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(54) DISPLAY DEVICE AND METHOD OF MANUFACTURING A DISPLAY DEVICE

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(57) **ABSTRACT**

A display device according to an embodiment of the present invention includes: a plurality of organic light emitting diodes, each including a lower electrode, an upper electrode, and an organic material layer between the lower electrode and the upper electrode, and fluorescent material disposed on the upper electrode of at least one of the organic light emitting diodes.

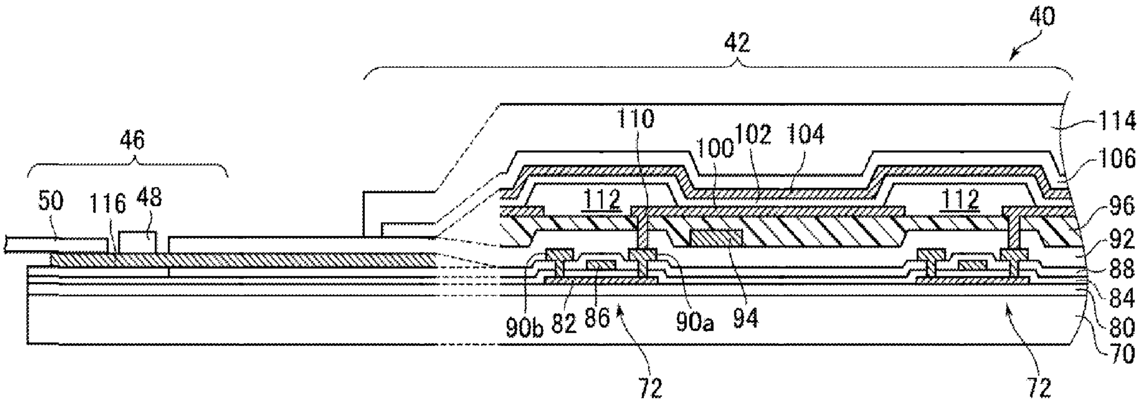


FIG.1

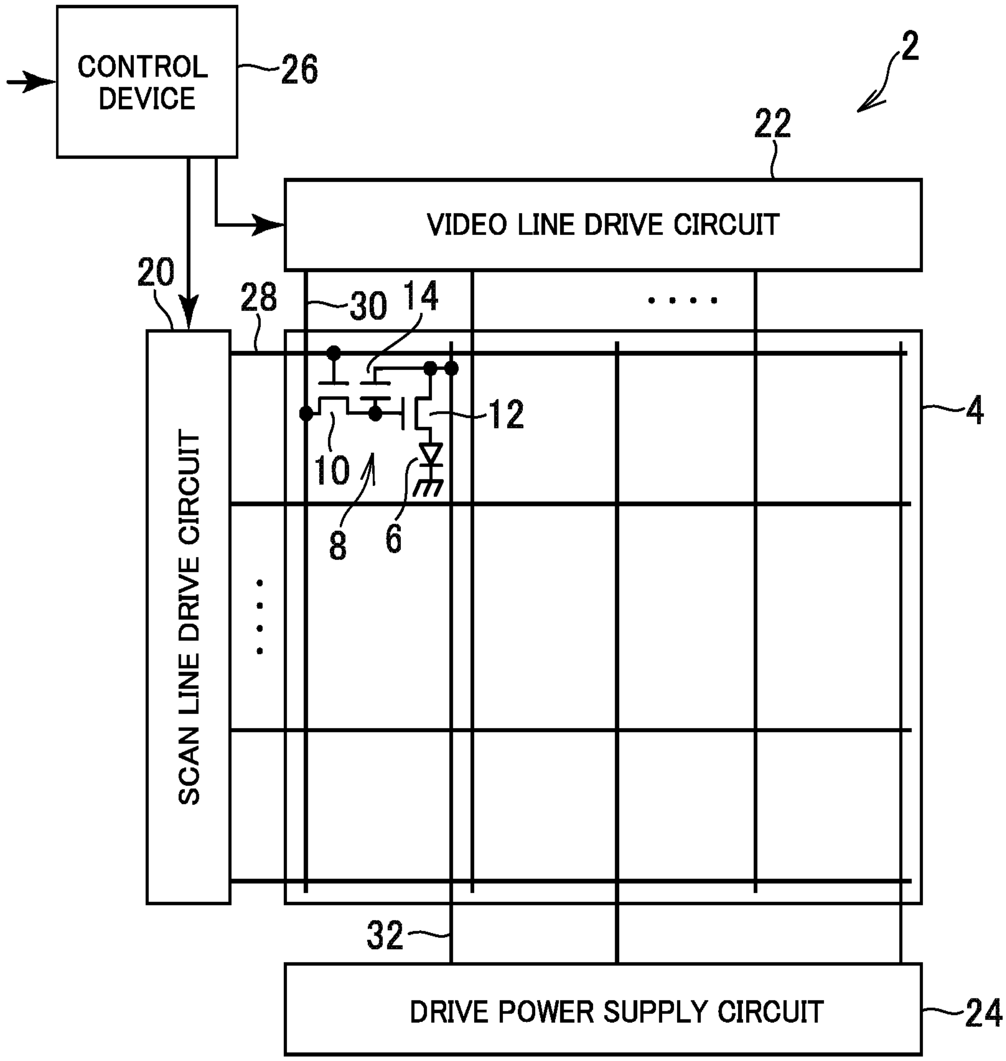

CONTROL DEVICE
26
2
22
VIDEO LINE DRIVE CIRCUIT
20
28
30
14
12
4
10
8
6
SCAN LINE DRIVE CIRCUIT
32
DRIVE POWER SUPPLY CIRCUIT
24

