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(19) **United States**(12) **Patent Application Publication**
TOJO et al.(10) **Pub. No.: US 2017/0250372 A1**(43) **Pub. Date: Aug. 31, 2017**(54) **DISPLAY DEVICE, AND METHOD AND APPARATUS FOR MANUFACTURING THE SAME***H01L 27/32* (2006.01)*H01L 51/00* (2006.01)*H01L 51/56* (2006.01)(71) Applicant: **Japan Display Inc.**, Minato-ku (JP)(72) Inventors: **Toshio TOJO**, Minato-ku (JP); **Hideki OZAWA**, Minato-ku (JP); **Yuki HAMADA**, Minato-ku (JP)(73) Assignee: **Japan Display Inc.**, Minato-ku (JP)(21) Appl. No.: **15/416,064**(22) Filed: **Jan. 26, 2017**(30) **Foreign Application Priority Data**

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(57)

ABSTRACT

A method for manufacturing a display device includes a first step of placing a substrate having a lower electrode formed thereon in a vacuum environment; a second step of forming in a vacuum an organic layer that includes a light emitting layer and covers the lower electrode; a third step of forming in a vacuum an upper electrode that covers the organic layer; a fourth step of forming in a vacuum a sealing layer that covers the upper electrode; and a cleaning step of cleaning the substrate after end of the first step before end of the fourth step.

