US 20050215163A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2005/0215163 A1

Tamura et al. (43) Pub. Date: Sep. 29, 2005

(54) METHOD FOR MANUFACTURING AN ORGANIC ELECTROLUMINESCENCE DISPLAY

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(21) Appl. No.: **10/878,550**

(22) Filed: **Jun. 29, 2004**

(30) **Foreign Application Priority Data**

Mar. 24, 2004 (JP) .................................... 2004-087527

**Publication Classification**

(51) **Int. Cl.**[7] ........................................................ **H01J 9/00**

(52) **U.S. Cl.** ................................................................ **445/24**

(57) **ABSTRACT**

When any of pixels is not lit in an organic EL display having an organic EL layer between a first electrode and a second electrode, an organic layer of the pixel is observed. If the organic layer of the pixel contains foreign matter, the second electrode is separated into a region in contact with the foreign matter and a region not in contact with both the contact region and the foreign matter. Thus, not-lit display regions are reduced as less as possible, making it possible to manufacture an organic EL display excellent in display performance.

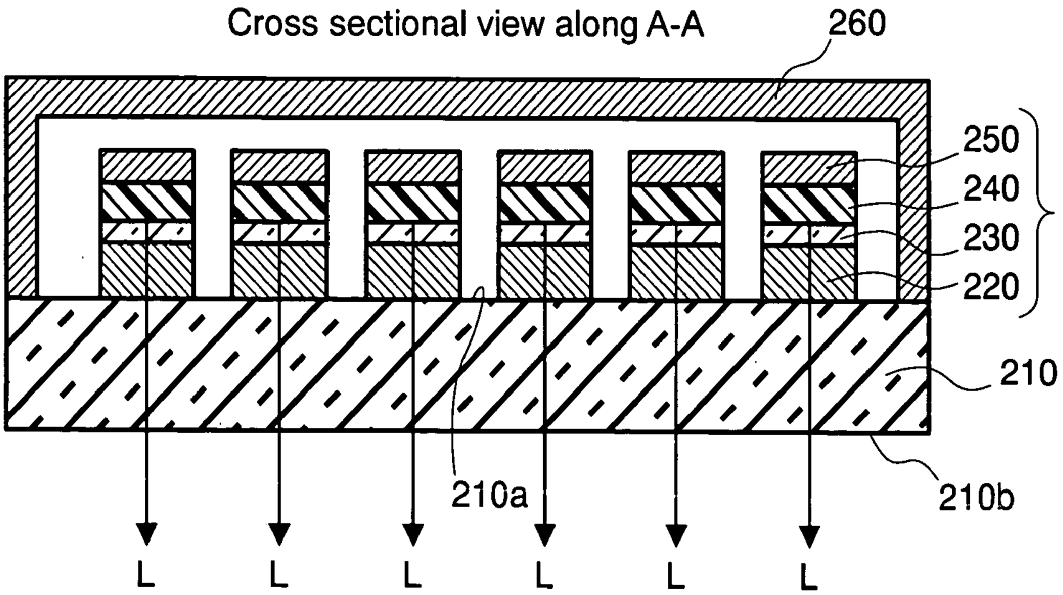
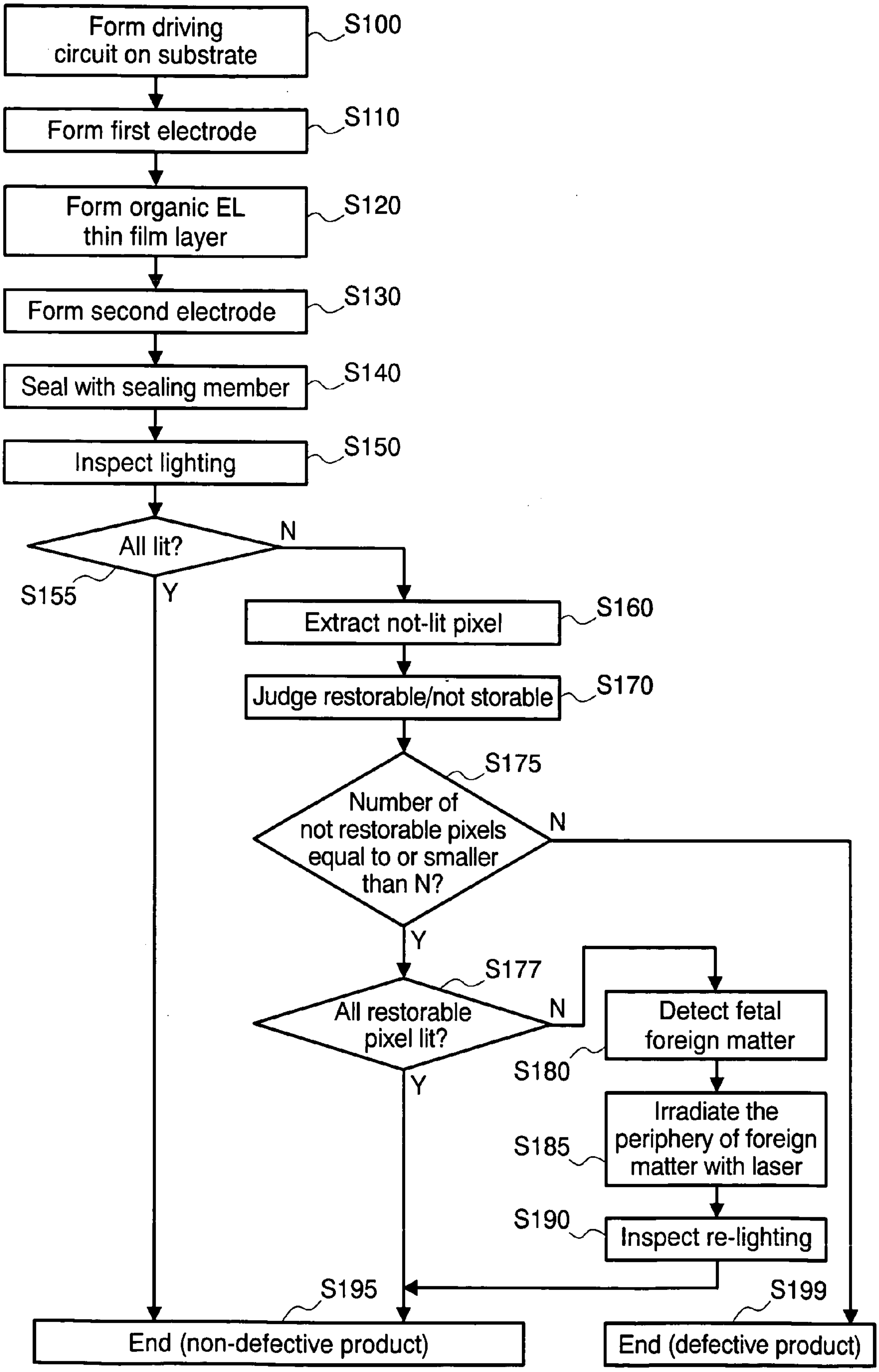
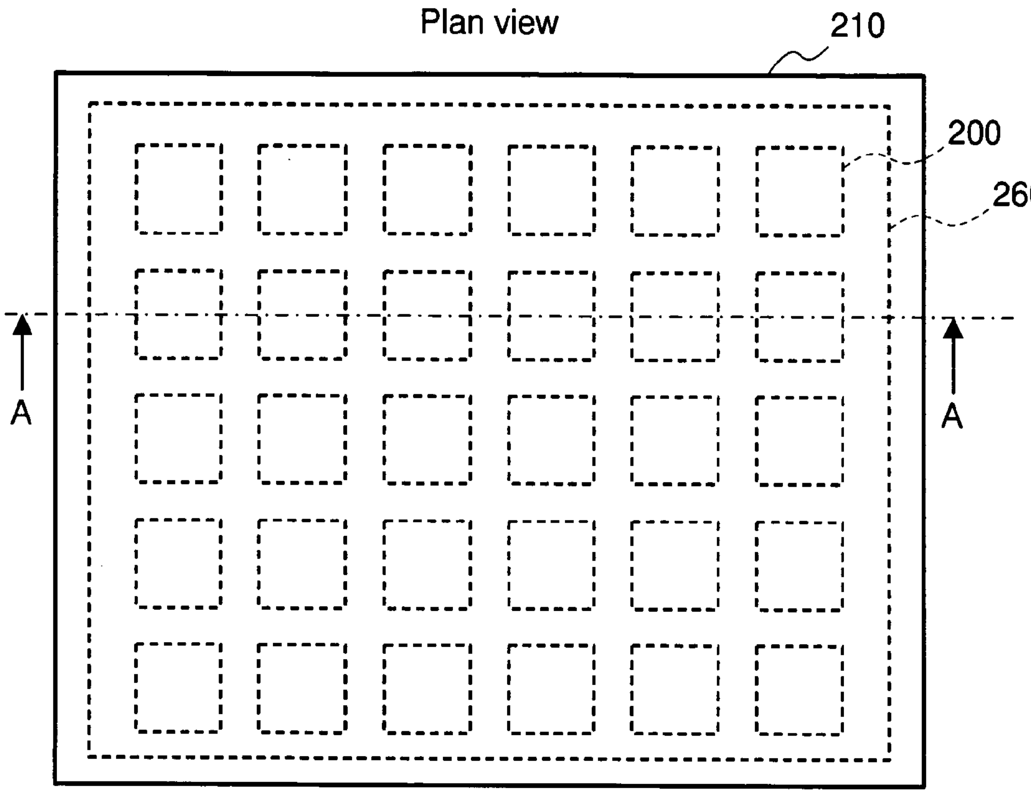