FIG.2

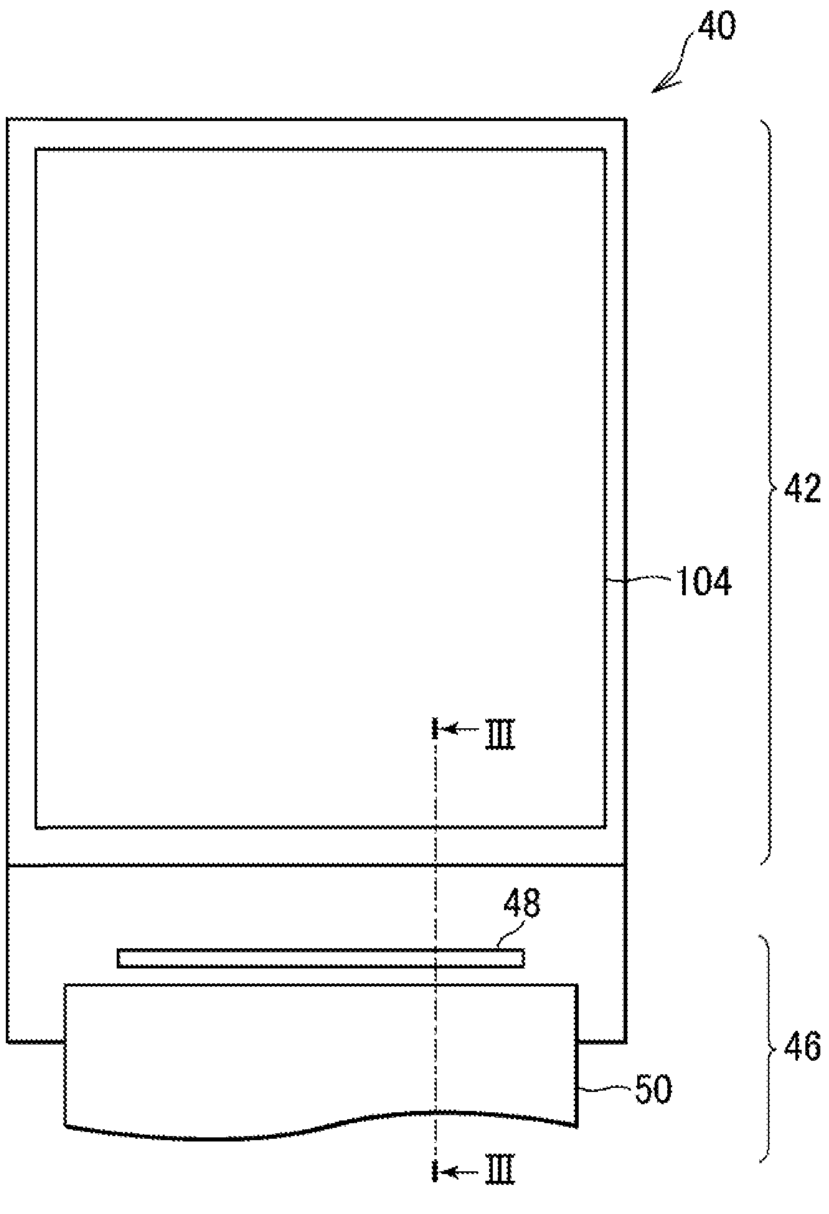


FIG.3

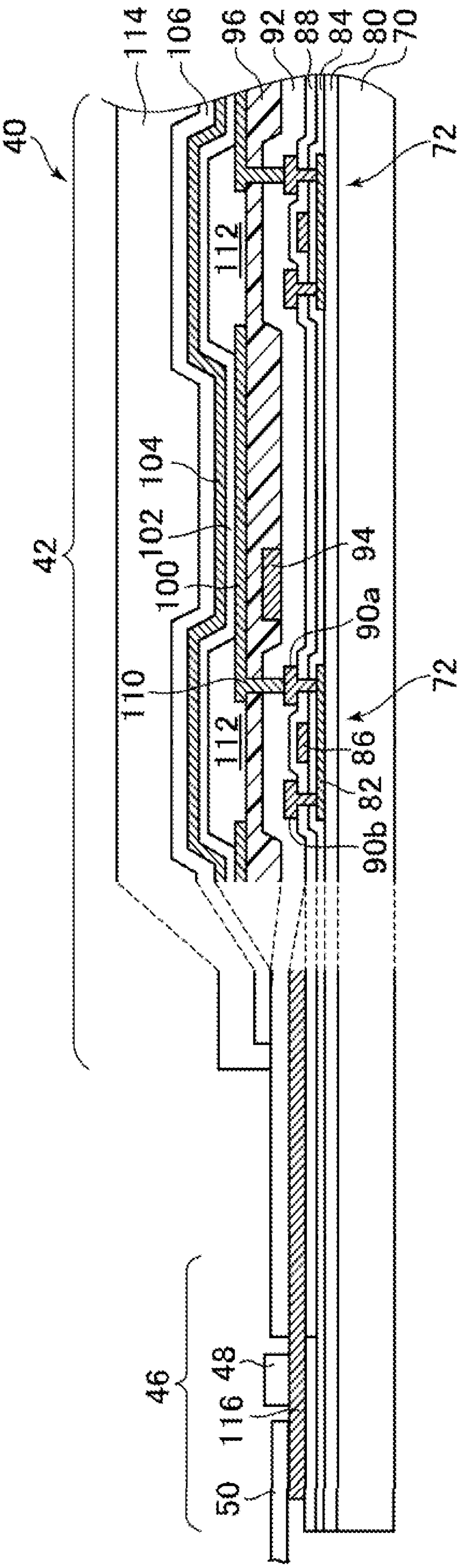

40
42
114
106
96
92
88
84
80
70
72
112
104
102
100
94
90a
110
112
86
82
90b
72
46
48
116
50