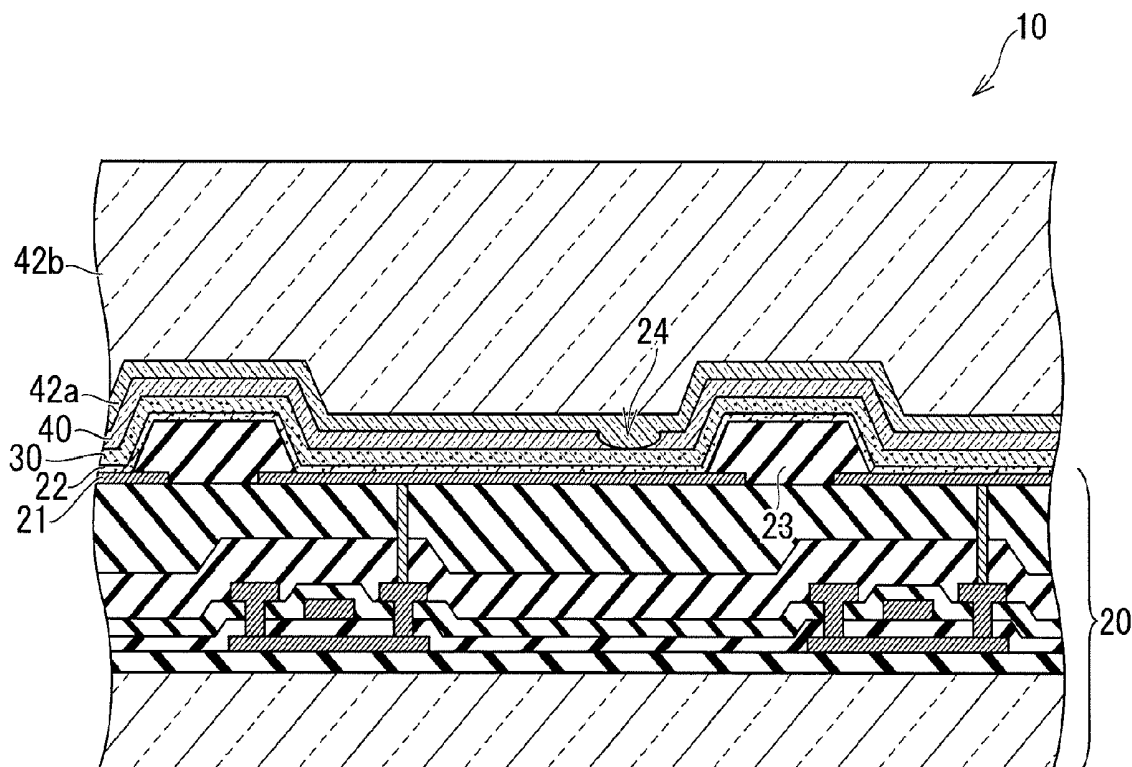


FIG. 1

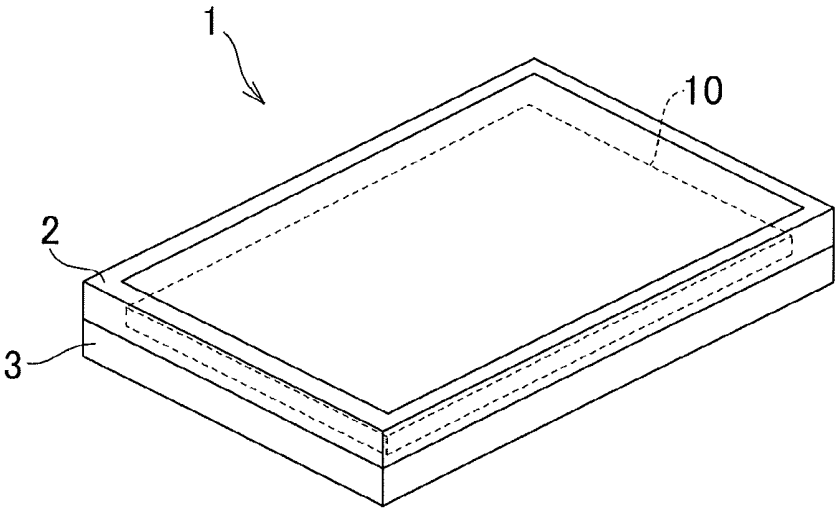


FIG.2

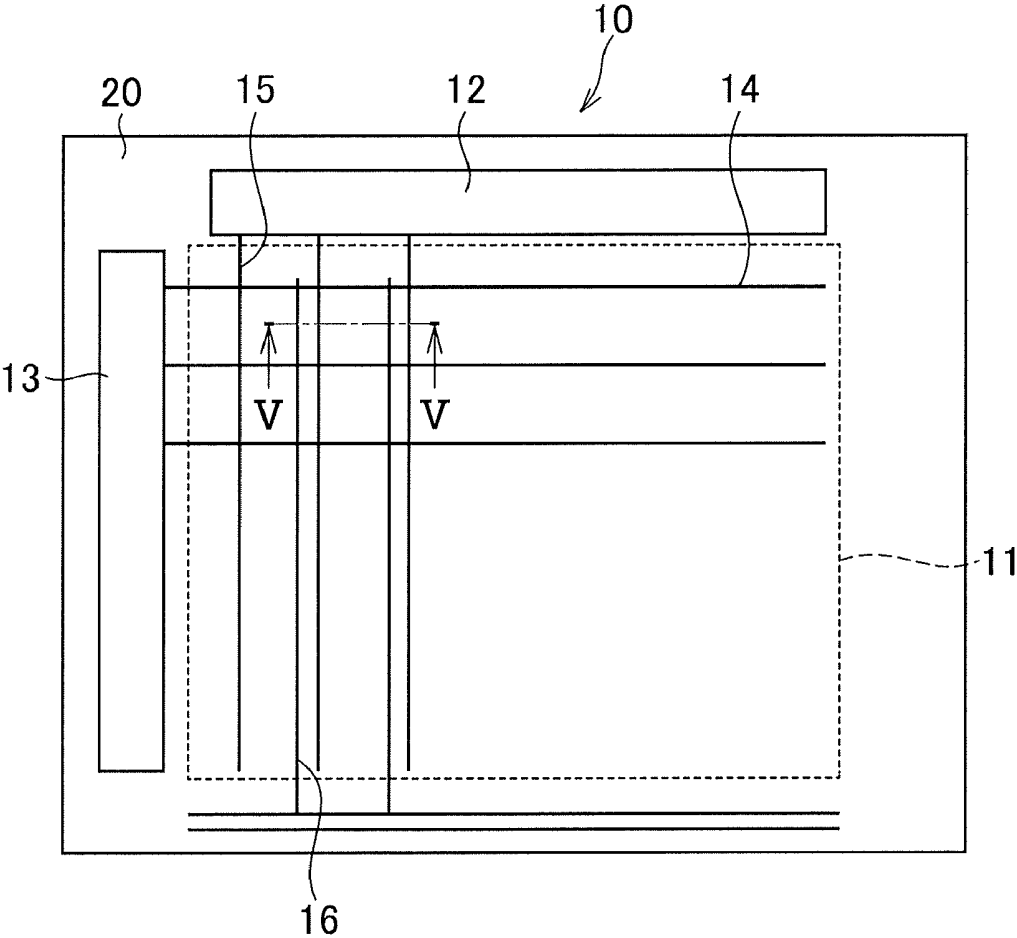


FIG.3

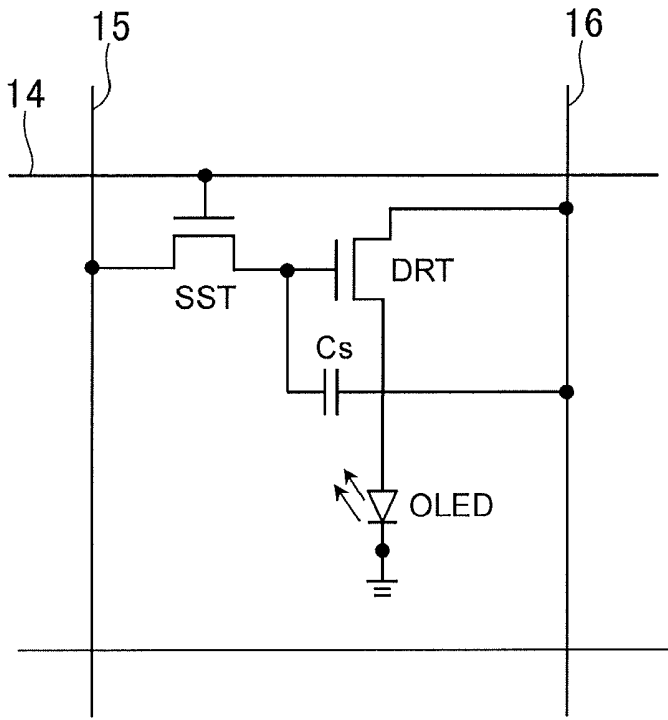


FIG.4

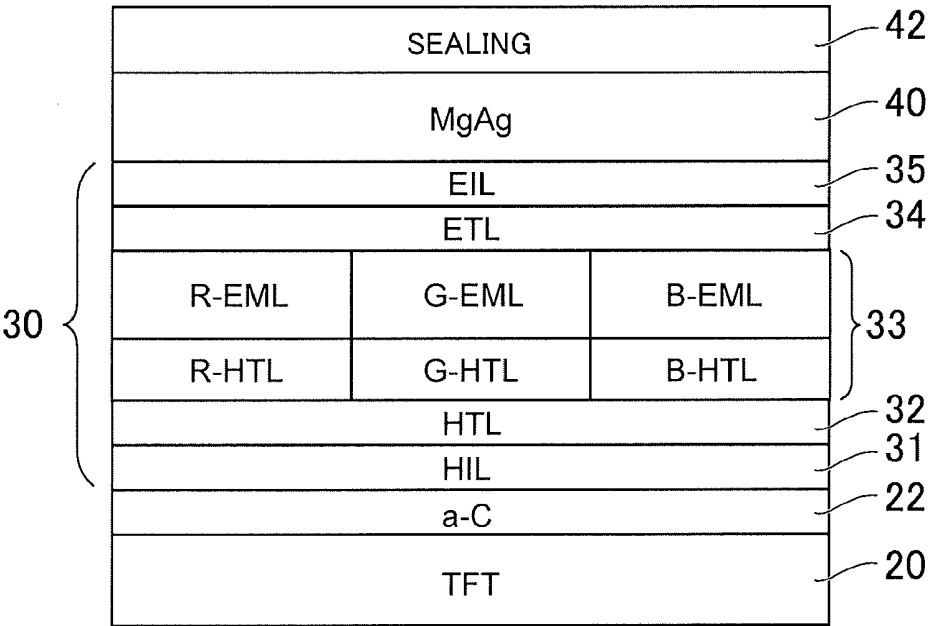


FIG. 5

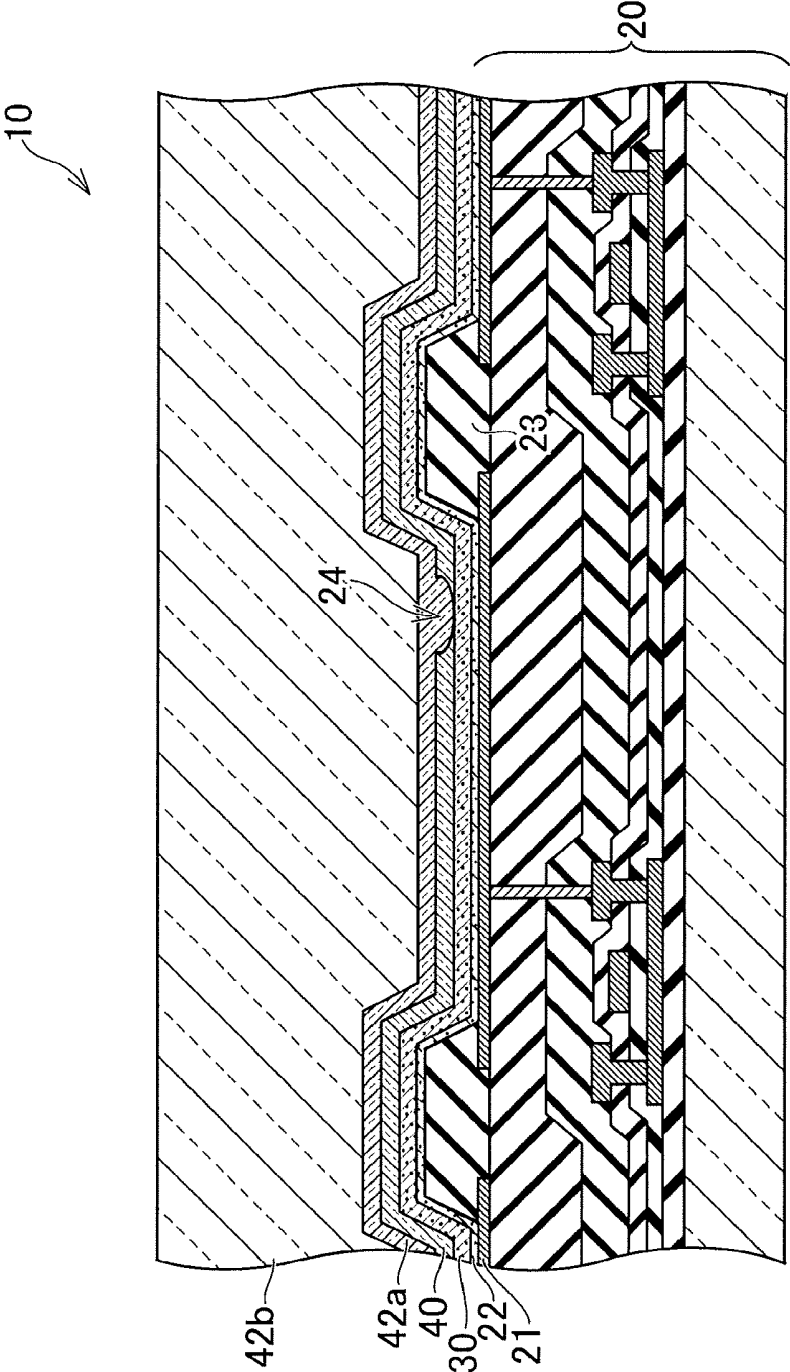


FIG. 6

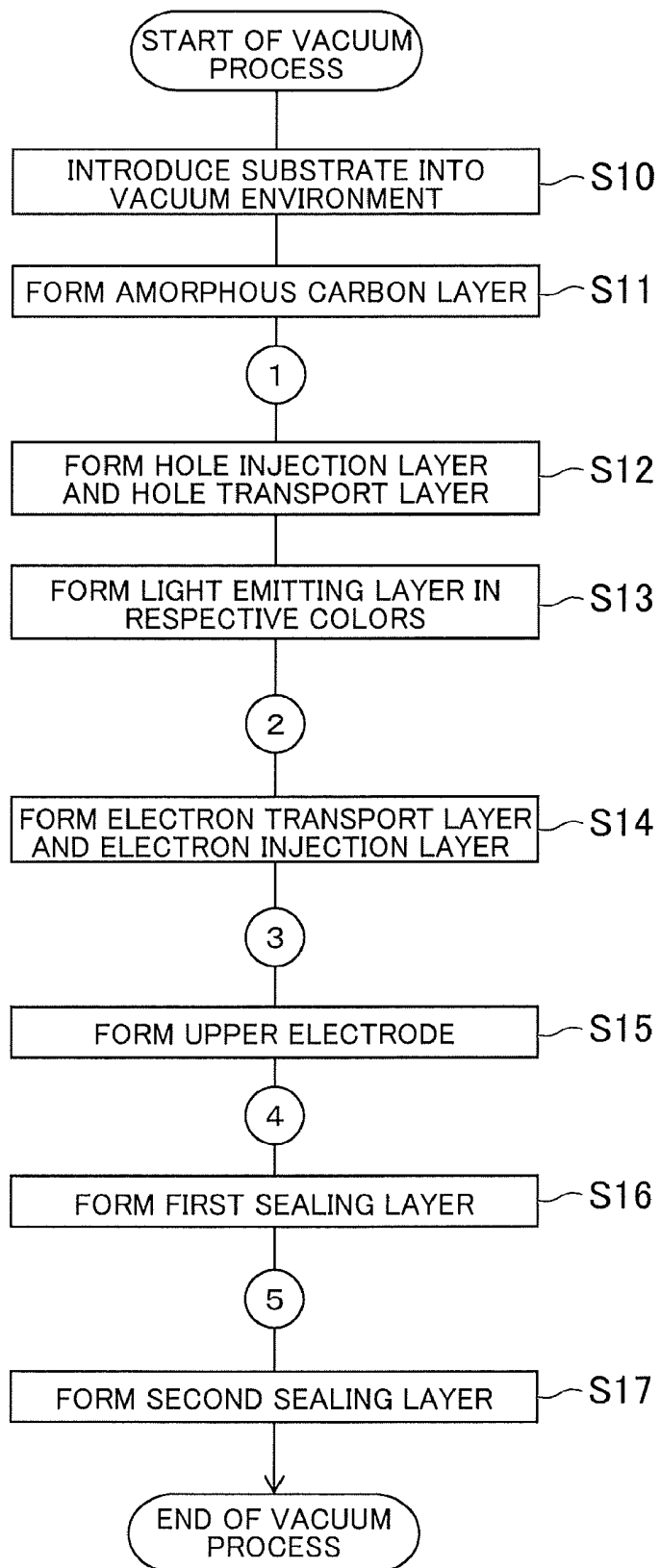


FIG. 7

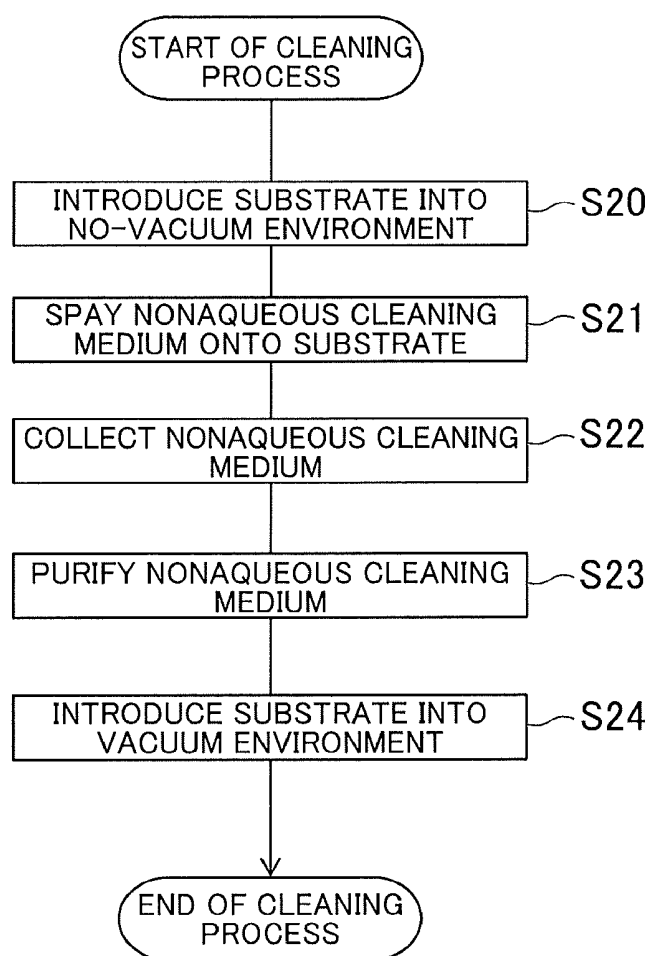


FIG.8

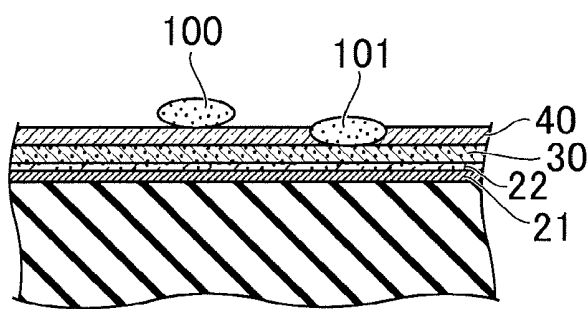


FIG.9

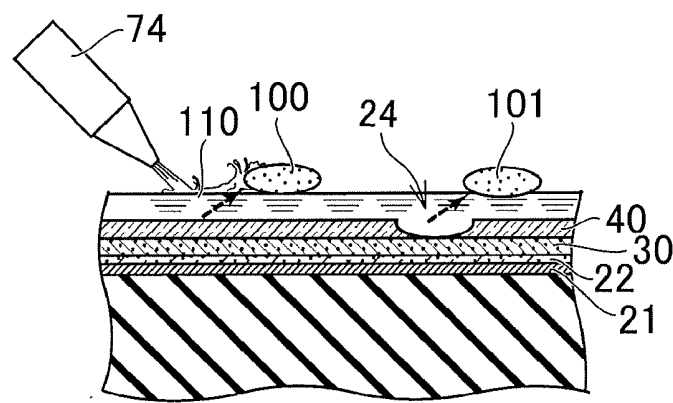


FIG. 10

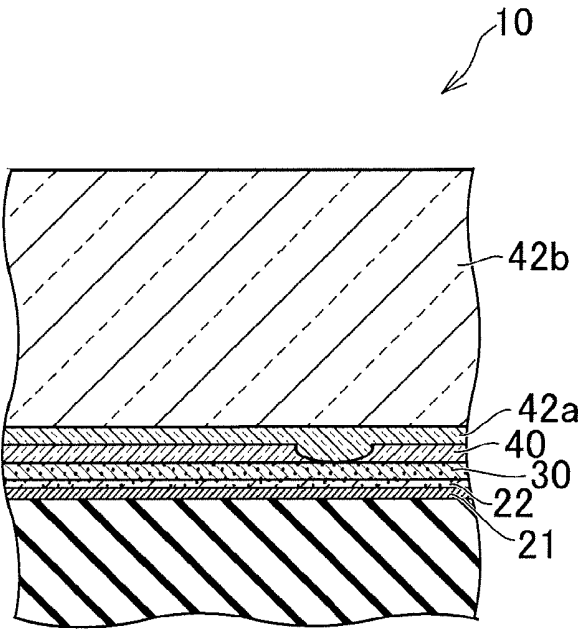


FIG. 11

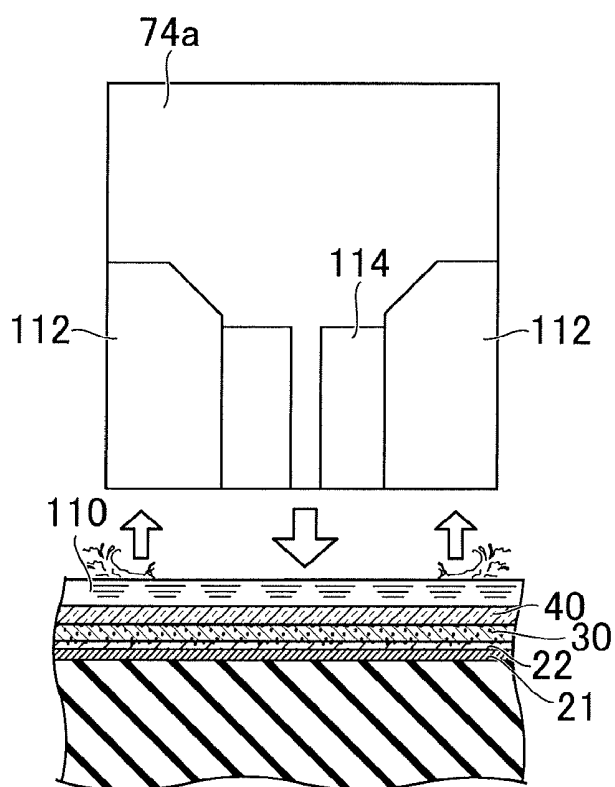


FIG. 12

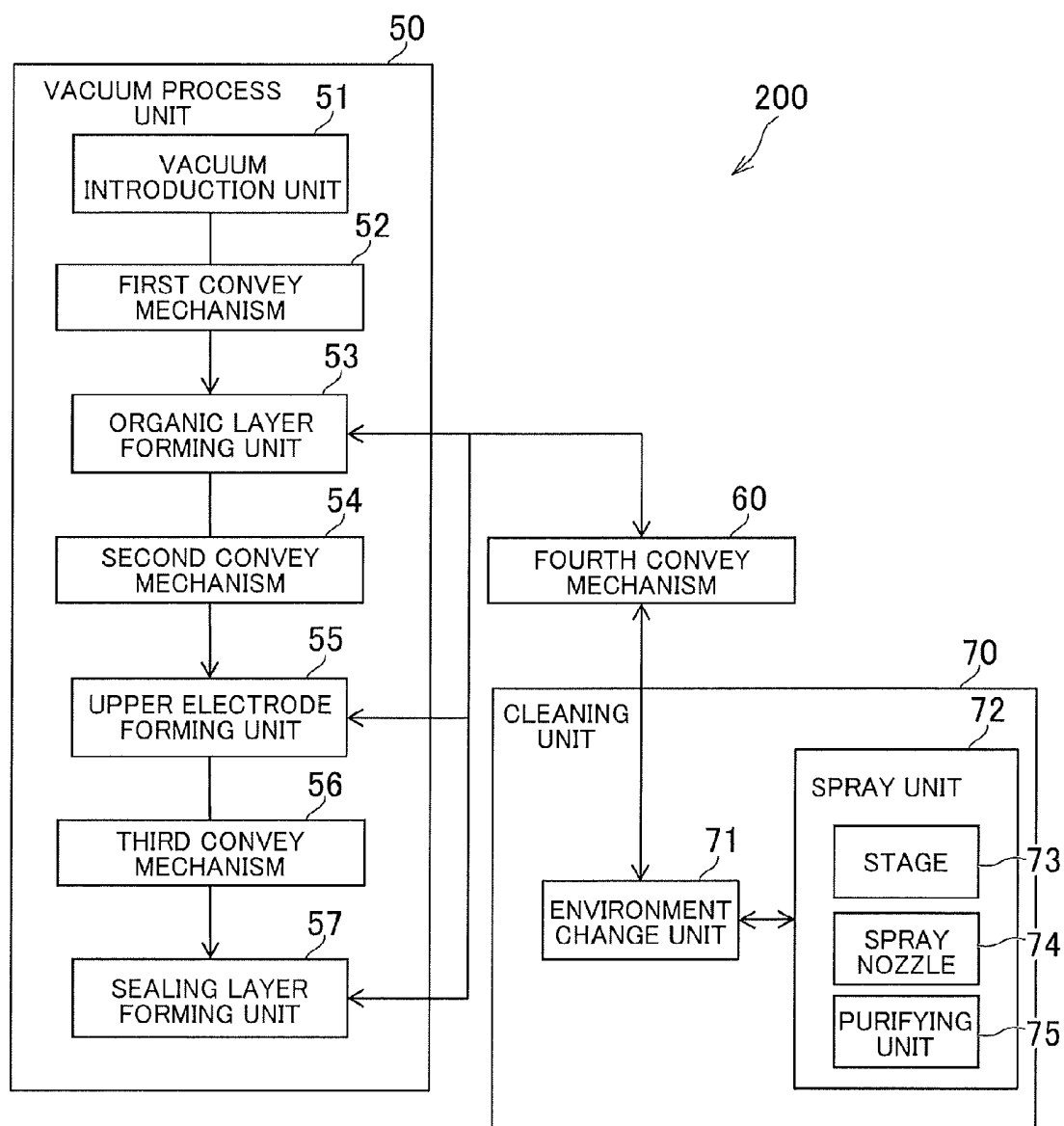
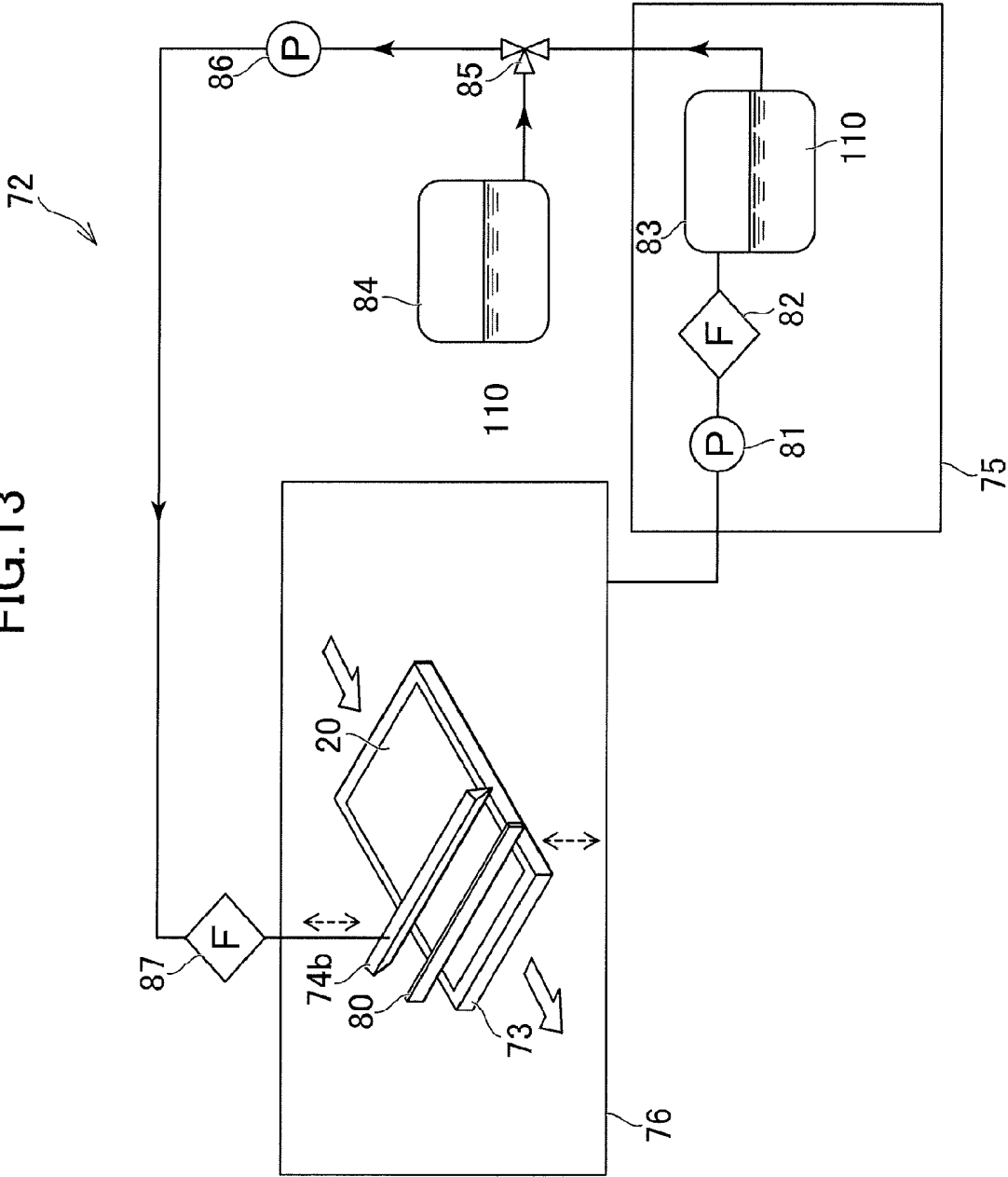


FIG. 13



DISPLAY DEVICE, AND METHOD AND APPARATUS FOR MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority from Japanese application JP2016-036011 filed on Feb. 26, 2016, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a method for manufacturing a display device, a display device, and an apparatus for manufacturing a display device.