FIG. 1


Form driving circuit on substrate
S100
Form first electrode
S110
Form organic EL thin film layer
S120
Form second electrode
S130
Seal with sealing member
S140
Inspect lighting
S150
All lit?
S155
N
Y
Extract not-lit pixel
S160
Judge restorable/not storable
S170
S175
Number of not restorable pixels equal to or smaller than N?
N
Y
S177
All restorable pixel lit?
N
Y
Detect fetal foreign matter
S180
Irradiate the periphery of foreign matter with laser
S185
S190
Inspect re-lighting
S195
End (non-defective product)
S199
End (defective product)

# FIG.2(A)


Plan view
210
200
260
A
A

# FIG.2(B)

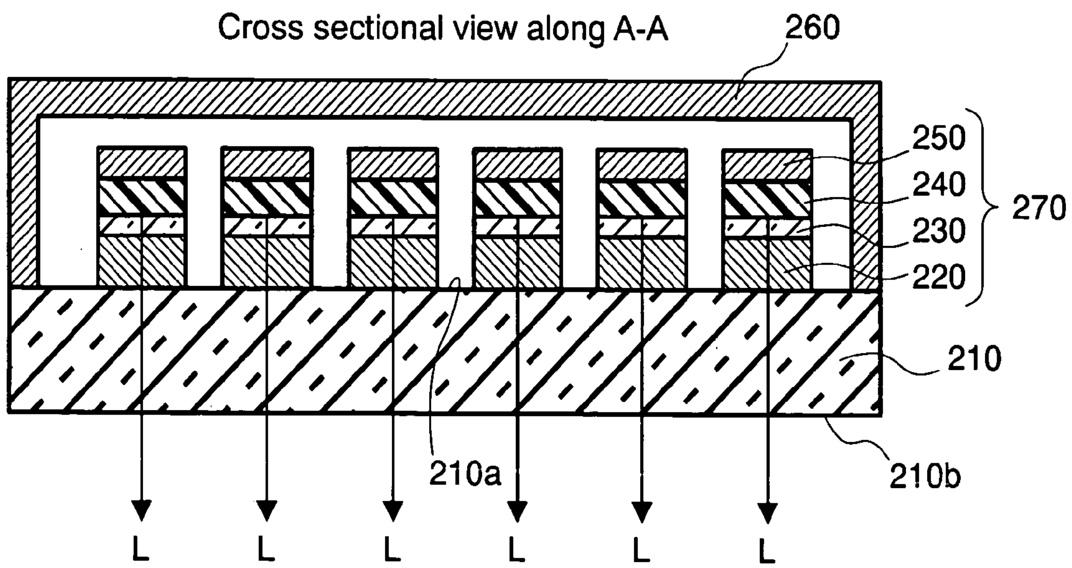

Cross sectional view along A-A
260
250
240
230
220
270
210
210a
210b
L
L
L
L
L
L

FIG.3(A)