FIG.4

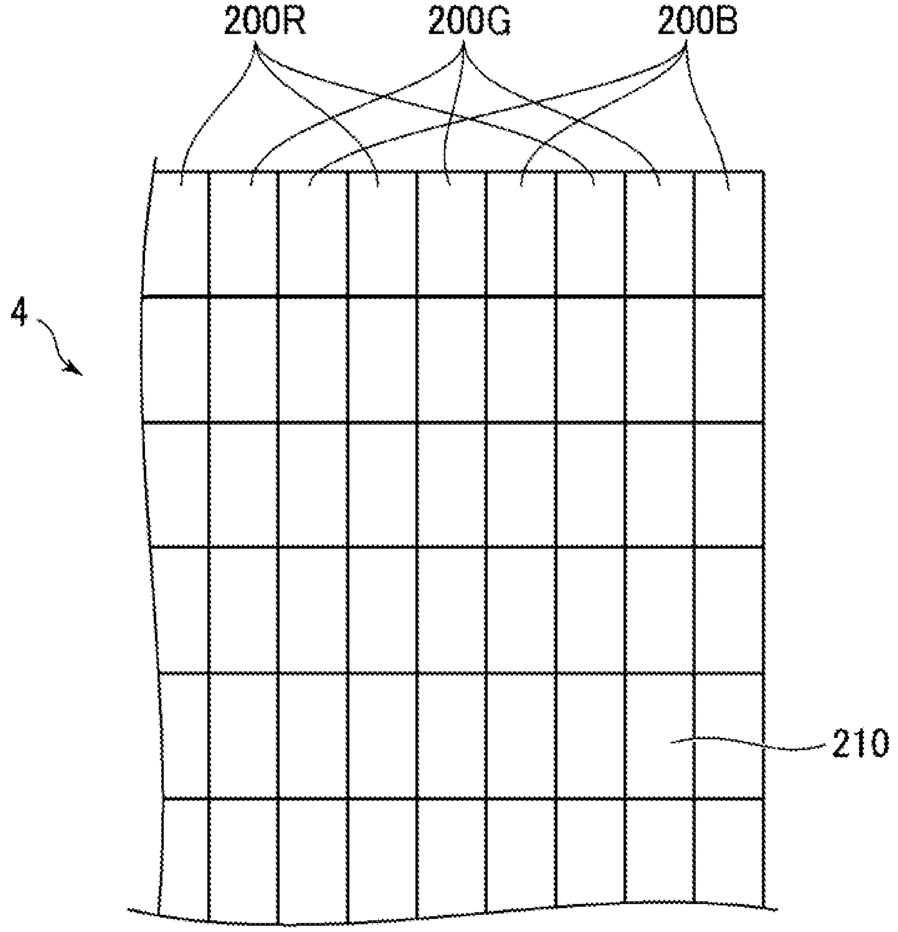


FIG.5

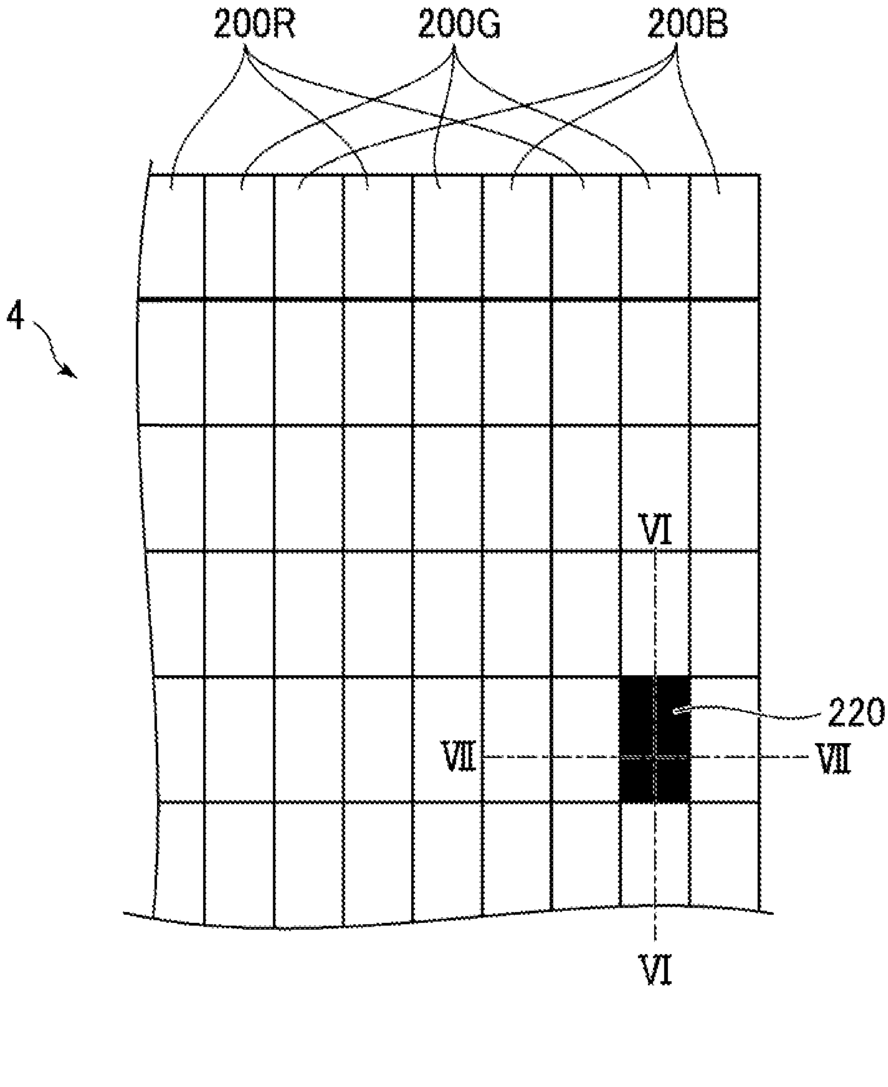


FIG.6

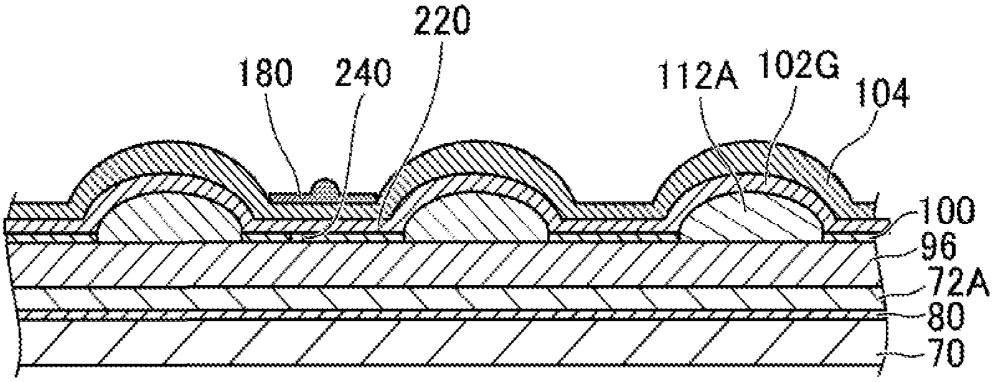

220
180
240
112A
102G
104
100
96
72A
80
70

FIG.7

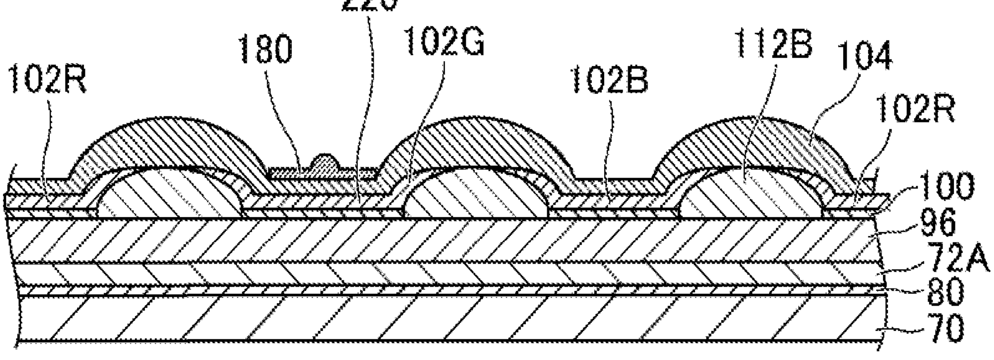

220
180
102G
102R
102B
112B
104
102R
100
96
72A
80
70

FIG.8

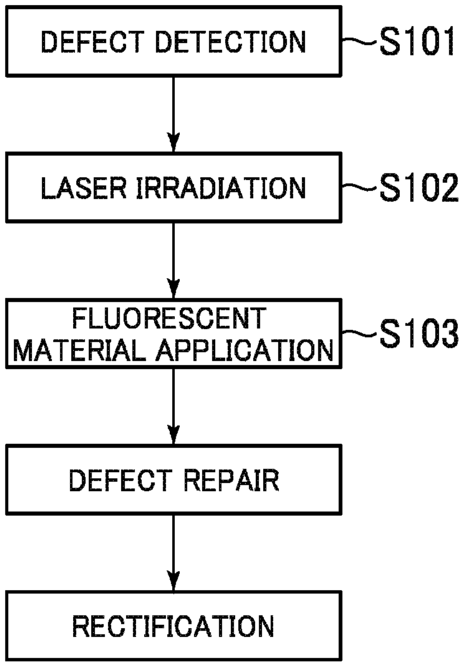

DEFECT DETECTION
S101
LASER IRRADIATION
S102
FLUORESCENT MATERIAL APPLICATION
S103