[0004] 2. Description of the Related Art

[0005] In a display device such as an organic EL (Electro Luminescence) display device, etc., there is a case in which a light emitting device, such as an organic light emitting diode (OLED) etc., is controlled using a switching element, such as a transistor, etc., to display an image. In the above, an organic light emitting diode may be manufactured in a vacuum as organic material for forming an organic light emitting diode may be deteriorated due to invasion of water, oxygen, etc.

[0006] Japanese Patent Laid-open Publication No. 2015-072770 describes an organic electro-luminescence device in which an OLED layer is formed in contact with an anode, an inorganic bank, and an organic planarization film.

[0007] In manufacturing an organic light emitting diode in a vacuum, the inside of a vacuum chamber should be kept clean. However, fine foreign matter may be mixed into the vacuum chamber via a deposition mask or a feeding mechanism. With foreign matter mixed into an organic light emitting diode, flickering pixels may be caused, which decreases the yield.

SUMMARY OF THE INVENTION

[0008] The present invention aims to provide a method for manufacturing a display device, a display device, and an apparatus for manufacturing a display device for preventing decrease in the yield due to foreign matter mixed.

[0009] According to the present invention, there is provided a method for manufacturing a display device including a first step of placing a substrate having a lower electrode formed thereon in a vacuum environment; a second step of forming in a vacuum an organic layer that includes a light emitting layer and covers the lower electrode; a third step of forming in a vacuum an upper electrode that covers the organic layer; a fourth step of forming in a vacuum a sealing layer that covers the upper electrode; and a cleaning step of cleaning the substrate after end of the first step before end of the fourth step.