Plan view

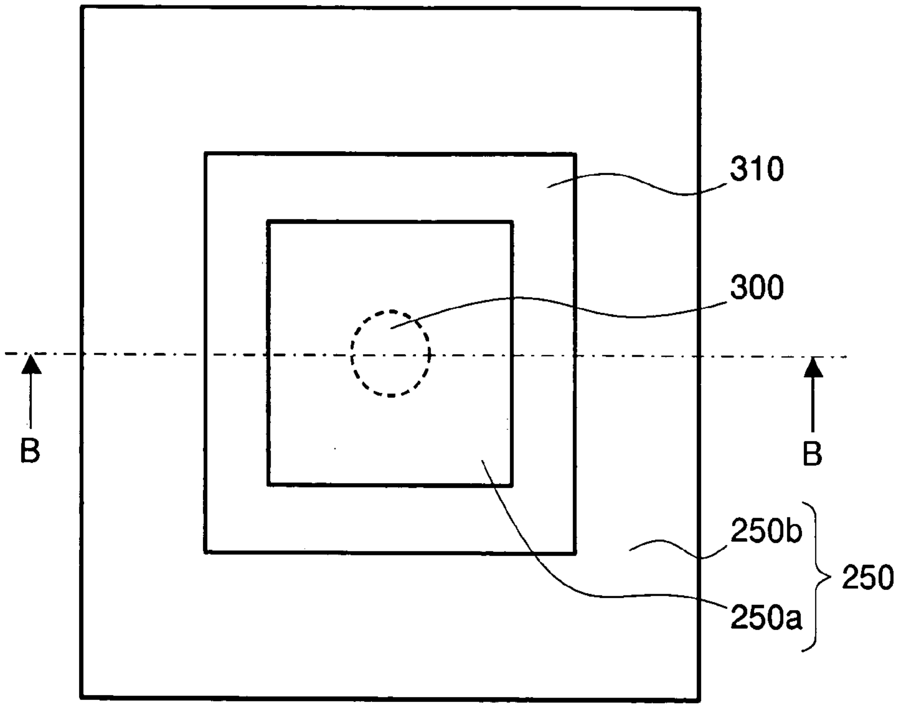



FIG.3(B)

Cross sectional view along B-B

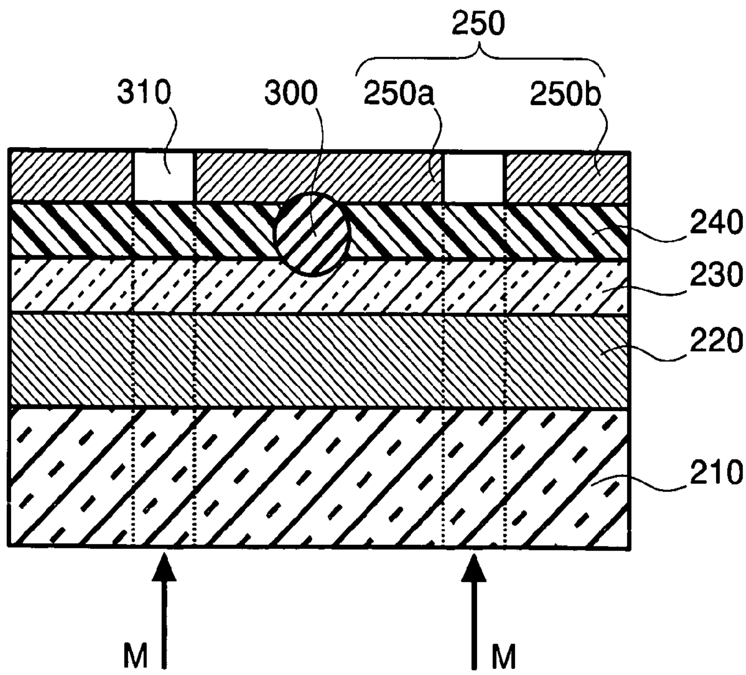


FIG.4(A)

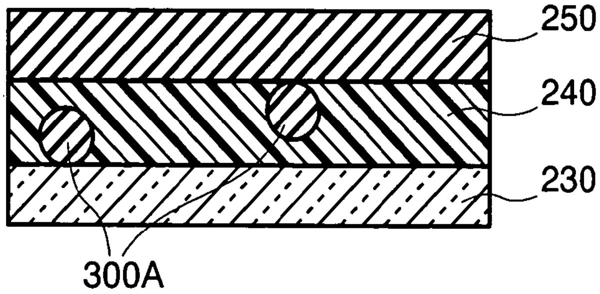



FIG.4(B)

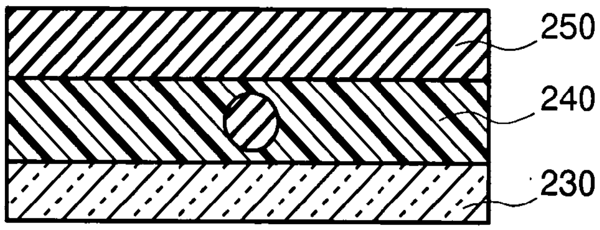



FIG.4(C)

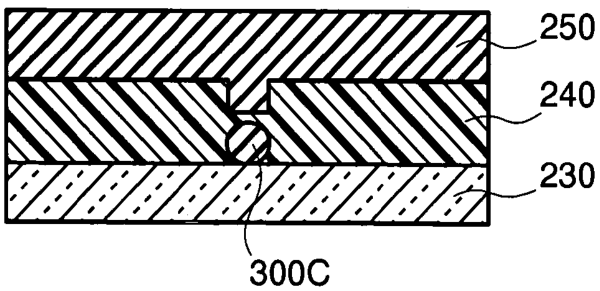
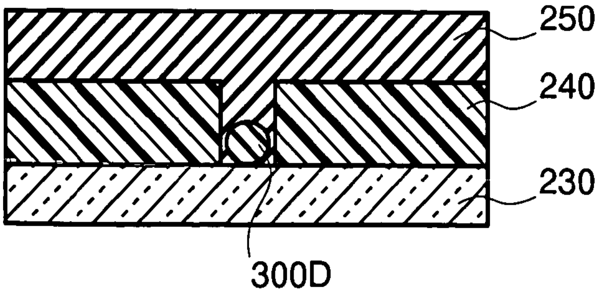
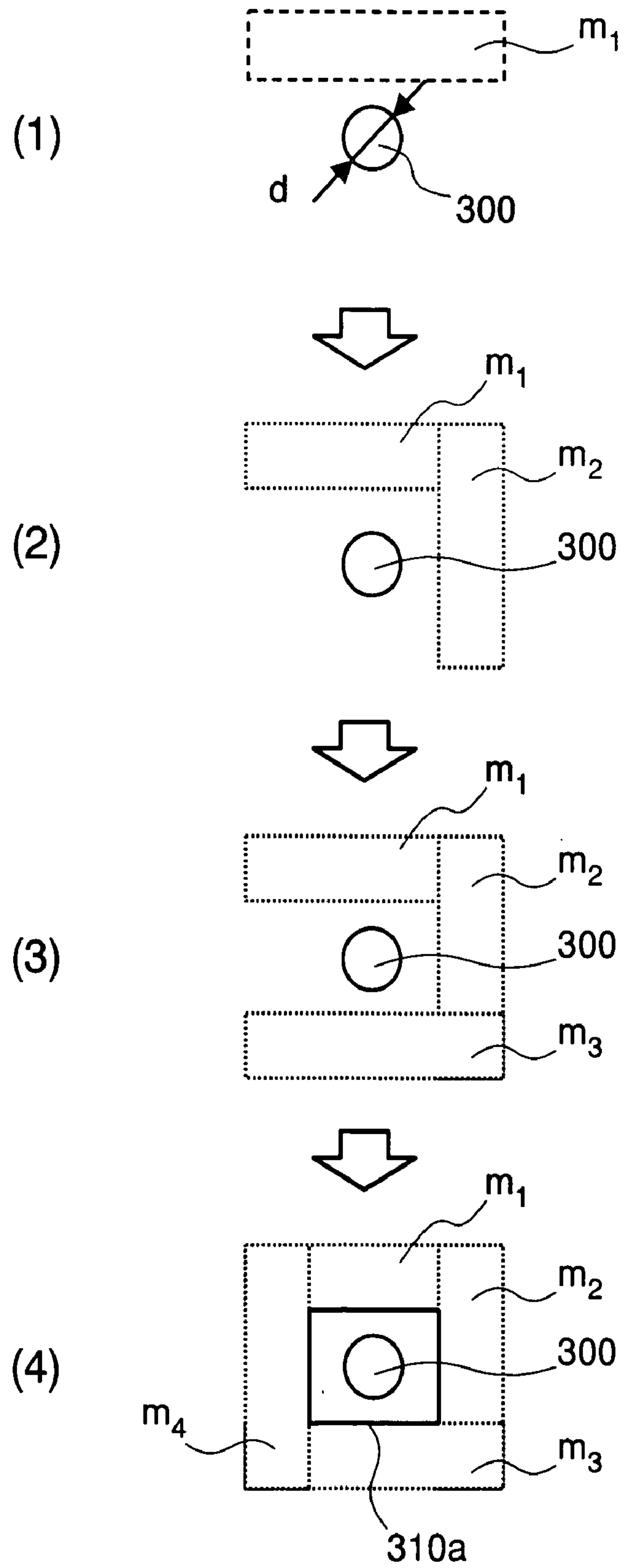