DEFECT REPAIR
RECTIFICATION

FIG.9

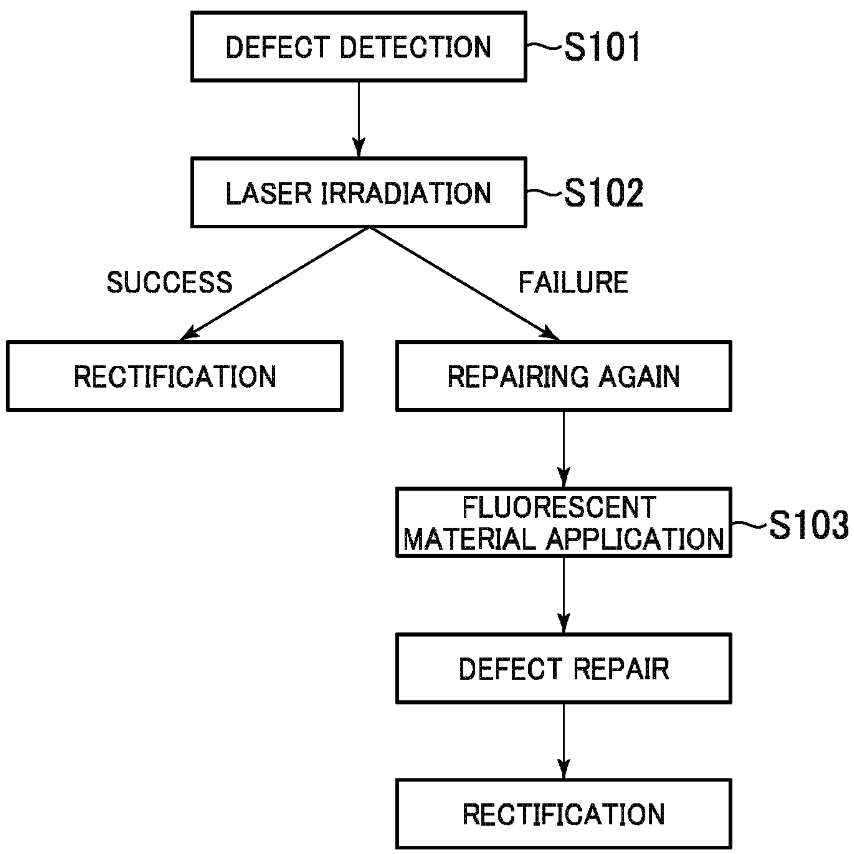

DEFECT DETECTION
S101
LASER IRRADIATION
S102
SUCCESS
FAILURE
RECTIFICATION
REPAIRING AGAIN
FLUORESCENT MATERIAL APPLICATION
S103
DEFECT REPAIR
RECTIFICATION

FIG.10

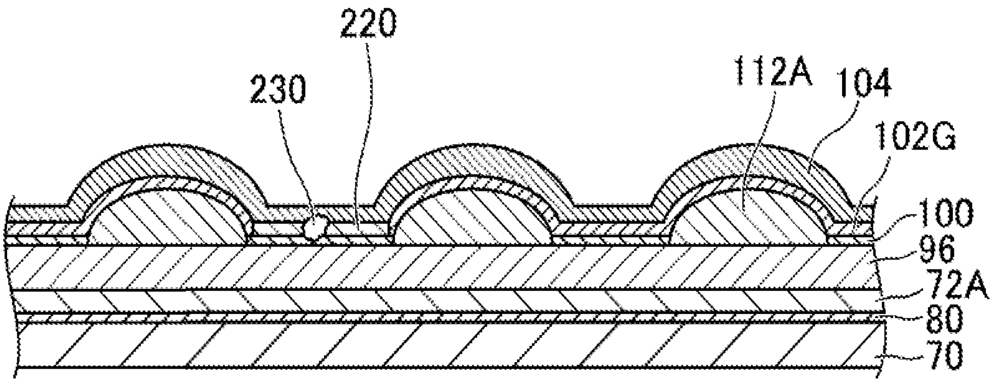


FIG.11

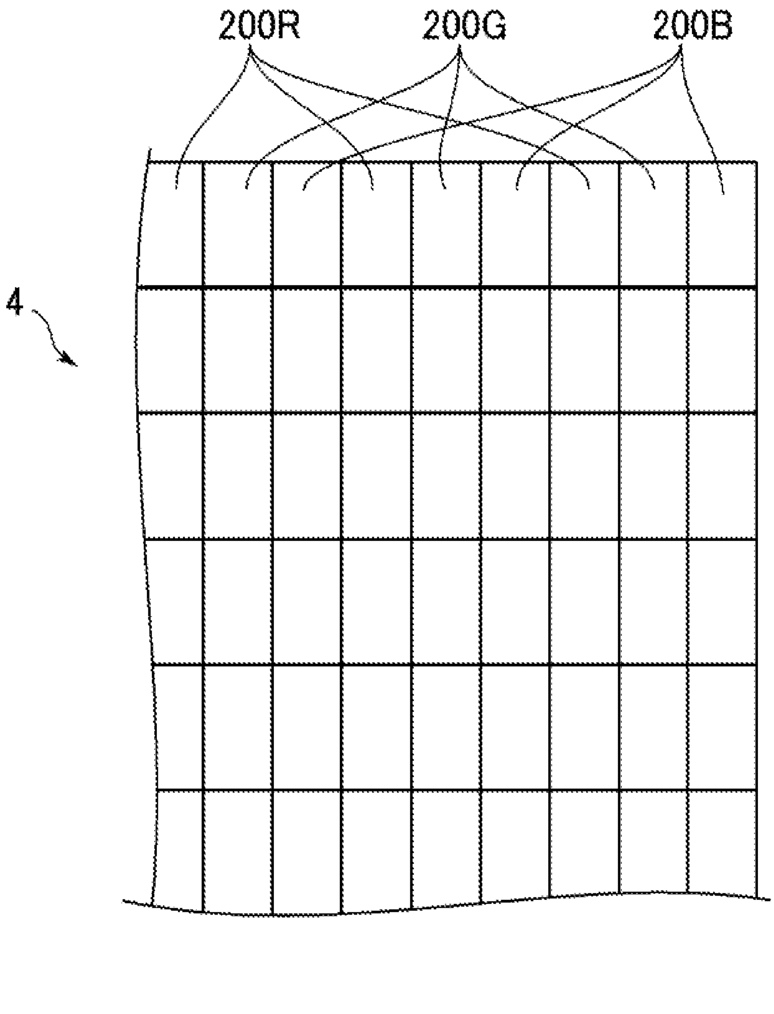


FIG.12

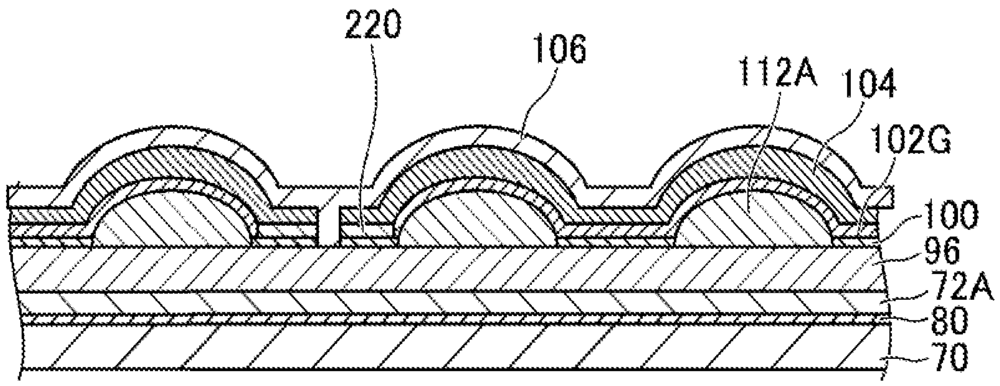
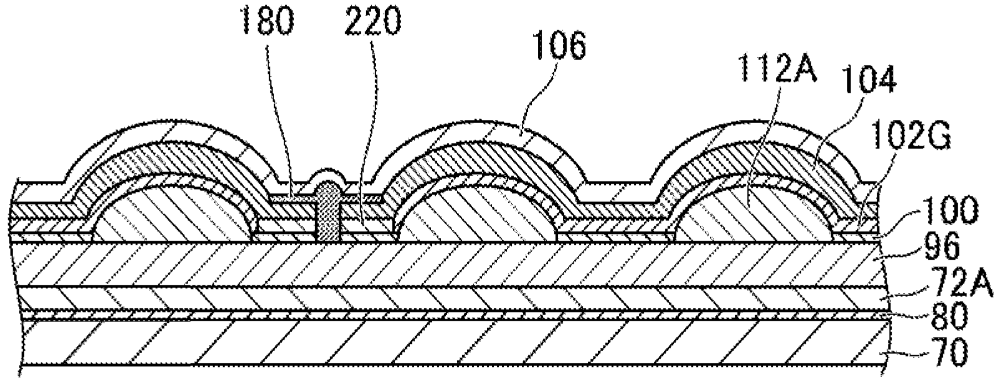