[0010] According to the present invention, there is provided a display device including a substrate; a plurality of pixels formed on the substrate; a lower electrode provided to each of the plurality of pixels; a pixel separation film formed on the substrate, configured to cover an end portion of the lower electrode so as to leave a middle part of the lower electrode exposed, and configured to define the plurality of pixels; an organic layer being in contact with the portion of the lower electrode exposed from the pixel separation film,

positioned on the pixel separation film, and including a light emitting layer; an upper electrode formed on the organic layer; and a sealing layer formed on the upper electrode, wherein the upper electrode has a hole formed on a surface thereof in contact with the sealing layer.

[0011] According to the present invention, there is provided an apparatus for manufacturing a display device including a vacuum introduction unit for placing a substrate having a lower electrode formed thereon in a vacuum environment; an organic layer forming unit connected to the vacuum introduction unit via a first convey mechanism, for forming in a vacuum an organic layer that includes a light emitting layer and covers the lower electrode on the substrate; an upper electrode forming unit connected to the organic layer forming unit via a second convey mechanism, for forming in a vacuum an upper electrode that covers the organic layer; a sealing layer forming unit connected to the upper electrode forming unit via a third convey mechanism, for forming in a vacuum a sealing layer that covers the upper electrode; and a cleaning unit connected to at least one of the organic layer forming unit, the upper electrode forming unit, and the sealing layer forming unit via a fourth convey mechanism, for cleaning the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a perspective view showing an organic EL display device according to an embodiment of the present invention;

[0013] FIG. 2 is a wiring diagram of an organic EL panel according to an embodiment of the present invention; FIG. 3 is a circuit diagram of a pixel of an organic EL panel according to an embodiment of the present invention;

[0014] FIG. 4 is a schematic diagram showing a laminated structure of a pixel of an organic EL panel according to an embodiment of the present invention;

[0015] FIG. 5 is a cross sectional view of a pixel of an organic EL panel according to an embodiment of the present invention;

[0016] FIG. 6 is a flowchart showing a method for manufacturing an organic EL display device according to an embodiment of the present invention;

[0017] FIG. 7 is a flowchart showing a cleaning process of a method for manufacturing an organic EL display device according to an embodiment of the present invention;

[0018] FIG. 8 shows first foreign matter and second foreign matter to be removed according to a method for manufacturing an organic EL display device according to an embodiment of the present invention;

[0019] FIG. 9 shows a cleaning process of a manufacturing method of an organic EL display device according to an embodiment of the present invention;

[0020] FIG. 10 is a cross sectional view of an organic EL panel according to an embodiment of the present invention;

[0021] FIG. 11 is a schematic diagram showing a first spray nozzle used in a cleaning process of a method for manufacturing an organic EL display device according to an embodiment of the present invention;

[0022] FIG. 12 is a block diagram showing a structure of an apparatus for manufacturing an organic EL display device according to an embodiment of the present invention; and

[0023] FIG. 13 is a schematic diagram showing a spray unit of an apparatus for manufacturing an organic EL display device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] In the following, respective embodiments of the present invention will be described while referring to the drawings. Note that the disclosure relates merely to one example, and any change readily conceived while retaining the gist of the present invention by a person skilled in the art is naturally included in the scope of the present invention. Further, in the drawings, the width, thickness, shape, etc., of the respective units may be shown schematically, compared to those according to the actual aspect, for the purpose of making the drawings clearer. The drawings merely show one example and do not limit in any way the interpretation of the present invention. In this specification and respective drawings, an element identical to one described earlier in connection with a drawing referred to earlier is given the same reference numeral, and detailed description thereof may be omitted.

[0025] FIG. 1 is a perspective view showing an organic EL display device 1 according to an embodiment of the present invention. An organic EL display device 1 is made using an organic EL panel 10 fixedly sandwiched by an upper frame 2 and a lower frame 3. An external drive circuit (not shown) for driving the organic EL panel 10 maybe provided, together with the organic EL panel 10, inside, that is, between, the upper frame 2 and the lower frame 3, or outside via a lead wire.

[0026] FIG. 2 is a wiring diagram of the organic EL panel 10 according to an embodiment of the present invention. FIG. 3 is a circuit diagram of a pixel of the organic EL panel 10 according to an embodiment of the present invention. The organic EL panel 10 controls respective pixels provided in a matrix in a display area 11 of a substrate 20, using a video signal driving circuit 12 and a scan signal driving circuit 13, to display an image. Note here that the video signal driving circuit 12 is a circuit for generating and sending a video signal to the respective pixels, and the scan signal driving circuit 13 is a circuit for generating and sending a scan signal to a TFT (Thin Film Transistor) provided to each pixel. Note that, although the video signal driving circuit 12 and the scan signal driving circuit 13 are arranged in two respective positions in FIG. 2, these may be built in a single IC (Integrated Circuit) or arranged separately in three or more positions.

[0027] A scan signal line 14, via which a signal from the scan signal driving circuit 13 is sent, is electrically connected to a gate of a pixel transistor SST formed in each pixel area. The scan signal line 14 is common to pixel transistors aligned in a single row. The pixel transistor SST is a transistor of which source or drain is electrically connected to the gate of a driving transistor DRT. A driving transistor DRT is, for example, an n-type channel field effect transistor, of which source is electrically connected to the anode of an organic light emitting diode OLED. The cathode of an organic light emitting diode OLED is fixed either to a ground potential or negative potential. In the above, in the organic light emitting diode OLED, a current flows from the anode to the cathode. A video signal line 15, via which a signal from the video signal driving circuit 12 is sent, is electrically connected to the source or drain of the pixel transistor SST. The video signal line 15 is common to pixel transistors aligned in one column. When a scan signal is applied to the scan signal line 14, the pixel transistor SST is turned on. When a video signal is then inputted to the video

signal line 15, a video signal voltage is applied to the gate of the driving transistor DRT, whereby a voltage in accordance with the video signal is applied to a holding capacitance Cs, upon which the driving transistor DRT is turned on. A power supply line 16 is electrically connected to the drain of the driving transistor DRT. A power supply voltage for causing the organic light emitting diode OLED to emit light is applied to the power supply line 16. When the driving transistor DRT is turned on, a current in accordance with the magnitude of the video signal voltage flows into the organic light emitting diode OLED, upon which the organic light emitting diode OLED emits light.

[0028] FIG. 4 is a schematic diagram showing a laminated structure of a pixel of the organic EL panel 10 according to an embodiment of the present invention. According to the organic EL panel 10 according to this embodiment, respective layers are formed on the substrate 20 on which a TFT (Thin Film Transistor), including a pixel transistor SST and a driving transistor DRT, is formed. In particular, FIG. 4 shows a layer that is formed in a process that is executed with the substrate 20 held in a vacuum environment (hereinafter referred to as a vacuum process). On the substrate 20, an amorphous carbon layer 22 (a-C), a hole injection layer 31 (HIL, a first injection layer), and a hole transport layer 32 (HTL, a first transport layer) are formed common to the respective pixels. On the hole transport layer 32, as to respective pixels that emit light in respective colors, namely, R, G, B, a light emitting layer 33 including a red hole transport layer (R-HTL) and a red light emitting layer (R-EML), a green hole transport layer (G-HTL) and a green light emitting layer (G-EML), and a blue hole transport layer (B-HTL) and a blue light emitting layer (B-EML) is formed. Further, on the light emitting layer 33, an electron transport layer (ETL, a second transport layer) 34 and an electron injection layer (EIL, a second injection layer) 35 are formed. On the electron injection layer 35, an upper electrode 40 is formed using MgAg. On the upper electrode 40, a sealing layer 42 is formed. The respective layers from the hole injection layer 31 to the electron injection layer 35 (the plurality of layers sandwiched by the amorphous carbon layer 22 and the upper electrode 40) are collectively referred to as an organic layer 30.

[0029] FIG. 5 is a cross sectional view of a pixel of the organic EL panel 10 according to an embodiment of the present invention. This drawing is a cross sectional view of a single pixel along the line V-V in FIG. 2. The organic EL panel 10 according to this embodiment includes a lower electrode 21 formed on the substrate 20. The lower electrode 21 is electrically connected to the source or drain of a TFT (a driving transistor DRT) formed on the substrate 20. The organic EL panel 10 includes a pixel separation film 23 formed on an end portion of the lower electrode 21 and the substrate 20 such that the middle part of the lower electrode 21 is exposed, for defining pixels. The pixel separation film 23 defines a pixel area to prevent short-circuit between the lower electrode 21 and the upper electrode 40.

[0030] The organic EL panel 10 includes an amorphous carbon layer 22 formed on the pixel separation film 23 and the part of the lower electrode 21 exposed from the pixel separation film 23. The amorphous carbon layer 22 improves adhesion of the organic layer 30. The organic EL panel 10 includes the organic layer 30 formed on the lower electrode 21 and the pixel separation film 23 and including the light emitting layer 33. Like the organic EL panel 10 according to

this embodiment, the organic layer 30 is not necessarily in contact with the lower electrode 21 and the pixel separation film 23, and may be formed on the lower electrode 21 and the pixel separation film 23 via other layers such as the amorphous carbon layer 22, etc.