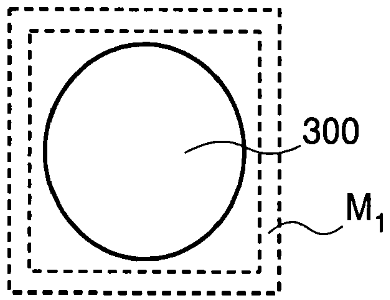

FIG.4(D)



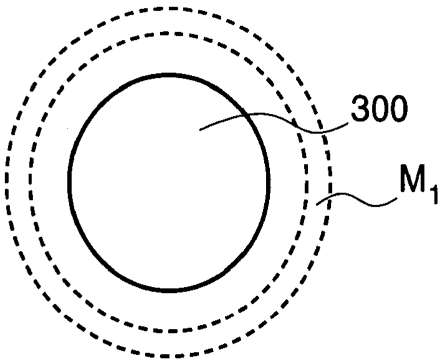
# FIG.5



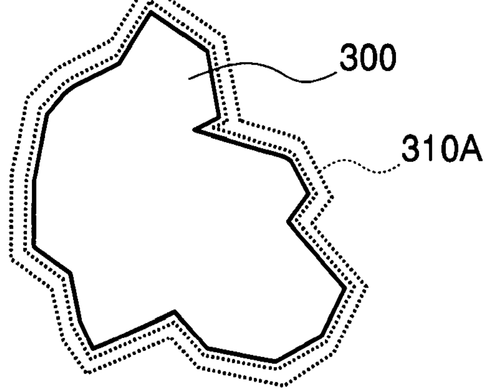
# FIG.6(A)



