A. The value of the bias voltage is set in consideration of pressure resistance of the organic layer **16** including the light-emission layer, and so on. It is to be noted that, in the example here, a thickness of the light-emission layer is assumed to be about 100 to 200 nm both inclusive.

[0153] In applying the reverse bias voltage, it is desirable that conditions such as an application time duration (a repair time duration) and a temperature are appropriately set. Specifically, a condition is set so as to allow the reverse current Id flowing through the resistor component R**1** to become maximized, according to the parasitic capacitor component C**1**, a value of the current Id, and a magnitude of the bias voltage, and so on. For example, a drive frequency of the cathode line voltage Vcat is set to, for example, 100 to 600 Hz both inclusive, preferably, 300 to 400 Hz both inclusive. The application time duration is preferably as short as possible, for example, 5 to 30 minutes both inclusive. The temperature condition may be desirably set to, for example, 35 to 75° C. using, for example, a hotplate or the like. In particular, in the example embodiment, as illustrated in FIG. **10**B, since a local region facing the foreign matter X is insulated (is made to have high resistance) by oxidation, it is desirable that the above-described reverse bias voltage drive is carried out in an oxygen atmosphere. Here, an oxygen concentration is desirably set to a condition that allows the insulated portion **17***a***1** to be formed and allows oxidation of a surface of the first conductive film **17**A (the presence of the oxide film **17**C as illustrated in FIG. **8**A) to be within an allowable range. However, this does not apply to a case that the oxide film **17**C is removed (as illustrated in FIG. **8**B).

[0154] As described above, by applying the reverse bias voltage under appropriate conditions, a large current flows through the resistor component R**1** (the short-circuited path or the short circuit due to the foreign matter X), causing an increase in temperature. As a result, in the first conductive film **17**A, a portion that is in contact with the foreign matter X is locally overheated to be insulated by oxidation (to form the insulated portion **17***a***1**). Thus, the short-circuited path due to the foreign matter X is electrically disconnected to eliminate a dark spot. In other words, in applying the forward bias voltage, a leak current to the resistor component R**1** decreases (the drain current Ids supplied to the organic EL element **10**A increases) to repair the organic EL element **10**A into a normal state.

[0155] As described above, in the example embodiment, a dark spot is repaired internally by way of a current or a temperature without an external repair by, for example, laser irradiation. Moreover, even in a case that part or all of the scan line drive circuit **130** and the signal line drive circuit **120** are formed on the same substrate as the organic EL element **10**A, it is possible to apply the reverse bias voltage to a specific region. Hence, it is possible to eliminate a dark spot effectively.

[0156] Here, depending on a magnitude of the parasitic capacitor component C**1** that occurs in the organic EL element **10**A, it may be difficult, in some cases, to allow the reverse current Id to flow through the resistor component R**1** effectively. The alternative drive of the reverse bias voltage allows the parasitic capacitor component C**1** to be charged, facilitating a current flow through the resistor R**1**. Moreover, the alternative drive allows excitons to be activated to repair the portion of a dark spot. This enables more effective repair.

[0157] Also, by performing the alternative reverse bias drive in a heated state, local oxidation in the first conductive film **17**A is enhanced, leading to an increased efficiency of repair. Application of temperature makes it possible to restrain kinetic energy of a molecule and to relieve a load on the organic layer **16** due to the reverse bias voltage. This allows concentrated repair of a dark spot, while reducing damage to other normal regions.

[0158] When the organic EL element **10**A goes into a normal state (where the insulated portion **17***a***1** is formed to eliminate a dark spot), in the above-described alternative drive, the cathode line voltage Vcat becomes, for example, 0 V to allow the forward bias voltage of 5 V to be applied to the organic EL element **10**A. That is, the pixel drive circuit **140** becomes equivalent to FIG. **13**B, allowing the drain current Ids to be supplied to the organic EL element **10**A. Consequently, in the above-described repair operation, the portion (the pixel) that had been a dark spot begins to emit light, which enables confirmation that the repair has been completed.