220
106
112A
104
102G
100
96
72A
80
70

FIG.13


180
220
106
112A
104
102G
100
96
72A
80
70

DISPLAY DEVICE AND METHOD OF MANUFACTURING A DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority from Japanese Application JP2017-65631 filed on Mar. 29, 2017, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to display devices and a method of manufacturing the display devices.

2. Description of the Related Art

[0003] Flat panel displays, such as organic electro-luminescent (EL) display devices, have a display panel where a thin film transistor (TFT), an organic light emitting diode (OLED) and the like are formed on a substrate.

[0004] If foreign matter should enter between the cathode and the anode of such an organic light emitting diode, the foreign matter can cause short-circuit between the cathode and the anode of the OLED, resulting in a short-circuited defect. The short-circuited defect becomes a bright spot with application of a predetermined signal voltage.

[0005] Japanese Patent Laid-open Publication No. 2013-251224 discloses a technique for irradiating such a short-circuited defect with a laser beam to increase the resistance of the short-circuited defect to thereby make the defect a dark spot that does not emit light upon application of a signal voltage.

SUMMARY OF THE INVENTION

[0006] The above conventional configuration can make a bright spot a less outstanding dark spot through laser irradiation. However, the dark spot remains.

[0007] One or more embodiments of the present invention have been conceived in view of the above, and an object thereof is to make dark spots further less outstanding in display devices.

[0008] 1. A display device according to an embodiment of the present invention includes: a plurality of organic light emitting diodes, each including a lower electrode, an upper electrode, and an organic material layer between the lower electrode and the upper electrode, and fluorescent material disposed on the upper electrode of at least one of the organic light emitting diodes.

[0009] 2. In the display device according to the above-mentioned item 1, the plurality of organic light emitting diodes may include first organic light emitting diodes for emission of light in a first color, the first organic light emitting diodes being arranged in a column direction, and second organic light emitting diodes for emission of light in a second color, the second organic light emitting diodes being arranged in the column direction in parallel with the first organic light emitting diodes, and the display device may further include a permeable bank disposed between some of the first organic light emitting diodes.

[0010] 3. The display device according to the above-mentioned item 2 may further include a plurality of light shielding banks disposed between the first organic light emitting diodes and the second organic light emitting diodes.

[0011] 4. In the display device according to any one of the above-mentioned items 1 to 3, the plurality of organic light emitting diodes may include a red organic light emitting diode for emission of red light, and the fluorescent material disposed on the upper electrode of the red organic light emitting diode may include rubrene-based material.

[0012] 5. In the display device according to any one of the above-mentioned items 1 to 3, the plurality of organic light emitting diodes may include a green organic light emitting diode for emission of green light, and the fluorescent material disposed on the upper electrode of the green organic light emitting diode may include coumarin-based material.

[0013] 6. In the display device according to any one of the above-mentioned items 1 to 3, the plurality of organic light emitting diodes may include a blue organic light emitting diode for emission of blue light, and the fluorescent material disposed on the upper electrode of the blue organic light emitting diode may include tris(8-quinolinorato)aluminium.

[0014] 7. In the display device according to the above-mentioned item 2, the fluorescent material may be disposed on an organic light emitting diode included in the first organic light emitting diodes, and the organic light emitting diode having the fluorescent material may have a color filter disposed on the organic light emitting diode having the fluorescent material, the color filter for a color same as the first color for light emission.

[0015] 8. In the display device according to any one of the above-mentioned items 1 to 7, the lower electrode included in the organic light emitting diode having the fluorescent material may have a hole formed at least in a part of the lower electrode.

[0016] 9. A method of manufacturing a display device according to an embodiment of the present invention, includes: a laser irradiation step of irradiating a defective part of a plurality of organic light emitting diodes with a laser beam; and a fluorescent material application step of applying fluorescent material onto an upper electrode included in the organic light emitting diode having the defective part irradiated with the laser beam.

[0017] 10. In the method of manufacturing a display device according to the above-mentioned item 9, at the laser irradiation step, electrical connection between a lower electrode included in the organic light emitting diode and a wire may be disconnected.

[0018] 11. In the method of manufacturing a display device according to the above-mentioned item 9, at the laser irradiation step, foreign matter between a lower electrode and the upper electrode included in the organic light emitting diode and a part of the lower electrode in contact with the foreign matter may be removed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** illustrates a schematic structure of a display device according to this embodiment;

[0020] FIG. **2** is a schematic plan view of a display panel of a display device according to this embodiment;

[0021] FIG. **3** is a schematic vertical cross-sectional view of the display panel along the line III-III in FIG. **2**;

[0022] FIG. **4** is a schematic plan view of a pixel array portion of a display device according to this embodiment;

[0023] FIG. **5** is a schematic plan view of a pixel array portion of a display device according to this embodiment;

[0024] FIG. **6** is a schematic vertical cross-sectional view of the display panel along the line VI-VI in FIG. **5**;

[0025] FIG. **7** is a schematic vertical cross-sectional view of the display panel along the line VII-VII in FIG. **5**;

[0026] FIG. **8** is a flowchart of a method of repairing a bright spot in a display device according to this embodiment;

[0027] FIG. **9** is a flowchart of a method of repairing a dark spot in a display device according to this embodiment;

[0028] FIG. **10** is a schematic vertical cross-sectional view of the display panel along the line VI-VI in FIG. **5**;

[0029] FIG. **11** is a schematic plan view of a display array portion of a display device according to this embodiment;

[0030] FIG. **12** is a schematic vertical cross-sectional view of the display panel along the line VI-VI in FIG. **5**; and

[0031] FIG. **13** is a schematic vertical cross-sectional view of the display panel along the Line VI-VI in FIG. **5**.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

[0032] The following describes embodiments of the present invention, based on the drawings.

[0033] The disclosure is a mere example, and any modifications readily conceived by a person skilled in the art without departing from the gist of the present invention are included in the scope of the present invention. The respective widths, thicknesses, shapes, and so forth of respective components may be illustrated more schematically in the drawings compared with actual widths, thicknesses, shapes, and so forth in order to make clearer the description of the present invention. These, however, are mere examples, and should not limit interpretation of the present invention in any way. Any elements similar to those having been described referring to drawings referred to earlier are given the same reference numerals in the specification and drawings, and may not be described in detail again.