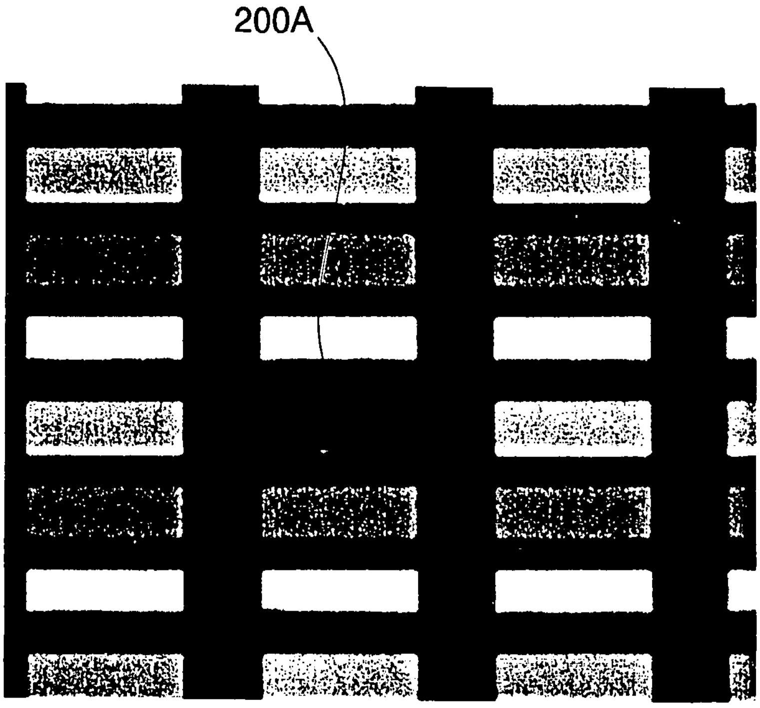

# FIG.6(B)



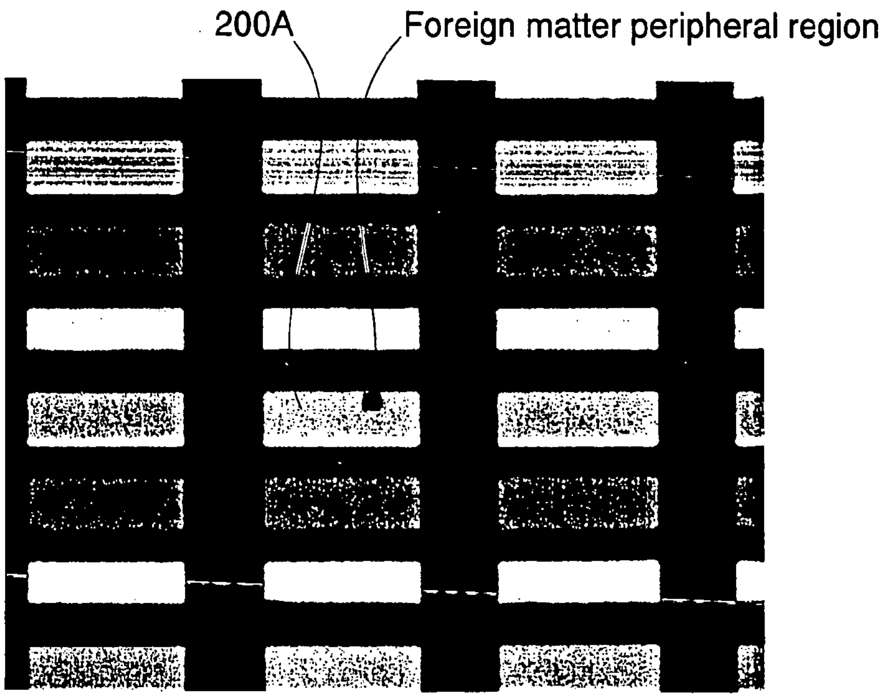

# FIG.6(C)



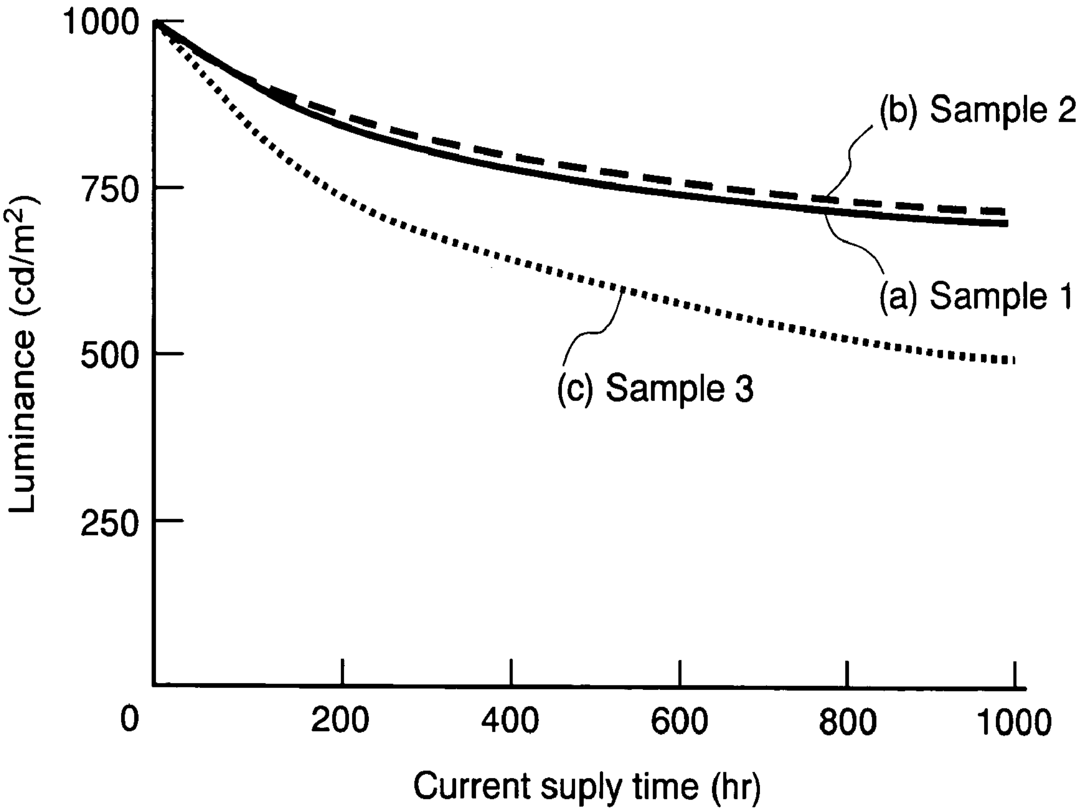
# FIG.7(A)




# FIG.7(B)



# FIG.8



1000
750
500
250
0
Luminance (cd/m2)
200
400
600
800
1000
Current suply time (hr)
(b) Sample 2
(a) Sample 1
(c) Sample 3

FIG.9(A)

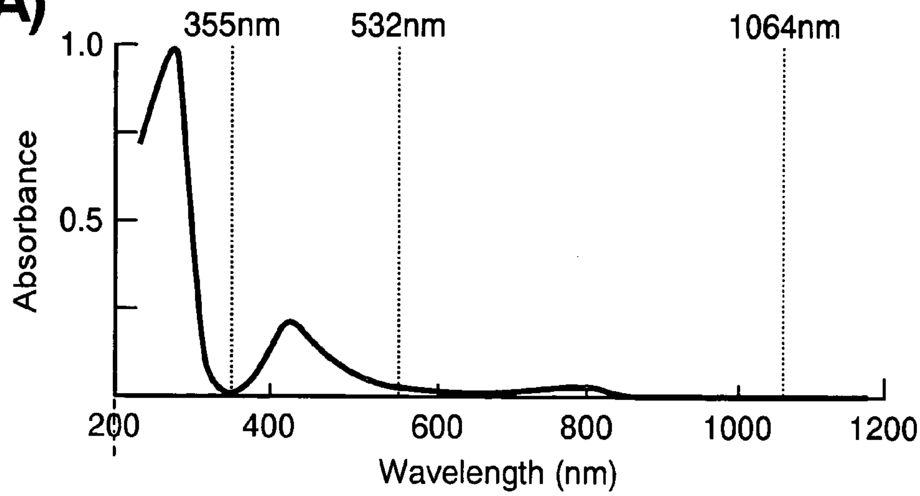



FIG.9(B)