(Repair Operation by Direct Reverse Bias Drive)

[0159] The reverse bias voltage applied to the organic EL element **10**A in the repair operation is not limited to alternative voltage as described above, but may be direct voltage. In this case, for example, 10 V is applied as the cathode line voltage Vcat, while 5 V is applied as the power supply voltage

Vcc. Thus, the reverse bias voltage (of 5 V) is continuously applied to the organic EL element **10**A. Also in the case of direct drive, by allowing the reverse current Id to flow continuously through the resistor component R**1**, it is possible to increase a temperature in the vicinity of the foreign matter X and to form the insulated portion **17***a***1** in the first conductive film **17**A.

(3 Panel Energization Method in Repair Operation)

[0160] In the repair operation as described above, as illustrated in FIG. **11**, the panel **43** is mounted on the mounting section **42**, and the panel **43** is energized (the reverse bias voltage is applied). At this time, the panel **43** is electrically connected to the repair device **41**, specifically, by allowing a needle (a probe) (needles **50***a* to **50***e*) to touch (to be in contact with) a pad (pads **49***a* to **49***e*) formed in a periphery of the panel **43**.

[0161] FIGS. **15**A to **15**E illustrate examples of energization methods. FIG. **15**A illustrates a case that two panels **43** are formed on one glass substrate. The pad **49***a* provided on the panel **43** has the same width as that of the needle **50***a*. In energization, the needle **50***a* is allowed to touch the panel **43** (the pad **49***a*) in turn in one-to-one correspondence. FIG. **15**B illustrates a case that even more (here, sixteen) panels **43** are formed on one glass substrate (a case of so-called multiple arrangement). The pad **49***b* provided on the panel **43** has the same width as that of the needle **50***b*. In energization, the needle **50***b* is allowed to touch the panel **43** (the pad **49***b*) in turn in one-to-one correspondence.

[0162] In FIG. **15**C, in a case of, for example, multiple arrangement, a width of the pad **49***c* is larger than that of the pad **49***b* as illustrated in FIG. **15**B. The width of the pad **49***c* is equal to a width of the needle **50***c*. In energization, the needle **50***c* is allowed to touch the panel **43** (the pad **49***c*) in turn in one-to-one correspondence. Since the pad width is larger, it is possible to allow accuracy in alignment with the needle **50***c* to be more relaxed than in an example of FIG. **15**B.

[0163] In FIG. **15**D, in a case of, for example, multiple arrangement, individual pads of the panel **43** are electrically connected along, for example, a row direction (or a column direction) to form, for each row, the pad **49***d* common to a plurality of panels **43**. A width of the pad **49***d* is equal to a width of the needle **50***d*. In energization, the needle **50***d* is allowed to touch the pad **49***d* in turn, allowing a plurality of panels **43** to be energized in a batch. This leads to relaxing alignment accuracy as well as shortening a tact time. Alternatively, as illustrated in FIG. **15**E, the pad **49***e* may be formed commonly to all the panels **43**, which is more advantageous in relaxing alignment accuracy as well as shortening a tact time.

[Operations and Effects]

[0164] In the display device **1** according to the example embodiment, as illustrated in FIGS. **1** and **2**, a scan signal is supplied from the scan line drive circuit **130** to the gate of the transistor Tr**2** of each pixel. In the meanwhile, an image signal is supplied from the signal line drive circuit **120** through the transistor Tr**2** to the storage capacitor Cs and is stored in the storage capacitor Cs. In response to the signal stored in the storage capacitor Cs, the transistor Tr**1** is controlled to turn on or off. Thus, a drive current (the drain current Ids) is injected into the organic EL element **10**A. The drive current is injected into the light-emission layer in the organic layer **16** through the first electrode **14** and the second electrode **17**. In the organic layer **16**, light-emission occurs due to recombination of holes and electrons. Here, white light is produced from the organic layer **16** of each of the organic EL elements **10**A.

[0165] When white light is produced from each of the organic EL elements **10**A, the white light passes through the second electrode **17**, the color filter layer **19** (any one of **19**R, **19**G, **19**B, and **19**W), and the sealing substrate **20** to be emitted upwardly of the display device **1**. In this way, image display is performed with a unit of the organic EL elements **10**A that produces color light of R, G, B, and W as one pixel.

[0166] Here, in the example embodiment, the second electrode **17** includes the first conductive film **17**A and the second conductive film **17**B that are laminated in order from the organic layer **16** side. This facilitates disconnecting electrically the short-circuited path that is formed between the first electrode **14** and the second electrode **17** (specifically, the first conductive film **17**A) due to the foreign matter X in the manufacturing process.