[0034] A display device **2** according to this embodiment is, for example, an organic electro-luminescent display device, which is to be mounted, for example, in television sets, personal computers, portable terminals, or portable phones. FIG. **1** schematically illustrates the structure of the display device **2** according to this embodiment. The display device **2** includes a pixel array portion **4** that displays an image and a drive unit that drives the pixel array portion **4**. The display device **2** is a flexible display device and includes a base member and a wire layer including a wire disposed inside or above the base member, the base member being made using a flexible resin film, for example.

[0035] The pixel array portion **4** has organic light emitting diodes **6** and pixel circuits **8** arranged in a matrix, each corresponding to each pixel. The pixel circuit **8** includes, for example, a lighting thin film transistor (TFT) **10**, a drive TFT **12**, and a capacitor **14**.

[0036] The drive unit includes a scan line drive circuit **20**, a video line drive circuit **22**, a drive power supply circuit **24**, and a control device **26**, and drives the pixel circuit **8** to control light emission from the organic light emitting diode **6**.

[0037] The scan line drive circuit **20** is connected to scan signal lines disposed each for every row of the pixels in the horizontal direction (a pixel row). The scan line drive circuit **20** sequentially selects a scan signal line **28** in response to a timing signal received from the control device **26**, and applies a voltage for turning on the lighting TFT **10** to the selected scan signal line **28**.

[0038] The video line drive circuit **22** is connected to video signal lines **30** disposed each for every column of the pixels in the vertical direction (a pixel column). The video line driving circuit **22** receives video signals from the control device **26**, and, in accordance with the scan signal line **28** selected by the scan line drive circuit **20**, outputs voltage corresponding to a video signal of the selected pixel row to each of video signal lines **30**. The voltage is written into the capacitor **14** via the lighting TFT **10** in the selected pixel row. The drive TFT **12** supplies a current in accordance with the voltage written to the organic light emitting diode **6**. With the above, the organic light emitting diode **6** corresponding to the selected scan signal line **28** emits light.

[0039] The drive power supply circuit **24** is connected to a drive power supply line **32** provided for every pixel column and supplies a current to the organic light emitting diode **6** via the drive power supply line **32** and the drive TFT **12** of the pixel row selected.

[0040] The lower electrode of the organic light emitting diode **6** is connected to the drive TFT **12**. The upper electrode of each organic light emitting diode **6** is made using an electrode that is common to the organic light emitting diodes **6** of all pixels. In the case of a lower electrode functioning as a positive electrode (an anode), the lower electrode receives a high potential, and the upper electrode, functioning as a negative electrode (a cathode), receives a lower potential. Meanwhile, in the case of a lower electrode functioning as a negative electrode (a cathode), the lower electrode receives a lower potential, and the upper electrode, functioning as a positive electrode (an anode), receives a higher potential.

[0041] FIG. **2** is a schematic plan view of the display panel **40** of the display device **2**. The display panel **40** has the pixel array portion **4** illustrated in FIG. **1**, formed in the display area **42** thereof. As described above, the organic light emitting diode **6** is disposed in the pixel array portion **4**. As described above, an upper electrode **104** of the organic light emitting diode **6** is formed common to the respective pixels, covering substantially the entire display area **42**.

[0042] The display panel **40**, which is rectangular, has a drive unit formation area **46** defined along one side of the display panel **40**. A wire for connection to the display area **42** is disposed in the drive unit formation area **46**. The drive unit formation area **46** additionally has a drive IC **48** that constitutes a drive unit, and is connected to flexible printed circuits (FPC) **50**. The FPC **50** is connected to, for example, the scan line drive circuit **20**, the video line drive circuit **22**, the drive power supply circuit **24**, and the control device **26**, and has an integrated circuit (IC) formed thereon.

[0043] FIG. **3** is a schematic vertical cross-sectional view of the display panel **40** along the line III-III in FIG. **2**. The display panel **40** has a laminated structure including a circuit layer, the organic light emitting diode **6**, and a sealing layer **106** stacked in this order on an insulating base member **70** made using a resin film, the circuit layer including a TFT **72**, the sealing layer **106** sealing the organic light emitting diode **6**. The insulating base member **70** may be made, for example, using a polyimide film. A protective film **114** can be formed on the sealing layer **106**. The pixel array portion **4** in this embodiment is of a top-emission type. The light generated by the organic light emitting diode **6** ejects toward the side opposite from the insulating base member **70**, that is, upward in FIG. **3**. In the case where the display device **2** employs color filters for coloring, a color filter is disposed between the sealing layer **106** and the protective film **114** or on the side closer to the counter substrate. The organic light emitting diode **6** generates a white light, which passes through the color filters to thereby constituting red (R), green (G), and blue (B) respective light beams.

[0044] The circuit layer in the display area **42** has the above-mentioned pixel circuit **8**, scan signal line **28**, video signal line **30**, drive power supply line **32**, or the like. At least a part of the drive unit can be formed as a circuit layer on the insulating base member **70** in an area adjacent to the display area **42**. As described above, the FPC **50** and the drive IC **48** constituting the drive unit can be connected to a wire **116** in the circuit layer in the drive unit formation area **46**.

[0045] Specifically, a polysilicon (p-Si) film is formed on the insulating base member **70** via a first insulating film **80**, or a base layer made of inorganic insulating material, such as silicon nitride (SiN_y) or silicon oxide (SiO_x). The p-Si film is patterned such that a part thereof to be used in the circuit layer is selectively left. For example, using the p-Si film, a semiconductor area **82** that makes a channel portion and the source and drain portions of a top-gate TFT **72** is formed. On the channel portion of the TFT **72**, a gate electrode **86** is disposed via a gate insulating film **84**. The gate electrode **86** is formed by patterning a metal film formed through sputtering or the like. Thereafter, an interlayer insulating film **88** is formed covering the gate electrode **86**. The p-Si that makes the source portion and drain portion of the TFT **72** is doped with impurities through ion injection, and a source electrode **90***a* and a drain electrode **90***b* for electrical connection thereto are formed. After formation of the TFT **72** as described above, an interlayer insulating film **92** is formed. On the surface of the interlayer insulating film **92**, a wire **94** or the like can be formed through patterning with a metal film formed through sputtering or the like. This metal film and a metal film used to form the gate electrode **86**, the source electrode **90***a*, and the drain electrode **90***b* together constitute a multi-layered wire structure including, for example, the wire **116** and the scan signal line **28**, the video signal line **30**, and the drive power supply line **32** illustrated in FIG. **1**. On the structure, for example, a planarization film **96** made of organic material such as acrylic resin or the like is formed, and the organic light emitting diode **6** is formed on the thus flattened surface of the display area **42**.

[0046] The organic light emitting diode **6** includes a lower electrode **100**, an organic material layer **102**, and the upper electrode **104**, laminated in this order from the insulating base member **70** side. In this embodiment, the lower electrode **100** is a positive electrode (an anode) of the organic light emitting diode **6**, and the upper electrode **104** is a negative electrode (a cathode). The organic material layer **102** includes a hole transport layer, a light emissive layer, an electron transport layer, or the like.