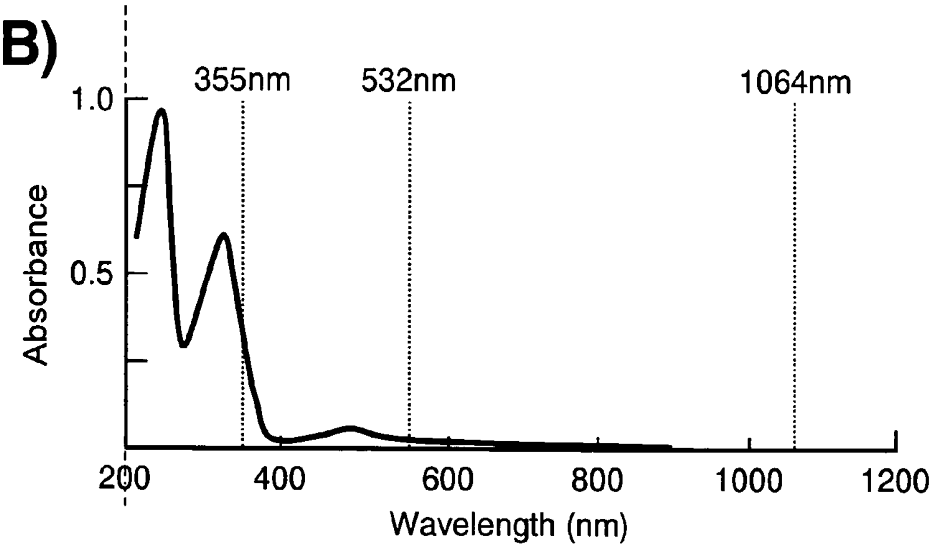
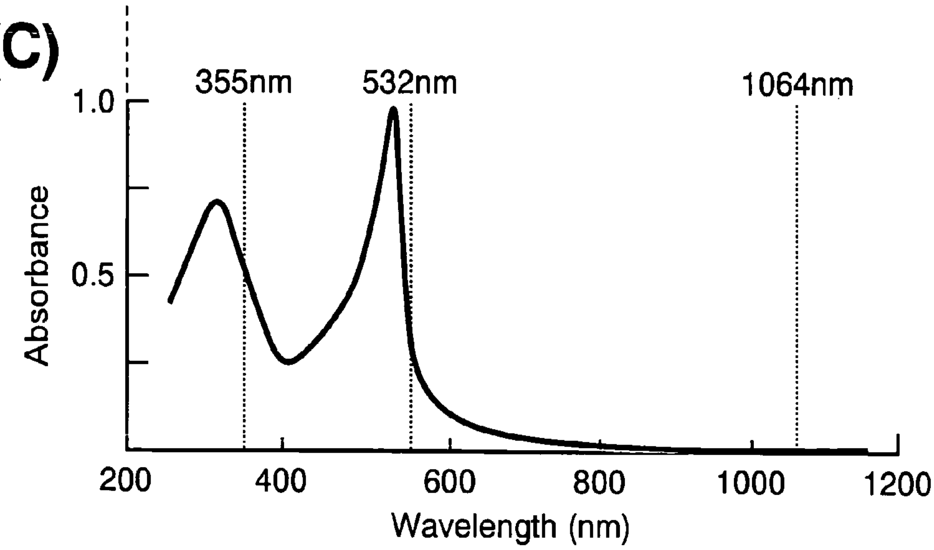
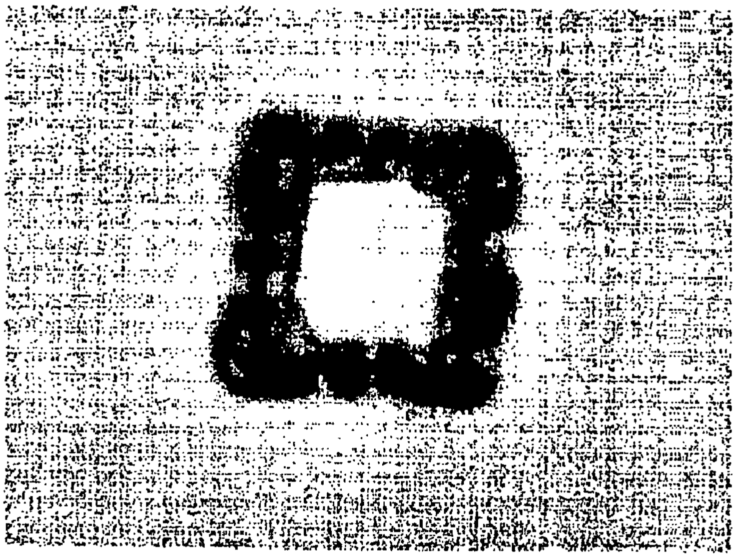



FIG.9(C)

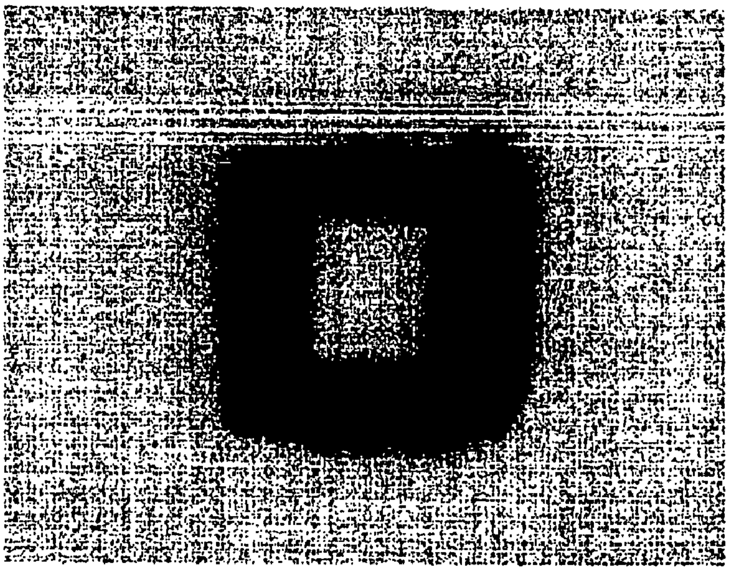


# FIG.10(A)



Laser wavelength: 355nm

# FIG.10(B)



Laser wavelength: 532nm

# METHOD FOR MANUFACTURING AN ORGANIC ELECTROLUMINESCENCE DISPLAY

## BACKGROUND OF THE INVENTION

[0001] The present invention relates to a technique for manufacturing an organic electroluminescence (EL) display and, more in particular, it relates to a method for manufacturing an organic electroluminescence display excellent in display performance with efficiency.

[0002] If foreign matter is contained in an organic light emission layer of an organic EL device, defective pixels (pixels of defective emission, pixels with no emission, etc.), sometimes occur due to short-circuit between electrodes (metal electrodes, transparent electrodes) sandwiching the organic light emission layer. Techniques described in Patent Documents 1 and 2 have been known as a technique for restoring such defective pixels.

[0003] According to the technique described in Patent Document 1, a region causing shortcircuit or the like is removed by laser from metal electrodes corresponding to a defective pixel. Since this enables the organic light emission layer between a partially removed metal electrode and a transparent electrode to emit light favolably, the defective pixels are restored.

[0004] Further, according to the technique described in Patent Document 2, each of pixels is divided into a plurality of pixel elements and, among the pixel elements constituting defective pixels, only the metal electrode of a pixel element containing a portion causing short-circuit is removed by laser. This can restore the defective pixel with no effects on pixel elements other than the pixel element containing a short-circuited portion.

[0005] [Patent Document 1]

[0006] Japanese Patent Laid-open No. 2001-118684

[0007] [Patent Document 2]

[0008] Japanese Patent Laid-open No. No. 2000-195677

## SUMMARY OF THE INVENTION

[0009] In the technique described in Patent Document 2, every pixel has to be separated into a plurality of pixel elements in a thin film pattern. Since this requires an additional step, the steps for manufacturing an organic EL display device are complicated.

[0010] On the other hand, according to the technique described in Patent Document 1, since foreign matter is directly irradiated with laser, it causes abrasion to possibly contaminate the organic light emission layer. Such contamination possibly causes lowering of the display performance (for example, optical characteristics such as luminance and device life) of the organic display device.

[0011] In view of the above, an object of the present invention is to provide a method for manufacturing a video display, which can efficiently manufacture an organic EL display excellent in display performance.

[0012] According to an aspect of the present invention, there is provided a method for manufacturing an organic electroluminescence display having an organic film and first and second electrode layers, the first and second electrode layers facing each other to interpose the organic film therebetween and allow the organic film to emit light passing through the first electrode layer. The method comprises the steps of: inspecting whether the organic film emits light or not and, if the organic film does not emit light, detecting foreign matter in the organic film from a side of the first electrode layer; and irradiating, if the foreign matter is detected, the second electrode layer with a laser beam capable of transmitting the first electrode layer and the organic film by way of an optical path not containing the foreign matter, so as to remove a band-like region surrounding a periphery of the foreign matter from the second electrode layer.