[0167] If, as illustrated in FIG. **46**A, a second electrode **107** is configured of a single layer of a transparent conductive film, it is desirable that the second electrode **107** is thickened for lowered resistance. However, when the second electrode **107** is thickened, as illustrated in FIG. **46**B, a spread of oxidation is limited to part (**107***a*) of a surface of the second electrode **107**, leading to a difficulty in insulating sufficiently a portion of a short circuit due to the foreign matter X.

[0168] On the other hand, in the example embodiment, since the second electrode **17** is two-layered, the first conductive film **17**A is thinned. It is therefore possible to allow the first conductive film **17**A to be insulated entirely in a thickness direction by applying the reverse bias voltage (as illustrated in FIG. **10**B). Thus, it is possible to reduce an electrical influence such as a dark spot caused by the foreign matter X. After a process of forming the first conductive film **17**A and the repair process, the second conductive film **17**B is formed. The thickness of the second conductive film **17**B may be set according to a desired resistance value. For example, in a case of an element configuration in which light-emission layers of different colors from one another are laminated to obtain white light, a transparent conductive film such as IZO is used for the second electrode **17**. It is desirable that such a transparent conductive film have a thickness in a certain extent for lowered resistance. Hence, it is possible to thicken the second conductive film **17**B, obtaining a desired resistance value (to reduce a resistance value). Thus, the second electrode **17** having a two-layered structure enables reduction in resistance of the second electrode **17**, as well as elimination of a dark spot due to the foreign matter. This contributes to improvement in display quality.

[0169] In the following, description will be given on modification examples of the above-described example embodiment. It is to be noted that the similar components to the above-described example embodiment are denoted by the same references, and description thereof will be appropriately omitted.

Modification Example 1-1

[0170] FIG. **16** illustrates an example of layout of the pixels PXLC according to a modification example 1-1. In the above-described example embodiment, description is given on a case that, for example, the four pixels PXLC of R, G, B, and W constitute the display unit U (a pixel). However, as in this modification example, the three pixels PXLC of R, G, B may constitute the display unit U. In this case of layout, the pixels PXLC in a strip shape are arranged in parallel in a stripe shape as a whole.

[0171] FIG. **17** illustrates an example of layouts of the color filter layer **19**, the organic layer **16** (specifically, the organic electroluminescent layer), and the apertures WIN (the apertures of the bank **15**) that constitute the above-mentioned three pixels PXLC. As illustrated, in the modification example 1-1, a color arrangement (R, G, and B) of the color filter layer **19** corresponds to a layout of the pixels PXLC, and the organic layer **16** includes a white light-emission layer (W) that is common to the three pixels PXLC. The apertures WIN of the bank **15** are provided in one-to-one correspondence with the pixels PXLC.

[0172] Also, in the modification example 1-1, as illustrated in FIG. **18**, the organic layer **16** (the light-emission layer) includes, similarly to the above-described example embodiment, the yellow light-emission layer **16**Y and the blue light-emission layer **16**B. The lamination order of the yellow light-emission layer **16**Y and the blue light-emission layer **16**B may be inverted from as described above. The constituent material of the yellow light-emission layer **16**Y is not limited to a material that configured to produce yellow (Y) light, but may be other material.

Modification Example 1-2

[0173] FIG. **19** illustrates an example of layouts of the color filter layer **19**, the organic layer **16**, and the apertures WIN that constitute the pixel PXLC according to a modification example 1-2. The modification example 1-2 is different from the above-described example embodiment in that the three pixels PXLC of R, G, and B constitute the display unit U, and that the organic layer **16** is formed separately for each color (that light-emission layers of different colors are formed for the respective pixels PXLC). In the modification example 1-2, as illustrated in FIG. **20**, the organic layer **16** is provided with the light-emission layers of three colors (**16**R, **16**G, and **16**B) facing the respective regions of R, G, and B in the color filter layer **19**.

[0174] In a case that, as mentioned above, the organic layer **16** is formed separately for each pixel PXLC, it is possible to increase a light-emission spectrum by an optical resonator effect utilizing a so-called micro cavity. In this case, for example, as the second electrode **17**, a translucent conductive film such as magnesium-silver may be used. In this way, it is possible to allow color light produced in the organic layer **16** to resonate between the second electrode **17** and the first electrode **14** as a reflective electrode, increasing intensity of a desired wavelength.