[0031] The organic EL panel 10 includes the upper electrode 40 formed on the organic layer 30 and the sealing layer 42 formed on the upper electrode 40. With the organic EL panel 10 according to this embodiment, the sealing layer 42 includes a first sealing layer 42a and a second sealing layer 42b. The first sealing layer 42a is a tentative sealing layer for protecting the organic layer 30, etc., in a cleaning process to be described later, and the second sealing layer 42b is a real sealing layer. The second sealing layer 42b is thicker than the first sealing layer 42a. The sealing layer 42 in this embodiment is formed by sequentially forming an SiN layer, an acrylic resin layer, and an SiN layer.

[0032] With the organic EL panel 10 according to this embodiment, at least the upper electrode 40 includes a hole 24. The hole 24 is a hole left after foreign matter has been removed, of which diameter is larger than the thickness of the upper electrode 40 and smaller than the size of the pixel area. The diameter of the hole 24 can vary depending on the diameter of foreign matter, being typically a few μm . Although the organic layer 30 immediately below the hole 24 does not contribute to light emission, as the organic layer 30 at a position other than a position immediately below the hole 24 emits light, the organic EL panel 10 as a whole can display an image with display performance equivalent to that in a case free from the hole 24. Note that although a pixel having a hole 24 is shown in FIG. 5, a hole 24 may not be formed in all pixels and there is a pixel free from a hole 24. A process in which a hole 24 is resulted will be described later in detail with reference to FIGS. 8 to 10.

[0033] FIG. 6 is a flowchart showing a method for manufacturing the organic EL display device 1 according to an embodiment of the present invention. This drawing shows a vacuum process executed after preparation of the substrate 20 having the lower electrode 21 formed thereon.

[0034] Specifically, the vacuum process begins with a first step of placing the substrate 20 having the lower electrode 21 and the pixel separation film 23 formed thereon in a vacuum environment (S10). At this step, the substrate 20 is placed into a vacuum chamber, for example, to be thereby introduced into a vacuum environment.

[0035] After the end of the first step before the start of a second step of forming the organic layer 30, the amorphous carbon layer 22 that covers the lower electrode 21 is formed in a vacuum (S11, a fifth step). Formation of the amorphous carbon layer 22 may be executed by means of sputtering. The second step is a step of forming the organic layer 30 that includes the light emitting layer 33 and covers the lower electrode 21 in a vacuum (S12 to S14). The second step may be executed by depositing organic material. The second step begins with an A step of forming in a vacuum the hole injection layer 31 (a first injection layer) and the hole transport layer 32 (a first transport layer) that cover the lower electrode 21 (S12), and includes a B step of forming in a vacuum the light emitting layer 33 that covers the first transport layer (S13) and a C step of forming in a vacuum the electron transport layer 34 (a second transport layer) and the electron injection layer 35 (a second injection layer) that cover the light emitting layer 33 (S14). According to a method for manufacturing the organic EL display device 1

according to this embodiment, the B step of forming the light emitting layer 33 is a step of depositing the light emitting layer 33 that emits light in different colors, using a deposition mask.

[0036] A method for manufacturing the organic EL display device 1 according to this embodiment includes a cleaning process of cleaning the substrate 20 that is executed after the end of the first step (S10) before the end of a fourth step (S16 to S17) of forming the sealing layer 42. For example, the cleaning process may be executed after the end of the fifth step (S11) before the start of the second step (S12 to S14). That is, the cleaning process may be executed at the timing indicated by "1" in FIG. 6. By cleaning the substrate 20 after the end of the fifth step of forming the amorphous carbon layer 22 (S11) before the start of the second step (S12 to S14) of forming the organic layer 30, it is possible to remove foreign matter mixed when sputtering is executed, before formation of the organic layer 30 even when the amorphous carbon layer 22 is formed by means of sputtering. This can prevent foreign matter from being mixed into the organic EL display device 1, and thus to increase the yield.

[0037] Further, the cleaning process may be executed after the end of the B step of forming the light emitting layer 33 (S13) before the start of the C step of forming the electron transport layer 34 and the electron injection layer 35 (S14). That is, the cleaning process may be executed at the timing indicated by "2" in FIG. 6. By cleaning the substrate 20 after the end of the B step of forming the light emitting layer 33 (S13) before the start of the C step of forming the electron transport layer 34 and the electron injection layer 35 (S14), it is possible to remove foreign matter even when organic material for respective light emission colors has been applied to a pixel, etc., using a deposition mask, and foreign matter has been mixed from the deposition mask. This can prevent foreign matter from being mixed into the organic EL display device 1, and thus to increase the yield.

[0038] Thereafter, a third step of forming in a vacuum the upper electrode 40 that covers the organic layer 30 is executed (S15). The cleaning process may be executed after the end of the second step (S12 to S14) of forming the organic layer 30 before the start of the third step (S15) of forming the upper electrode 40 (S15). That is, the cleaning process may be executed at the timing indicated by "3" in FIG. 6. By cleaning the substrate 20 after the end of the second step (S12 to S14) of forming the organic layer 30 before the start of the third step (S15) of forming the upper electrode 40, it is possible to collectively remove foreign matter even when foreign matter has been mixed into any of the plurality of layers constituting the organic layer 30. This can prevent foreign matter from being mixed into the organic EL display device 1, and thus to increase the yield.

[0039] Also, the cleaning process may be executed after the end of the third step (S15) of forming the upper electrode 40 before the start of the fourth step (S16 to S17) of forming the sealing layer 42. That is, the cleaning process may be executed at the timing indicated by "4" in FIG. 6. By cleaning the substrate 20 after the end of the third step (S15) of forming the upper electrode 40 before the start of the fourth step (S16 to S17) of forming the sealing layer 42, it is possible to collectively remove foreign matter even when foreign matter has been mixed into any of the plurality of layers constituting the organic layer 30. This can prevent foreign matter from being mixed into the organic EL display device 1, and thus to increase the yield.

[0040] Thereafter, the fourth step of forming in a vacuum the sealing layer **42** that covers the upper electrode **40** is executed (S16 to S17). The fourth step may be executed by means of CVD (Chemical Vapor Deposition). The fourth step includes a D step of forming in a vacuum the first sealing layer **42a** that covers the upper electrode **40** (S16) and an E step of forming in a vacuum the second sealing layer **42b** that covers the first sealing layer **42a** (S17). The cleaning process may be executed after the end of the D step (S16) before the start of the E step (S17). That is, the cleaning process may be executed at the timing indicated by “5” in FIG. 6. In the case of a display device having flexibility, foreign matter mixed into the sealing layer **42** may deteriorate the bending tolerance of a part of the device where foreign matter is mixed, and the display device may be broken at the part. To address the above, by cleaning the substrate **20** after the end of the D step (S16) before the start of the E step (S17), it is possible to prevent foreign matter from being mixed into the first sealing layer **42a** and thus to prevent breakage of the organic EL display device **1**, which can increase the yield.

[0041] Note that as a typical diameter of foreign matter is a few μm , and the total of the typical thicknesses of the amorphous carbon layer **22**, the organic layer **30**, the upper electrode **40**, and the first sealing layer **42a** is a few hundreds of nm, it is expected that foreign matter protrudes from the first sealing layer **42a** in any case in which the foreign matter has been mixed at any step in the vacuum process. Accordingly, it is possible to remove the foreign matter in a cleaning process even after the first sealing layer **42a** has been formed.

[0042] The cleaning process may be executed at any time after the end of the first step (S10) of introducing the substrate **20** into a vacuum environment before the end of the fourth step (S16 to S17) of forming the sealing layer **42**, that is, at any of the timings indicated by “1” to “5” in FIG. 6. Also, the cleaning process may be executed twice or more times at different timings.

[0043] FIG. 7 is a flowchart showing a cleaning process of a method for manufacturing the organic EL display device **1** according to an embodiment of the present invention. A cleaning process is executed in a non-vacuum in the midst of the vacuum process after breaking the vacuum. The cleaning process begins with introduction of the substrate **20** into a non-vacuum environment (S20).