[0013] According to the invention, an organic EL display excellent in display performance can be manufactured efficiently.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0014] These and other features, objects and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings wherein:

[0015] **FIG. 1** is a flow chart of manufacturing steps for an organic EL display for explaining a preferred embodiment of the invention;

[0016] **FIG. 2A** is a plan view of the organic EL display according to the embodiment of the invention;

[0017] **FIG. 2B** is a cross sectional view taken along line A-A in the plan view of the organic EL display;

[0018] **FIG. 3A** is a plan view for a stacked film in the organic EL display for explaining the embodiment of the invention;

[0019] **FIG. 3B** is a cross sectional view taken along line B-B in the stacked film in the organic EL display;

[0020] **FIGS. 4A** to **4D** are plan views of a stacked film containing foreign matter in an organic EL display;

[0021] **FIG. 5** shows diagrams for explaining a method of irradiating a glass substrate with a laser beam in a pixel restoring treatment according to the embodiment of the invention;

[0022] **FIGS. 6A, 6B** and **6C** are diagrams showing examples of the shape of an irradiation region of a laser beam usable in the pixel restoring treatment according to the embodiment of the invention;

[0023] **FIG. 7A** is a view showing an image of an optical microscopic photograph of a pixel before restoration;

[0024] **FIG. 7B** is a view showing an image of an optical microscopic photograph of a pixel after restoration;

[0025] **FIG. 8** is a graph showing a relation between the luminance and the current supply time in terms of pixels after restoration according to the embodiment of the invention and a comparative pixel;

[0026] **FIGS. 9A, 9B** and **9C** show absorption spectral charts of materials forming a thin organic EL film;

[0027] **FIGS. 10A and 10B** are views for comparing optical microscopic photographs showing the difference in the fabrication characteristics of a thin organic EL film depending on the difference in the wavelength of the laser beam used for the pixel restoration.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] A preferred embodiment according to the present invention will below be described with reference to the accompanying drawings.

[0029] At first, a description is to be made of manufacturing steps for an organic EL display according to the embodiment with reference to an example of a bottom emission type organic EL display as an object of manufacture.

[0030] **FIG. 1** is a schematic flow chart of steps for manufacturing an organic EL display according to this embodiment. **FIG. 2A** is a plan view of an organic EL manufactured by the manufacturing steps and **FIG. 2B** is a cross sectional view taken along line A-A of **FIG. 2A**.

[0031] At first, driving circuit layers **220** for driving pixels are formed respectively in a plurality of pixel regions **200** defined as a matrix in one surface (hereinafter referred to as rearface) **210***a* of a glass substrate **210** (S**100**). First electrodes **230** optically transparent in a visible light region are respectively deposited on the driving circuit layers **220** (S**110**).

[0032] Then, organic El thin films **240** are respectively deposited on the first electrodes **230**, and metal films not transparent in the visible light region are deposited as second electrodes **250** on the thin organic EL films **240**, respectively. (S**130**).

[0033] In each of the stacked films **270** formed as described above, when a DC current is supplied between the first and the second electrodes **230** and **250**, the thin organic EL film **240** sandwiched between the electrodes **230** and **250** emits light. The light L is taken out on the side of the other surface (hereinafter referred to as surface) **210***b* of the substrate **210**. By the way, when such current supply is conducted in atmospheric air, moistures and contaminants in the atmospheric air intrude into the stacked film **270** to gradually degrade the emission characteristics of the stacked film **270**.

[0034] In view of the above, to isolate the stacked film **270** from the atmospheric air, the glass substrate **200** is sealed on the side of the rear face **210***a* by a sealer **260**, e.g., a sealing can in a circumstance isolated from the atmospheric air (S**140**). Thus, an organic EL display panel is completed.

[0035] Then, under a predetermined inspection environment, a lighting test for the organic EL display panel is carried out in a front elevational view from a predetermined distance (S**150**).

[0036] As a result of the lighting test, if all pixels **200** are lit (S**155**), the organic EL display panel is judged intact (S**195**) and then sent to other testing steps such as a performance test.

[0037] On the other hand, as shown in **FIG. 7A**, if any one (**200***a*) of the plurality of pixels **200** is not lit, that is, a pixel defect is found (S**155**), the inside of the organic EL display is observed under an optical microscope from the side of the glass substrate **210** and a not-lit pixel is extracted (S**160**).

[0038] As a result, in a case where the thin organic EL film **240** at the not-lit pixel **200**A contains foreign matter **300**, it is judged that the pixel **200**A can be restored by the laser beam and, in other cases than described above, it is judged that the pixel **200**A cannot be restored by the laser beam (S**170**).

[0039] As described above, the number of restorable pixels and the number of not-restorable pixels are counted. As a result, if the number of not-restorable pixels is more than a number N determined by the specification required for products, the organic EL display panel is rejected without pixel restoration by the laser beam (S**199**). On the contrary, if the number of the not restorable pixels is less than N, pixel restoration by the laser beam is performed on the organic EL display panel.

[0040] For example, if the number N of defects to be allowed for the entire organic EL display panel is 4, an organic EL display panel having not-restorable pixels by the number of 4 or more is rejected, whereas an organic EL display panel having not-restorable pixels by the number of less than 4 undergoes pixel restoration by the laser beam.

[0041] The pixel restoration by the laser beam is performed as described below.

[0042] At first, foreign matter in the restorable pixel is detected (S**180**). In order to accurately detect the position for the foreign matter in the pixel, this embodiment also uses an image processing system of detecting the position of foreign matter in the pixel by digitalizing output images from a camera that has photographed pixels and image processing the digitalized images.

[0043] Then, a laser beam M at a wavelength optically transparent for the glass substrate **210**, the driving circuit layer **220** and the first electrode **230** is shaped through a slit into a long rectangular form longer than the diameter d of the foreign matter **300** and then allowed to be incident on the surface **210***b* of the glass substrate **210** (S**185**).

[0044] In this case, as shown in **FIG. 5**, the laser beam M is directed to a region $m_1$ at a position spaced appropriately apart from the position of the outer shape of foreign matter **300** observed from the side of the surface **210**(*b*) of the glass substrate **210** as indicated at (1). For example, if the diameter (d) of the foreign matters **300** is about 5 $\mu$m, a laser beam M shaped to about 20 $\mu$m long×about 5 $\mu$m wide is directed to a square region $m_1$. The square region $m_1$ is defined on the outside of a rectangle **310***a* having a side of about 10 $\mu$m. (The rectangle is an imaginal rectangle defined on the surface **210***b* of the glass substrate **210** so as to surround the foreign matter **300** observed from the side of the surface **210***b* of the glass substrate **210** not in contact with the profile thereof.) In addition, the square region $m_1$ has a side comprising the side of the rectangle and two segments each extending from the end of the side of the rectangle at a distance corresponding to the width of the laser beam M.