[0047] In the case where the TFT **72** illustrated in FIG. **3** is a drive TFT **12** including an n-channel, the lower electrode **100** is connected to the source electrode **90***a* of the TFT **72**. Specifically, after formation of the above mentioned planarization film **96**, a contact hole **110**, through which the lower electrode **100** is to be connected to the TFT **72**, is formed, and a conductive film is formed on the surface of the planarization film **96** and inside the contact hole **110** and then patterned, whereby the lower electrode **100** connected to the TFT **72** is formed for every pixel.

[0048] After formation of the lower electrode **100**, a bank **112** is formed on the boundary between pixels. In the effective area of the pixel, defined by the surrounding bank **112**, the lower electrode **100** remains exposed. After formation of the bank **112**, the respective layers constituting the organic material layer **102** are laminated in order on the lower electrode **100**. The upper electrode **104** is formed on the organic material layer **102**, using transparent electrode material.

[0049] On the surface of the upper electrode **104**, for example, an SiN_y film is formed as the sealing layer **106** by chemical vapor deposition (CVD). In order to secure mechanical endurance of the surface of the display panel **40**, the protective film **114** is formed on the surface of the display area **42**. Meanwhile, to facilitate connection of an IC or an FPC, the protective film **114** is not formed on the drive unit formation area **46**. The wires of the FPC **50** or terminals of the driver IC **48** are electrically connected to, for example, the wire **116**.

[0050] FIG. **4** is a schematic plan view of the pixel array portion **4** of the display device **2**. As illustrated in FIG. **4**, the pixel array portion **4** has a plurality of pixels, each pixel having an organic light emitting diode **6** for light emission in any of the colors including red, green, and blue. In this embodiment, the organic light emitting diodes for the same color are disposed in each column. That is, a pixel column **200**R for red light emission, a pixel column **200**G for green light emission, and a pixel column **200**B for blue light emission are sequentially disposed.

[0051] In this embodiment, an example will be described in which the pixel column **200**G for green light emission includes a bright spot **210**, or a spot that lights constantly. The bright spot **210** is caused, for example, as the lower electrode **100**, or an anode, of the organic light emitting diode **6** of this pixel is connected to a wire or the like having an irregular shape due to abnormality in process.

[0052] The following describes a method of repairing a bright spot in this embodiment, referring to the flowchart in FIG. **8**.

[0053] Initially, at a defect detection step S**101**, a bright spot is detected. In this embodiment, as illustrated in FIG. **4**, the position of a bright spot **210** in the pixel column **200**G for green light emission is detected. The detection may be made by any method without limitation. For example, scattered light or reflection light attributed to the light emitted from the display surface side of the display panel **40** may be imaged by a detector to thereby obtain an optical image of the display panel **40**, and whether there is a defect in the optical EL device is determined based on the optical image.

[0054] Thereafter, a laser irradiation step S**102** of irradiating an object pixel with a laser beam is performed. Specifically, the bright spot **210** is irradiated with a laser beam emitted from the display surface side of the display panel **40**, that is, the upper electrode **104** side, to thereby disconnect the connection between the lower electrode **100** and a wire having an irregular shape. That is, the organic light emitting diode **6** and the pixel circuit **8** in the relevant pixel are disconnected from each other. This can make the bright spot **210** a dark spot **220**, or a spot that does not light at all, as illustrated in FIG. **5**. The laser irradiation step S**102**

resultantly causes a hole in a part of the lower electrode **100** due to laser irradiation. Laser beams can be emitted from the insulating base member **70** side, though laser beam irradiation from the upper electrode **104** side is preferred. Laser beam irradiation from the upper electrode **104** side enables efficient execution of the laser irradiation step S**102** as no TFT layer **72**, or the like, containing a TFT **72** forming a part of the pixel circuit **8** is present in the laser beam path.

[0055] Thereafter, a fluorescent material application step S**103** is performed. FIG. **6** is a schematic vertical cross-sectional view of the display panel **40** along the line VI-VI in FIG. **5**. FIG. **6** is a simplified version of the cross-sectional view in FIG. **3**. In FIG. **6**, the first insulating film **80** is formed on the insulating base member **70**, and the TFT layer **72**A containing the TFT **72** is formed on the insulating film **80**. The planarization film **96** is formed on the TFT layer **72**A, and the lower electrode **100** is formed on the planarization film **96**. In this embodiment, the lower electrode **100** is an anode, and has a hole **240** resulted at the laser irradiation step S**102**. The organic material layer **102** and the bank **112** are formed on the lower electrode **100**, the bank **112** being formed between pixels. As FIG. **6** illustrates a vertical cross section of the pixel column **200**G for green light emission illustrated in FIG. **5**, the organic material layer **102** here is an organic material layer **102**G that emits green light upon application of a voltage. The bank **112** formed between the organic material layers **102**G that emit light in the same color, or green here, is a permeable bank **112**A. A cathode, or the upper electrode **104**, is formed on the upper surface of the organic material layer **102**.

[0056] The pixel column **200**G for green light emission contains a dark spot **220**, which used to be a bright spot **210** and is darkened by laser irradiation. The dark spot **220** does not emit green light despite application of a voltage to the relevant anode and cathode. Regarding this point, in this embodiment, at the fluorescent material application step S**103**, fluorescent material **180** is applied onto the cathode, that is, the upper electrode **104** of the pixel that makes the dark spot **220**. The fluorescent material **180** is material that absorbs green light and emits green fluorescent light and is, for example, coumarin-based material. With this structure, green light emitted from an adjacent pixel passes through the permeable bank **112**A made of permeable material and enters the fluorescent material **180**. The fluorescent material **180** absorbs the green light and emits green fluorescent light. As a result, as illustrated in the plan view in FIG. **11**, the dark spot **220** is compensated for color, and becomes less outstanding. That is, the defect is repaired and then rectified.

[0057] The permeable bank **112**A may be made of material having permeability at least in the wavelength range for green light. Although coumarin-based material that absorbs green light and emits green fluorescent light is mentioned as the fluorescent material **180** in this embodiment, any material that emits at least green fluorescent light is applicable. Material that additionally emits light in a wavelength range other than that for green is applicable. In the case where the fluorescent material **180** additionally emits light in a wavelength range other than that for green light, a green color filter may be disposed on the upper surface side of the material so that only green light can be extracted.

[0058] FIG. **7** is a schematic vertical cross-sectional view of the display panel **40** along the line VII-VII in FIG. **5**. FIG. **7** illustrates a simplified version of the cross-sectional view illustrated in FIG. **3**, similar to FIG. **6**. An organic material layer **102** is formed on the upper surface of the lower electrode **100**. As FIG. **7** illustrates a vertical cross section along a line traversing the pixel column **200**R for red light emission, the pixel column **200**G for green light emission, and the pixel column **200**B for blue light emission illustrated in FIG. **5**, the organic material layer **102** includes an organic material layer **102**R, an organic material layer **102**G, and an organic material layer **102**B that emit red, green, and blue respective light beams upon application of a voltage thereto. A cathode, or the upper electrode **104**, is formed on the upper surface of the organic material layer **102**.

[0059] A light shielding bank **112**B is formed between a pixel including the organic material layer **102**G for green light emission and another pixel for emission of light in another color. This structure can prevent mixture of green light emitted from the fluorescent material **180** on the organic light emitting diode for green light emission and light in other colors emitted from other pixels.