[0044] Then, the cleaning process is executed by spraying a nonaqueous cleaning medium onto the substrate **20** (S21). Note that a nonaqueous cleaning medium refers to a medium that does not include water as cleaning solvent. A nonaqueous cleaning medium may be any of solid, liquid, and gas. In general, use of a solid medium as a nonaqueous cleaning medium can ensure relatively strong detergency, which, however may cause relatively strong damage to the substrate **20**. Meanwhile, use of liquid medium as a nonaqueous cleaning medium may result in the level of detergency and damage caused to the substrate **20** that is intermediate between those in using solid and gas solvents respectively. Use of a gas medium as a nonaqueous cleaning medium is resulted in a relatively small damage caused to the substrate **20**, though the detergency is relatively weak. Specifically, the nonaqueous cleaning medium may be any of dry ice, hydrofluoroether, and nitrogen. Hydrofluoroether may be $\text{C}_4\text{F}_9\text{OCH}_3$, $\text{C}_4\text{F}_9\text{OC}_2\text{H}_5$, and $\text{C}_2\text{F}_5\text{CF}(\text{OCH}_3)\text{C}_3\text{F}_7$, etc. Note that the nonaqueous cleaning medium mentioned

above as examples is advantageous in that the medium does not deteriorate the organic layer **30**, the ozone depletion potential and global warming potential of the medium are small, and the medium can be readily handled.

[0045] The cleaning process may be executed using a gas or liquid nonaqueous cleaning medium after the start of the second step (S12 to S14) of forming the organic layer **30** before the start of the fourth step (S16 to S17) of forming the sealing layer **42**. In the case where the cleaning process is executed after the start of the second step (S12 to S14) of forming the organic layer **30** before the start of the fourth step (S16 to S17) of forming the sealing layer **42**, the organic layer **30**, which is very vulnerable to damage, is brought into direct contact with the nonaqueous cleaning medium. Therefore, by using a gas or liquid nonaqueous cleaning medium, it is possible to ensure a relatively small damage caused to the organic layer **30**, while removing foreign matter mixed into the organic layer **30**.

[0046] The cleaning process may include an F step of collecting the nonaqueous cleaning medium having been sprayed onto the substrate **20** (S22) and purifying the medium collected (S23). With the above, even when a relatively expensive medium is used as a nonaqueous cleaning medium, the cleaning process is achieved at lower cost.

[0047] Finally, the substrate **20** having been cleaned is introduced into a vacuum environment (S24) to end the cleaning process. After the end of the cleaning process, the vacuum process having been stopped halfway is resumed.

[0048] FIG. 8 shows first foreign matter **100** and second foreign matter **101** to be removed according to a method for manufacturing the organic EL display device **1** according to the present invention. The first foreign matter **100** is mixed after formation of the upper electrode **40** and stays on the upper electrode **40**. Meanwhile, the second foreign matter **101** is mixed after formation of the organic layer **30** before formation of the upper electrode **40** and is embedded in the upper electrode **40**. Note that the first foreign matter **100** and the second foreign matter **101** are mere examples, and foreign matter may be mixed in any other condition or no foreign matter may be mixed at all.

[0049] FIG. 9 shows a cleaning process of a method for manufacturing the organic EL display device **1** according to an embodiment of the present invention. Specifically, FIG. 9 shows a cleaning process that is executed at the timing indicated by “4” in FIG. 6, using a nonaqueous cleaning medium **110** that is liquid. The nonaqueous cleaning medium **110** is sprayed onto the surface of the upper electrode **40** by a spray nozzle **74**. The first foreign matter **100** and the second foreign matter **101** are blown by the nonaqueous cleaning medium **110** sprayed. FIG. 9 shows the first foreign matter **100** and the second foreign matter **101** being blown. After the second foreign matter **101** is blown, a hole **24** is left on the upper electrode **40**.

[0050] FIG. 10 is a cross sectional view of the organic EL panel **10** according to an embodiment of the present invention. FIG. 10 shows the first sealing layer **42a** and the second sealing layer **42b** that are formed after the first foreign matter **100** and the second foreign matter **101** has been removed in the cleaning process.

[0051] The first sealing layer **42a** is filled in the hole **24** resulted on the upper electrode **40**, so that the organic layer **30** can be prevented from being exposed. As described above, a structure of the organic EL panel **10** according to this embodiment shown in FIG. 5 is formed.

[0052] FIG. 11 is a schematic diagram showing the first spray nozzle 74a used in the cleaning process of a method for manufacturing the organic EL display device 1 according to an embodiment of the present invention. The first spray nozzle 74a includes a sucking port 112 for sucking the nonaqueous cleaning medium 110 sprayed and foreign matter, and a spraying port 114 for spraying a nonaqueous cleaning medium. The spraying port 114 includes a supersonic wave oscillator for finely vibrating the nonaqueous cleaning medium to enhance cleaning effect. Note that although a case in which a liquid nonaqueous cleaning medium is sprayed is shown in FIG. 11, either a solid or gas nonaqueous cleaning medium may be sprayed, depending on the first spray nozzle 74a.

[0053] FIG. 12 is a block diagram showing a structure of a manufacturing apparatus 200 for the organic EL display device 1 according to an embodiment of the present invention. The manufacturing apparatus 200 for the organic EL display device 1 includes a vacuum process unit 50, a cleaning unit 70, and a fourth convey mechanism 60 for connecting the vacuum process unit 50 and the cleaning unit 70.

[0054] The vacuum process unit 50 includes a vacuum introduction unit 51 for introducing vacuum into the environment where the substrate 20 having the lower electrode 21 formed thereon is placed. The vacuum introduction unit 51 includes a chamber for accommodating the substrate 20 having the lower electrode 21 formed thereon, and vacuums the inside of the chamber to thereby place the substrate 20 in a vacuum environment. The structure included in the vacuum process unit 50 to be described below is arranged in the vacuum chamber.

[0055] The vacuum process unit 50 includes an organic layer forming unit 53 connected to the vacuum introduction unit 51 via a first convey mechanism 52, for forming in a vacuum the organic layer 30 including the light emitting layer 33 and covering the lower electrode 21 on the substrate 20. Note here that the first convey mechanism 52 is placed in the vacuum chamber and conveys the substrate 20. Specifically, the first convey mechanism 52 is a belt conveyor or a robot arm.

[0056] The vacuum process unit 50 includes an upper electrode forming unit 55 connected to the organic layer forming unit 53 via a second convey mechanism 54, for forming in a vacuum the upper electrode 40 covering the organic layer 30. Further, the vacuum process unit 50 includes a sealing layer forming unit 57 connected to the upper electrode forming unit 55 via a third convey mechanism 56, for forming in a vacuum the sealing layer 42 covering the upper electrode 40. Note here that each of the second convey mechanism 54 and the third convey mechanism 56 has a structure similar to that of the first convey mechanism 52, and is placed in a vacuum chamber.

[0057] The cleaning unit 70 is connected to at least one of the organic layer forming unit 53, the upper electrode forming unit 55, and the sealing layer forming unit 57 via the fourth convey mechanism 60 to clean the substrate 20. In the manufacturing apparatus 200 for the organic EL display device 1 according to the embodiment, the cleaning unit 70 is connected to the organic layer forming unit 53, the upper electrode forming unit 55, and the sealing layer forming unit 57 via the fourth convey mechanism 60, and the fourth convey mechanism 60 selects a distribution designation. The

fourth convey mechanism 60 has a structure similar to that of the first convey mechanism 52 and is placed in the vacuum chamber.

[0058] According to the manufacturing apparatus 200 for the organic EL display device 1 according to the embodiment, it is possible to insert a cleaning process executed in a non-vacuum into the midst of the vacuum process without deteriorating the vacuum environment for the vacuum process. With the above, it is possible to execute a cleaning process before foreign matter is sealed in the sealing layer 42.

[0059] The cleaning unit 70 includes an environment change unit 71 connected to the fourth convey mechanism 60, for changing a vacuum environment into a carbon dioxide-filled environment or a nitrogen-filled environment, and a carbon dioxide-filled environment or a nitrogen-filled environment into a vacuum environment, and a spray unit 72 connected to the environment change unit 71, for spraying a nonaqueous cleaning medium onto the substrate 20. Before the cleaning process is executed, the environment change unit 71 receives the substrate 20 from the fourth convey mechanism 60 in a vacuum environment, and thereafter, changes the vacuum environment to either the carbon dioxide-filled environment or the nitrogen-filled environment. Note that in using dry ice as a nonaqueous cleaning medium, the environment change unit 71 changes the vacuum environment into a carbon dioxide-filled environment, and in using hydrofluoroether or nitrogen as a nonaqueous cleaning medium, the environment change unit 71 changes the vacuum environment into a nitrogen-filled environment. Then, after completion of the cleaning process, the environment change unit 71 changes the carbon dioxide-filled environment or the nitrogen-filled environment into a vacuum environment before returning the substrate 20 to the fourth convey mechanism 60.

[0060] The spray unit 72 includes a stage 73, a spray nozzle 74, and a purifying unit 75. A specific structure of the spray unit 72 will be described in detail with reference to the next drawing.