Modification Example 1-3

[0175] FIG. **21** illustrates an example of layouts of the color filter layer **19**, the organic layer **16**, and the apertures WIN that constitute the pixel PXLC according to a modification example 1-3. The modification example 1-3 is different from the above-described example embodiment in that the three pixels PXLC of R, G, and B constitute the display unit U, and that the organic layer **16** is formed separately for two colors, i.e. Y and B. In the modification example 1-3, as illustrated in FIG. **22**, the organic layer **16** is provided with a yellow (Y) light-emission layer (the yellow light-emission layer **16**Y) facing the regions of R and G in the color filter layer **19**. The organic layer **16** is provided with a blue (B) light-emission layer (the blue light-emission layer **16**B) facing the region of B in the color filter layer **19**.

[0176] As mentioned above, the organic layer **16** may be formed separately for yellow (Y) in the region corresponding to the pixels PXLC of R and G, and blue (B) in the region corresponding to the pixel PXLC of B. Also in this case, similarly to the above-described modification example 1-2, it is possible to increase a light-emission spectrum by an optical resonator effect utilizing a micro cavity.

Modification Example 1-4

[0177] FIG. **23** illustrates an example of layouts of the color filter layer **19**, the organic layer **16**, and the apertures WIN that constitute the pixel PXLC according to a modification example 1-4. The modification example 1-4 is different from the above-described example embodiment in that the four pixels PXLC of R, G, B, and Y constitute the display unit U, and that the organic layer **16** is formed separately for two colors, i.e. Y and B. In the modification example 1-4, as illustrated in FIG. **24**, the organic layer **16** is provided with the yellow light-emission layer **16**Y in a region facing R, Y, and G in the color filter layer **19**. The organic layer **16** is provided with the blue light-emission layer **16**B in a region facing B in the color filter layer **19**.

[0178] As mentioned above, the four pixels PXLC of R, G, B, and Y may constitute one pixel. In this case, the organic layer **16** may be formed separately so that the yellow light-emission layer **16**Y is formed in a region corresponding to the pixels PXLC of R, Y, and G, and the blue light-emission layer **16**B is formed in a region corresponding to the pixel PXLC of B. Also in this case, similarly to the above-described modification example 1-2, it is possible to increase a light-emission spectrum by an optical resonator effect utilizing a micro cavity.

Modification Example 2

[0179] The above-described example embodiment exemplifies a configuration in which the apertures WIN of the bank **15** are provided in one-to-one correspondence with the pixels PXLC (the organic EL elements **10**A). However, as in a modification example 2, a plurality of apertures WIN may be provided in one pixel PXLC to form a so-called reflector (an anode reflector). FIG. **25** illustrates, in section, a configuration of an element having an anode reflector according to the modification example 2. The modification example 2 is different from the example embodiment in that the bank **15** is provided with the plurality of apertures WIN in a part of a region where the first electrode **14** is formed. In an upper part of the first electrode **14** and the bank **15**, the organic layer **16** is formed to cover the plurality of apertures WIN.

[0180] FIG. **26** illustrates a schematic arrangement of the apertures WIN on the first electrode **14**. It is to be noted that the first electrodes **14**(R), **14**(G), **14**(B), and **14**(W) indicates anodes of the subpixels PXLC of R, G, B, and W. The first electrodes **14**(R), **14**(G), **14**(B), and **14**(W) (hereinbelow, simply referred to as the first electrode **14**, if not particularly distinguished) are spaced from each other, though they are illustrated without any space between them for convenience in the figure. Each of the first electrodes **14** is connected to the drain of the transistor Tr**1** for driving formed in the pixel drive circuit **140** through a contact **205**. In the example here, the contact **205** is disposed at the upper left of each of the first electrodes **14**.