[0060] Although an example is described in this embodiment in which a green organic light emitting diode including the organic material layer **102**G for green light emission becomes a bright spot **210** and the bright spot **210** is darkened to be rectified later, the above description is applicable to a case in which an optical light emitting diode including the organic material layer **102**R for red light emission or the organic material layer **102**B for blue light emission becomes a bright spot **210**.

[0061] In the case where a red organic light emitting diode including the organic material layer **102**R for red light emission becomes a bright spot **210**, material, such as rubrene-based material, that absorbs red light and emits red fluorescent light may be used as the fluorescent material **180** to be disposed on the upper electrode **104** of the red organic light emitting diode that is darkened at the laser irradiation step S**102**. In the case where the fluorescent material **180** additionally emits light in a wavelength range other than that for red, a red color filter may be disposed on the upper surface side of the fluorescent material **180**, so that only red light can be extracted. In this case, the permeable bank **112**A for use in the pixel column **200**R for red light emission may be made of any permeable material having permeability at least in the wavelength range for red light.

[0062] Similarly, in the case where a blue organic light emitting diode including the organic material layer **102**B for blue light emission becomes a bright spot, material, such as tris(8-quinolinorato)aluminium, that absorbs blue light and emits blue fluorescent light may be used as the fluorescent material **180** to be disposed on the upper electrode **104** of the blue organic light emitting diode that is darkened at the laser irradiation step S**102**. In the case where the fluorescent material **180** additionally emits light in a wavelength range other than that for blue, a blue color filter may be disposed on the upper surface side of the fluorescent material **180**, so that only blue light can be extracted. In this case, the permeable bank **112**A for use in the pixel column **200**B for blue light emission may be made of any permeable material having permeability at least in the wavelength range for blue light.

[0063] Thereafter, the sealing layer **106** illustrated in FIG. **3** is formed over the entire upper electrode **104**. As the sealing layer **106** covers the repaired part described above, invasion of moisture or oxygen through the repaired part into the display panel **40** can be prevented.

[0064] The following describes a method of repairing a defect in the case where the organic light emitting diode **6** makes a dark spot **220**, referring to the flowchart in FIG. **9**.

[0065] For example, as illustrated in FIG. **10**, if foreign matter should enter between the upper electrode **104** and the lower electrode **100** and causes short-circuit between the cathode and the anode, the organic light emitting diode **6** makes a dark spot **220**.

[0066] In this case as well, the defect detection step S**101** and the laser irradiation step S**102**, described referring to FIG. **9**, are executed. That is, a laser beam is emitted from the upper surface side of the display panel **40** to remove the foreign matter and a part of the lower electrode **100**, the part being in contact with the foreign matter. At this step, although light is not emitted from where a part of the organic material layer **102** has been removed, the remaining part of the organic material layer **102** in the same pixel emits light. Using the light from the remaining part, the fluorescent material **180** disposed on the upper surface of the upper electrode **104** can emit light. That is, as the fluorescent material **180** can emit light using the light from the same pixel in this case, as described above, the permeable bank **112**A is unnecessary. This allows formation of all banks **112** as the light shielding banks **11**B. When the dark spot **220** is rectified by this laser irradiation, the repairing process completes.

[0067] Thereafter, as illustrated in FIG. **12**, the sealing layer **106** is formed on the entire upper electrode **104**. As the sealing layer **106** covers the repaired part, invasion of moisture and oxygen through the repaired part into the display panel **40** can be prevented. As illustrated in FIG. **12**, the sealing layer **106** may fill inside the repaired part, and the fluorescent material **180** may reach the planarization film **96**.

[0068] If the foreign matter **230** cannot be fully removed by the laser irradiation at the laser irradiation step S**102** or the dark spot **220** cannot be fully rectified despite removal of the foreign matter **230**, the above mentioned fluorescent material application step S**103** is executed as illustrated in FIG. **13** to apply the fluorescent material **180** onto the part irradiated with the laser. This can repair the defect, and the dark spot **220** can be rectified. As illustrated in FIG. **13**, the fluorescent material **180** may fill inside the repaired part and reach the planarization film **96**.

[0069] Note that a person skilled in the art can conceive various kinds of changes and modifications within the gist of the present invention. Such changes and modifications are included in the scope of the present invention. For example, any addition, deletion, change in design of any structural components, addition and deletion of a process, and change in a condition are included in the scope of the present invention when these retain the gist of the present invention.

What is claimed is:

1. A display device, comprising:

a plurality of organic light emitting diodes, each including
  a lower electrode,
  an upper electrode, and
  an organic material layer between the lower electrode and the upper electrode, and

fluorescent material disposed on the upper electrode of at least one of the organic light emitting diodes.

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

the plurality of organic light emitting diodes include
  first organic light emitting diodes for emission of light in a first color, the first organic light emitting diodes being arranged in a column direction, and
  second organic light emitting diodes for emission of light in a second color, the second organic light emitting diodes being arranged in the column direction in parallel with the first organic light emitting diodes, and

the display device further comprises a permeable bank disposed between some of the first organic light emitting diodes.

3. The display device according to claim **2**, further comprising a plurality of light shielding banks disposed between the first organic light emitting diodes and the second organic light emitting diodes.

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

the plurality of organic light emitting diodes include a red organic light emitting diode for emission of red light, and

the fluorescent material disposed on the upper electrode of the red organic light emitting diode includes rubrene-based material.

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

the plurality of organic light emitting diodes include a green organic light emitting diode for emission of green light, and

the fluorescent material disposed on the upper electrode of the green organic light emitting diode includes coumarin-based material.

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

the plurality of organic light emitting diodes include a blue organic light emitting diode for emission of blue light, and

the fluorescent material disposed on the upper electrode of the blue organic light emitting diode includes tris(8-quinolinorato)aluminium.

7. The display device according to claim **2**, wherein

the fluorescent material is disposed on an organic light emitting diode included in the first organic light emitting diodes, and

the organic light emitting diode having the fluorescent material has a color filter disposed on the organic light emitting diode having the fluorescent material, the color filter for a color same as the first color for light emission.

8. The display device according to claim **1**, wherein the lower electrode included in the organic light emitting diode having the fluorescent material has a hole formed at least in a part of the lower electrode.

9. A method of manufacturing a display device, comprising:

a laser irradiation step of irradiating a defective part of a plurality of organic light emitting diodes with a laser beam; and

a fluorescent material application step of applying fluorescent material onto an upper electrode included in the organic light emitting diode having the defective part irradiated with the laser beam.

10. The method of manufacturing the display device according to claim **9**, wherein at the laser irradiation step, electrical connection between a lower electrode included in the organic light emitting diode and a wire is disconnected.

11. The method of manufacturing the display device according to claim **9**, wherein at the laser irradiation step, foreign matter between a lower electrode and the upper electrode included in the organic light emitting diode and a part of the lower electrode in contact with the foreign matter are removed.

* * * * *

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摘要(译)

根据本发明实施例的显示装置包括：多个有机发光二极管，每个有机发光二极管包括下电极，上电极和位于下电极和上电极之间的有机材料层，以及设置在其上的荧光材料。至少一个有机发光二极管的上电极。