[0061] FIG. 13 is a schematic diagram showing the spray unit 72 of the manufacturing apparatus 200 for the organic EL display device 1 according to an embodiment of the present invention. The spray unit 72 includes a cleaning chamber 76 for receiving and cleaning the substrate 20, using the nonaqueous cleaning medium 110, and the purifying unit 75 for collecting and purifying the nonaqueous cleaning medium 110. The cleaning chamber 76 of the spray unit 72 includes the stage 73 for holding the substrate 20 inclined. In the case of a nonaqueous cleaning medium 110 that is liquid, when the substrate 20 is held inclined by the stage 73, the nonaqueous cleaning medium sprayed onto the substrate 20 runs down from the stage 73 so that the nonaqueous cleaning medium 110 can be readily collected.

[0062] The cleaning chamber 76 includes a second spray nozzle 74b and an ionizer 80. The second spray nozzle 74b sprays the nonaqueous cleaning medium 110 onto the substrate 20. The second spray nozzle 74b can change the distance to the substrate 20. As it is possible to change the distance from the second spray nozzle 74b to the substrate 20, it is possible to keep constant the distance between the second spray nozzle 74b and the substrate 20 even when the stage 73 is inclined. The second spray nozzle 74b is provided traversing the substrate 20. Note here that the substrate 20 may include a part that makes a plurality of display panels,

which maybe cut out by dicing into display panels. With the second spray nozzle **74b** traversing the substrate **20**, the cleaning process can be executed with high efficiency.

[0063] The ionizer **80** removes electric charge from the substrate **20**. With the nonaqueous cleaning medium **110** sprayed onto the substrate **20**, electric charge of a few kV may be generated. Removing the electric charge by the ionizer **80** can prevent occurrence of defect in subsequent layer formation.

[0064] The purifying unit **75** is connected to the cleaning chamber **76**, and collects and purifies the nonaqueous cleaning medium **110** sprayed onto the substrate **20**. The purifying unit **75** collects the nonaqueous cleaning medium **110** used and accumulated in the cleaning chamber **76**, using a circulation pump **81**, and purifies the nonaqueous cleaning medium **110** collected, using a filtration filter **82**. The purifying unit **75** may distill to thereby purify the nonaqueous cleaning medium **110** collected. The nonaqueous cleaning medium **110** purified is stored in a recycling tank **93**. As the nonaqueous cleaning medium **110** is recycled, as described above, the cleaning process can be executed at lower cost compared to a case where the nonaqueous cleaning medium **110** is used once and then disposed.

[0065] The spray unit **72** includes a new material tank **84**, in which unused nonaqueous cleaning medium **110** is stored. A switch valve **85** switches to connect a feeding pump **86** to either the new material tank **84** or a recycle tank **83**. The nonaqueous cleaning medium **110** is sent to a final filter **87** via the feeding pump **86**, and the nonaqueous cleaning medium **110** filtered is sprayed onto the substrate **20** by the second spray nozzle **74b**.

[0066] Note that all display devices that can be achieved through desirable change in design by a person skilled in the art based on the display device **1** described above as an embodiment of the present invention are included in the scope of the present invention as long as such display devices contain the gist of the present invention. For example, while the organic EL panel **10** according to this embodiment has the light emitting layer **33** for emitting light in respective R, G, B colors formed thereon, the present invention can be applied to a display device in which a light emitting layer for emitting light in white color is formed and a color filter is provided on the sealing layer **42** to therewith achieve full-color display. Further, while the nonaqueous cleaning medium **110** is sprayed onto the substrate **20** to clean the substrate **20** in the manufacturing apparatus **200** for manufacturing the organic EL display device **1** according to this embodiment, the substrate **20** may be dipped in the nonaqueous cleaning medium **110** to be cleaned.

[0067] While there have been described what are at present considered to be certain embodiments of the invention, it will be understood that various modifications may be made thereto, and it is intended that the appended claims cover all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A method for manufacturing a display device, the method comprising:

placing a substrate having a lower electrode formed thereon in a vacuum environment, as a first step;

forming an organic layer that includes a light emitting layer and covers the lower electrode in a vacuum environment, as a second step;

forming an upper electrode that covers the organic layer in a vacuum environment, as a third step;

forming a sealing layer that covers the upper electrode in a vacuum environment, as a fourth step; and

cleaning the substrate after end of the first step before end of the fourth step, as a cleaning step.

2. The method according to claim 1, wherein

the second step includes

an A step of forming a first injection layer and a first transport layer that cover the lower electrode in a vacuum environment,

a B step of forming a light emitting layer that covers the first transport layer in a vacuum environment, and

a C step of forming a second transport layer and a second injection layer that cover the light emitting layer in a vacuum environment, and

the cleaning step is executed after end of the B step before start of the C step.

3. The method according to claim 2, wherein the B step is a step of depositing a light emitting layer that emits light in different colors, using a deposition mask.

4. The method according to claim 1, wherein the cleaning step is executed after end of the second step before start of the third step.

5. The method according to claim 1, wherein the cleaning step is executed after end of the third step before start of the fourth step.

6. The method according to claim 1, further comprising a fifth step of forming an amorphous carbon layer that covers the lower electrode in a vacuum environment after the end of the first step before start of the second step, wherein

the cleaning step is executed after end of the fifth step before start of the second step.

7. The method according to claim 1, wherein

the fourth step includes

a D step of forming a first sealing layer that covers the upper electrode in a vacuum environment, and

an E step of forming a second sealing layer that covers the first sealing film in a vacuum environment, and

the cleaning step is executed after end of the D step before start of the E step.

8. The method according to claim 1, wherein the cleaning step is executed by spraying a nonaqueous cleaning medium onto the substrate.

9. The method according to claim 8, wherein the cleaning step includes an F process of collecting and purifying the nonaqueous cleaning medium sprayed onto the substrate.

10. The method according to claim 8, wherein

the nonaqueous cleaning medium is gas or liquid, and

the cleaning step is executed after start of the second step before start of the fourth step.

11. The method according to claim 8, wherein the nonaqueous cleaning medium is any of dry ice, hydrofluoroether, and nitrogen.

12. The method according to claim 1, wherein the cleaning step is executed in a non-vacuum.

13. A display device, comprising:

a substrate;

a plurality of pixels formed on the substrate;

a lower electrode provided to each of the plurality of pixels;

a pixel separation film formed on the substrate, configured to cover an end portion of the lower electrode so as to

leave a middle part of the lower electrode exposed, and configured to define the plurality of pixels;
 an organic layer being in contact with the portion of the lower electrode exposed from the pixel separation film, positioned on the pixel separation film, and including a light emitting layer;
 an upper electrode formed on the organic layer; and
 a sealing layer formed on the upper electrode, wherein the upper electrode has a hole formed on a surface thereof in contact with the sealing layer.

14. An apparatus for manufacturing a display device, comprising:

a vacuum introduction unit for placing a substrate having a lower electrode formed thereon in a vacuum environment;
 an organic layer forming unit connected to the vacuum introduction unit via a first convey mechanism, for forming an organic layer that includes a light emitting layer and covers the lower electrode on the substrate in a vacuum environment;
 an upper electrode forming unit connected to the organic layer forming unit via a second convey mechanism, for forming an upper electrode that covers the organic layer in a vacuum environment;
 a sealing layer forming unit connected to the upper electrode forming unit via a third convey mechanism, for forming a sealing layer that covers the upper electrode in a vacuum environment; and
 a cleaning unit connected to at least one of the organic layer forming unit, the upper electrode forming unit,

and the sealing layer forming unit via a fourth convey mechanism, for cleaning the substrate.

15. The apparatus according to claim **14**, wherein the cleaning unit includes

an environment change unit connected to the fourth convey mechanism, for changing a vacuum environment into a carbon dioxide-filled environment or a nitrogen-filled environment, and a carbon dioxide-filled environment or a nitrogen-filled environment into a vacuum environment, and

a spraying unit connected to the environment change unit, for spraying a nonaqueous cleaning medium onto the substrate.

16. The apparatus according to claim **15**, wherein the spraying unit includes a stage for holding the substrate inclined.

17. The apparatus according to claim **15**, wherein the spraying unit includes a spray nozzle capable of changing a distance to the substrate, for spraying the nonaqueous cleaning medium onto the substrate.

18. The apparatus according to claim **15**, wherein the spraying unit includes a purifying unit for collecting and purifying the nonaqueous cleaning medium sprayed onto the substrate.

19. The apparatus according to claim **14**, wherein the spraying unit includes an ionizer for removing electric charge from the substrate.

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专利名称(译)	显示装置及其制造方法和装置		
公开(公告)号	US20170250372A1	公开(公告)日	2017-08-31
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申请(专利权)人(译)	日本展示INC.		
当前申请(专利权)人(译)	日本展示INC.		
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摘要(译)

一种制造显示装置的方法,包括将其上形成有下电极的基板放置在真空环境中的第一步骤;第二步,在真空中形成包括发光层并覆盖下电极的有机层;第三步,在真空中形成覆盖有机层的上电极;第四步,在真空中形成覆盖上电极的密封层;以及在第四步骤结束之前的第一步骤结束后清洁基板的清洁步骤。