[0181] Each of the first electrodes **14** is provided with the plurality of apertures WIN of various shapes in a random arrangement. Specifically, the apertures WIN have various shapes of, for example, a circle, an ellipse, a combined shape thereof, or the like. It is to be noted that an ellipse is not limited to an ellipse as strictly defined but also may simply refer to an elongated circle. The plurality of apertures WIN are arranged, on each of the first electrodes **14**, without clear regularity, for example, without being arranged orderly in a predetermined direction. It is to be noted that, in the example here, the apertures WIN have substantially equal area to one another. In this way, it is possible to facilitate determining photolithography conditions in a manufacturing process. The apertures WIN are disposed at different positions from that of the contact **205**. Also in the example here, the plurality of apertures WIN are arranged in the same pattern for all the first electrodes **14**.

[0182] FIG. **27** illustrates, in section, a main part of the aperture WIN. Strictly, the aperture WIN is formed based on a design as follows. The bank **15** is formed with a thickness of a height H. An aperture width R1 of the bank **15** on the first electrode **14** side is smaller than an aperture width R2 on the display surface side. In other words, the bank **15** is provided with a sloped portion PS surrounding the aperture WIN. Thus, as described later, in the aperture WIN, light emitted from the organic layer **16** toward the sloped portion PS is reflected at the sloped portion PS due to a difference in refractive index between the bank **15** and the protective film (an insulating film) **18**, and the reflected light proceeds in a front direction of the display surface. In this way, the sloped portion PS serves as a so-called reflector that is configured to reflect light emitted from the organic layer **16**. Consequently, it is possible to improve, in each of the pixels PXLC, efficiency in extracting light externally. To allow the sloped portion PS to reflect light effectively, it is preferable that a refractive index (n1) of the protective film **18** and a refractive index (n2) of the bank **15** satisfy expressions as follows.

$$1.1 \leq n1 \leq 1.8 \quad (1)$$

$$n1 - n2 \geq 0.20 \quad (2)$$

[0183] FIG. **28** illustrates an example of a simulation result of rays in the vicinity of the aperture WIN. FIG. **28** illustrates how light emitted downwardly from the organic layer **16** is reflected by a portion corresponding to the sloped portion PS to proceed upwardly. As illustrated, light after being reflected proceeds toward various directions. For example, some proceeds in a direction of a normal to the organic layer **16** (upwardly in FIG. **28**), and some proceeds in a direction that is shifted from the normal direction (obliquely). A part of obliquely proceeding light enters the sloped portion PS to be reflected. Specifically, light is reflected at the sloped portion PS due to a difference in refractive index, since the bank **15** and the protective **18**, which have different refractive indices from each other, are adjacent with the organic layer **16** and the second electrode **17** in between. The reflected light proceeds toward the display surface side to be extracted externally.

[0184] As described above, it is possible to improve efficiency in extracting light externally by the sloped portion PS of the aperture WIN. If no sloped portion PS is provided, there is a possibility that light emitted in a direction that is shifted from a direction normal to a light-emission layer **214** is attenuated in the display device or is shielded by a black matrix layer BM. In this case, a ratio of light extracted externally of the display device with respect to light emitted from the organic layer **16** is lowered, leading to lowered efficiency in extracting light externally. In the example embodiment 2, since the sloped portion PS is provided, it is possible to allow light to be reflected at the sloped portion PS, improving efficiency in extracting light externally. Moreover, the plurality of apertures WIN of various shapes are disposed in a random arrangement, it is possible to reduce a possibility of difficulty in viewing a display screen due to reflection of external light, improving image quality.

[0185] In the above-described example, the plurality of apertures WIN of various shapes are disposed in a random arrangement. However, the layout of the apertures WIN is not limited to the above-described example, but other various patterns may be adopted. In the following, some examples are given.

[0186] As illustrated in FIG. **29**, the plurality of apertures WIN (WIN1 and WIN2) of various shapes may be disposed regularly in a predetermined pattern. In the example here, around a round aperture WIN1, six oval apertures WIN2 are disposed to surround the aperture WIN1. In other words, similarly to a so-called closest packed arrangement, three of the apertures WIN1 and WIN2 are arranged so as to be adjacent to one another. The six oval apertures WIN2 are arranged in different orientations from one another. Also in a case that the apertures WIN1 and WIN2 are arranged as mentioned above, it is possible to reduce a possibility of difficulty in viewing a display screen due to reflection of external light. Moreover, since the oval apertures WIN2 are arranged in different orientations from one another, it is possible to expand a view angle.

[0187] It is to be noted that, though in the example here the round apertures WIN1 and the oval apertures WIN2 are used, this is not limitative. Alternatively, apertures of various shapes as illustrated in FIGS. **30**A to **30**E may be used. Specifically, for example, the aperture WIN may have a shape of a rounded square as illustrated in FIG. **30**A, or a shape of a rounded rectangular as illustrated in FIG. **30**B, or a shape of a combination of a plurality of ellipses as illustrated in FIGS. **30**C to **30**E.

[0188] Alternatively, as illustrated in FIG. **31**, the number of apertures (WIN3) provided in the pixel PXLC for white may be smaller than that of the apertures provided in the pixels for other colors. On the first electrodes **14**(R), **14**(G), and **14**(B), similarly to the above-described example as illustrated in FIG. **26**, the plurality of apertures WIN of various shapes are disposed in a random arrangement. On the other hand, on the first electrodes **14**(W), a large aperture WIN3 in the example here is disposed.

[0189] In this configuration, it is possible to restrain diffraction of external light in the pixel PXLC for white, lowering a possibility of difficulty in viewing a display screen due to reflected light. Since the pixel PXLC for white is provided with the white color filter **19**W that allows light of a wide wavelength range to pass through, external light (in white) is allowed to pass through the color filter **19**W to enter inside. Therefore, in a case of occurrence of diffraction in the pixel PXLC for white, light tends to be reflected over a large region, causing difficulty in viewing a display screen. Since, in the modification example 2, the pixel PXLC for white is provided with a single aperture WIN3, it is possible to restrain occurrence of diffraction.

[0190] It is to be noted that the number of the aperture WIN3 in the pixel PXLC for white is not limited to one. As illustrated in FIG. **32**, the plurality of apertures WIN3 may be provided, and the number of apertures WIN3 may be fewer than the number of the apertures in the pixels PXLC for other colors. In this case, for improving aperture rate, each of the apertures WIN3 has preferably large area.

[0191] Further, as illustrated in FIGS. **33**A and **33**B, the apertures WIN may have a quadrangle shape such as a square, a rectangle or the like.

[0192] In addition, as illustrated in FIGS. **34** and **35**, the contact **205** may have a round shape of the substantially same size as the aperture WIN. In this case, it is possible to arrange the contact **205** and the apertures WIN more effectively within limited area. Also as illustrated in FIG. **35**, the contact **205** and the apertures WIN may be in a so-called closest packed arrangement. In the closest packed arrangement here, for example, three apertures WIN are disposed adjacently to one another. Thus, it is possible to arrange the contact **205** and the apertures WIN even more effectively. In this case, the sides of the first electrode **14**, which defines an outline of the first electrode **14**, are provided in a gap between the contact **205** and the apertures WIN. In this way, in the example here, an upper side and a lower side of the first electrode **14** extend in a lateral direction, while two left sides and two right sides each constitute a V shape in the alphabet, with each side extending in a direction that shifts from the lateral direction by 60°.

[0193] Alternatively, as illustrated in FIGS. **36**A to **36**D, FIGS. **37**A to **37**F, and FIGS. **38**A and **38**B, the first electrode **14** may have a shape of, for example, a horizontally(laterally)-elongated hexagon. Thus, it is possible to secure larger area of the first electrode **14**. Moreover, it is possible to arrange the plurality of apertures WIN effectively in each region over the first electrode **14**. Specifically, in a case that the first electrode **14** has a shape of a horizontally-enlarged regular hexagon, the aperture WIN may have a shape of an ellipse obtained by enlarging a circle at the same ratio as an enlargement ratio of the first electrode **14**. Thus, a closest packed arrangement is easily obtained. However, the number of the apertures WIN may be one, or the apertures WIN may be smaller in density than a closest packed arrangement.

[0194] It is to be noted that, in FIG. **36**D, the apertures WIN are provided in seven rows. As illustrated, in a case that the apertures WIN are provided in an odd-number of rows, it is possible to dispose all the apertures WIN in a closest packed arrangement. However, as illustrated in FIGS. **36**B and **36**C, even in a case that the apertures WIN are provided in an even number of rows, the apertures WIN in an upper region may be disposed in a closest packed arrangement, while the apertures WIN in a lower region may be disposed in a closest packed arrangement. Alternatively, as illustrated in FIGS. **37**A to **37**F, the aperture WIN may have a round shape. Alternatively, as illustrated in FIG. **38**A, both the oval apertures WIN and the round apertures WIN may be provided. Alternatively, as illustrated in FIG. **38**B, both the vertically-long oval apertures WIN and the laterally-long oval apertures WIN may be provided. In this case, it is possible to expand a view angle in an up-and-down direction as well as a left-and-right direction.

Application Examples

[0195] The display device as described in the above example embodiment and modification examples may be applied to an electronic apparatus in various fields that is configured to display a picture based on a picture signal input from outside or a picture signal generated inside. The display device is incorporated, in a form of a module as illustrated in FIG. **39**, in an electronic apparatus such as a television set, a digital camera, a video camera, a notebook personal computer, a mobile phone and a smart phone, which are exemplified in the following. In FIG. **39**, on the substrate **11**, provided are the display region **110**, and the signal line drive circuit **120** and the scan line drive circuit **130** and so on. The display region **110** includes, for example, the subpixels (the pixels PXLC including the above-described organic EL elements **10**A) arranged in a two-dimensional array. Along one side of the substrate **11**, provided is a region **210** exposed from the sealing substrate **20**. In the region **210**, provided are external connection terminals (not illustrated) that are extended from wirings of the signal line drive circuit **120** and the scan line drive circuit **130**. On the external connection terminals, provided is a flexible printed circuit (FPC) **220** for signal input and output.

[0196] FIG. **40** illustrates an appearance of a television set. The television set includes, for example, a picture display screen section **300** that includes a front panel **310** and a filter glass **320**. The picture display screen section **300** is configured of the display device according to the above-described embodiment and so on.

[0197] FIGS. **41**A and **41**B illustrate an appearance of a digital camera. The digital camera includes, for example, a lighting section for flash lighting **410**, a display section **420**, a menu switch **430**, and a shutter button **440**. The display section **420** is configured of the display device according to the above-described embodiment and so on.

[0198] FIG. **42** illustrates an appearance of a notebook personal computer. The notebook personal computer includes, for example, a main body **510**, a keyboard **520** for input operations of characters and the like, and a display section **530** for image display. The display section **530** is configured of the display device according to the above-described embodiment and so on.

[0199] FIG. **43** illustrates an appearance of a video camera. The video camera includes, for example, a main body **610**, a lens **620** for photographing an object, which is provided on a front side face of the main body **610**, a start/stop switch **630** in photographing, and a display section **640**. The display section **640** is configured of the display device according to the above-described embodiment and so on.

[0200] FIGS. **44**A and **44**B illustrate an appearance of a mobile phone. The mobile phone has a configuration, for example, in which an upper casing **710** and a lower casing **720** are linked by a connection section (a hinge section) **730**, and includes a display **740**, a sub-display **750**, a picture light **760**, and a camera **770**. The display **740** or the sub-display **750** is configured of the display device according to the above-described embodiment and so on.

[0201] FIGS. **45**A and **45**B illustrate an appearance of a smart phone. The smart phone includes, for example, a display section **810** and a non-display section (a casing) **820**, and an operation section **830**. The operation section **830** may be provided either on a front face (FIG. **45**A) or on a top face (FIG. **45**B) of the non-display section **820**. The display section **810** is configured of the display device according to the above-described embodiment and so on.

[0202] Although description has been made by giving the example embodiment and the modification examples as mentioned above, the contents of the present disclosure are not limited to the above-mentioned embodiments and so forth and may be modified in a variety of ways. For example, in the repair operation, the reverse bias voltage may be applied to a selective region that is to be a dark spot, but this is not limitative. Alternatively, the reverse bias voltage may be applied to a large region including a portion of a dark spot. The latter method contributes to shortened time for the repair operation, and is advantageous in mass-production. It is to be noted that the reverse bias voltage may be applied to a normal region, but it is possible to enjoy an effect of improving repair efficiency by controlling application conditions appropriately.

[0203] Moreover, in the above-described embodiments and so forth, an example of the two-layered second electrode **17** is given. However, the second electrode **17** may be a multi-layered film of three or more layers including other conductive films.

[0204] Further, a material and a thickness of each layer as described in the above-mentioned embodiments and so forth are not limited to as exemplified above, but other materials or other thicknesses may be adopted. In addition, in the display device, it is not necessary to include all the layers described above, and rather a layer or layers other than the above-mentioned layers may be also included. It is to be noted that effects described in the above-described embodiments and so forth are merely exemplified and not limitative, and effects of the present disclosure may be other effects or may further include other effects.

[0205] It is possible to achieve at least the following configurations from the above-described example embodiments of the disclosure.

(1) A display device, including:

[0206] a first electrode;

[0207] an organic layer that is provided on the first electrode and includes a light-emission layer; and

[0208] a second electrode that includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer.

(2) The display device according to (1), wherein a thickness of the first conductive film is smaller than a thickness of the second conductive film.

(3) The display device according to (2), wherein the thickness of the first conductive film is equal to or smaller than one tenth of the thickness of the second conductive film.

(4) The display device according to any one of (1) to (3), wherein the first conductive film and the second conductive film have light-transmittance.

(5) The display device according to (4), wherein the first conductive film includes a local portion having higher resistance than that of another portion.

(6) The display device according to (4) or (5), wherein the first conductive film and the second conductive film are configured of a same material.

(7) The display device according to (6), wherein the first conductive film and the second conductive film are configured of indium zinc oxide (IZO).

(8) The display device according to (4) or (5), wherein

[0209] the first conductive film includes an alloy of magnesium (Mg) and silver (Ag), and

[0210] the second conductive film includes indium zinc oxide (IZO).

(9) The display device according to any one of (1) to (8), further including an oxide film that is interposed between the first conductive film and the second conductive film.

(10) The display device according to any one of (1) to (3), wherein

[0211] the first conductive film is a transparent conductive film, and

[0212] the second conductive film is a metal film having light-reflectivity.

(11) An electronic apparatus provided with a display device, the display device including:

[0213] a first electrode;

[0214] an organic layer that is provided on the first electrode and includes a light-emission layer; and

[0215] a second electrode that includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer.

(12) A display device, including:

[0216] a first electrode;

[0217] an organic layer that is provided on the first electrode and includes a light-emission layer; and

[0218] a second electrode that is provided on the organic layer and includes a local portion having higher resistance than that of another portion.

(13) The display device according to (12), wherein

[0219] the second electrode includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer, and

[0220] the local portion is provided in the first conductive film.

[0221] It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. A display device, comprising:

a first electrode;

an organic layer that is provided on the first electrode and includes a light-emission layer; and

a second electrode that includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer.

2. The display device according to claim **1**, wherein a thickness of the first conductive film is smaller than a thickness of the second conductive film.

3. The display device according to claim **2**, wherein the thickness of the first conductive film is equal to or smaller than one tenth of the thickness of the second conductive film.

4. The display device according to claim **1**, wherein the first conductive film and the second conductive film have light-transmittance.

5. The display device according to claim **4**, wherein the first conductive film includes a local portion having higher resistance than that of another portion.

6. The display device according to claim **4**, wherein the first conductive film and the second conductive film are configured of a same material.

7. The display device according to claim **6**, wherein the first conductive film and the second conductive film are configured of indium zinc oxide (IZO).

8. The display device according to claim **4**, wherein

the first conductive film includes an alloy of magnesium (Mg) and silver (Ag), and

the second conductive film includes indium zinc oxide (IZO).

9. The display device according to claim **1**, further comprising an oxide film that is interposed between the first conductive film and the second conductive film.

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

the first conductive film is a transparent conductive film, and

the second conductive film is a metal film having light-reflectivity.

11. An electronic apparatus provided with a display device, the display device comprising:

a first electrode;

an organic layer that is provided on the first electrode and includes a light-emission layer; and

a second electrode that includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer.

12. A display device, comprising:

a first electrode;

an organic layer that is provided on the first electrode and includes a light-emission layer; and

a second electrode that is provided on the organic layer and includes a local portion having higher resistance than that of another portion.

13. The display device according to claim **12**, wherein

the second electrode includes a first conductive film and a second conductive film, the first conductive film and the second conductive film being laminated in order on the organic layer, and

the local portion is provided in the first conductive film.

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摘要(译)

提供一种显示装置，包括：第一电极;有机层，设置在第一电极上并包括发光层;第二电极包括第一导电膜和第二导电膜，第一导电膜和第二导电膜依次层叠在有机层上。