[0045] The laser beam M used herein preferably has a wavelength of higher transmittance for the material used to form the thin organic EL film **240** so that it can transmit through the thin organic EL film **240** and allows the object to be cut (second electrode) to absorb higher energy. This will described be later.

**[0046]** Now, the laser beam M irradiated from the surface **210** of the glass substrate **210** passes through an optical path not containing foreign matter **300** through the glass substrate **210**, driving circuit layer **220**, first electrode **230** and thin organic EL film **240** and reaches the second electrode **250**. As a result, the laser irradiation region of the second electrode **250** is heated instantaneously and removed by the so-called abrasion phenomenon.

**[0047]** Then, as shown in **FIG. 3**, to completely isolate the region **250***a* in contact with the foreign matter **300** (region short-circuited to the first electrode **230** by the foreign matter **300**) from the second electrode **250**, the similar rectangular laser beam M is irradiated several times from the side of the surface **210***b* of the glass substrate **230** such that it is not incident on the foreign matter **300**. Specifically, as shown in **FIG. 5**, a rectangular laser beam M is allowed to be successively incident on rectangular regions $m_2$ to $m_4$ on the outside of the imaginal rectangle **310**A and in contact with each of remaining sides of the rectangle **310**A, so as to constitute a closed profile completely surrounding the contact point between the foreign matter **300** and the second electrode **250** as indicated at (2) to (4).

**[0048]** Then, as shown in **FIG. 3**, a band-like region **310** along the profile (outer shape) of a rectangle having a side of about 20 $\mu$m that surrounds the foreign matter **300** in a frame like form is removed from the second electrode **250**. As a result, a region **250***a* in contact with the foreign matter **300** narrower than the region **250***b* is completely isolated in an island shape from the region in not contact with the foreign matter **300** (region not short-circuited with the first electrode **230**).

**[0049]** As described above, when the region **250***a* in contact with the foreign matter **300** is isolated, since the region of the thin organic EL film **240** other than the region where the foreign matter **300** is present (that is, a region put between the region **250***b* not short-circuited with the first electrode **230**, and the first electrode **230**) can emit light by the current supply between the remaining region **250***b* not short-circuited with the first electrode **230**, and the first electrode **230**, the pixel **200***a* can be lit as shown in **FIG. 7B**. In other words, since the pixel defect can be restored, the yield of the products can be improved.

**[0050]** Then, in a predetermined inspection environment, lighting test for the organic EL display is conducted in the front elevational view from a predetermined distance (S190). Processing at **S175** to **S190** is repeated till it is judged that all the pixels **200** are lit finally (S177). In this way, at the instance all the restorable pixels are lit, the organic EL display panel is judged as an intact product (S195). For the organic EL display panel, other tests such as a performance test are conducted in the same manner as for the organic EL display panel judged to be an intact product as a result of the initial lighting inspection (S150).

**[0051]** According to the manufacturing processing described above, (1) in a case where the foreign matter **300** is present in the organic thin film **240**, an island-like region **250***a* in contact with the foreign matter **300** and a region **250***b* not in contact with the foreign matter **300** (the region functioning as the second electrode for the restored pixel) are completely isolated from each other by removing only the band-like region **310** completely surrounding the foreign matter **300** from the second electrode **250**; therefore, the not-lit pixel can be restored only by the countermeasure for that pixel even when the entire pixels are not divided into the plurality of pixel elements in a thin film pattern. Accordingly, it does not complicate the manufacturing steps for the organic EL display device.

**[0052]** Further, (2) as shown in **FIG. 3**, since the laser beam M passes only through the peripheral region **320** of the foreign matter **300** and reaches the second electrode **250** while circumventing the foreign matter **300**, it is not absorbed to the foreign matter **300** but can cut the second electrode **250** smoothly. Further, (3) since the laser beam M is not incident on foreign matter **300** in the thin organic EL film **240**, contamination to the thin organic EL film **240** due to the scattering of the foreign matter **300** can be prevented.

**[0053]** Thus, in the manufacturing step for the organic EL display according to this embodiment, an organic EL display excellent in display performance can be manufactured efficiently.

**[0054]** In the foregoing, foreign matter **300** in contact with both of the first electrode **230** and the second electrode **250** is mentioned as an example of the foreign matter causing the pixel defect; however, foreign matter in a state other than described above may also actually cause formation of current leak path between the first electrode **230** and the second electrode **250**. **FIG. 4A** to **FIG. 4D** show examples of the state of foreign matters capable of forming the current leak path between the first electrode **240** and the second electrode **250**.

**[0055]** **FIG. 4A** shows conductive foreign matter **300**A in contact with one of the first electrode **230** and the second electrode **250**. **FIG. 4B** shows electroconductive foreign matter **300**B not in contact with any of the first electrode **230** or the second electrode **250**. In a case where such foreign matter **300**A or **300**B is contained in the thin organic film **240**, the effective distance between the first electrode **230** and the second electrode **250** is narrowed at the position of the foreign matter **300**A or **300**B. Therefore, when a voltage is applied between the electrodes **230** and **250**, a current leak path may possibly be formed at the position of the foreign matter **300**A or **300**B.

**[0056]** **FIG. 4C** shows a case in which the thickness of the thin organic EL film **240** is locally reduced by the presence of the foreign matter **300**C. In this case, the distance between the first electrode **230** and the second electrode **250** is narrowed at a portion where the thickness of the thin organic EL film **240** is reduced. Accordingly, a current leak path may possibly be formed at the position of the foreign matter **300**C irrespective of whether the foreign matter **300**C is electroconductive or not.

**[0057]** **FIG. 4D** shows a case in which a defect is formed in the thin organic EL film **240** by the presence of the foreign matter **300**D. In this case, the first electrode **230** and the second electrode **250** are short-circuited at the defective portion of the thin organic EL film **240**. Accordingly, a current leak path is formed at the position of the foreign matter **300** irrespective of whether the foreign matter **300**D is electroconductive or not.

**[0058]** Also for the foreign matters **300**A to **300**D referred to herein as the specific examples, the pixel restoration by laser according to this embodiment is also effective. That is, formation of the current leak path between the first electrode

230 and the second electrode 250 can be prevented by isolating the second electrode 250 into an island-like region larger than the outer shape of the foreign matter 300A to 300D (cross section of the foreign matter along the in-plane direction of the second electrode) and other region (region functioning as the second electrode of the restored pixel) by irradiating with a laser beam a band-like region surrounding the outer profile of the foreign matter 300A to 300D of the observed from the side of the surface 210*b* of the glass substrate 210.

**[0059]** To confirm the effects (2), (3) in those described above, a comparative experiment was conducted by using the following three types of samples.

**[0060]** (a) Sample 1

**[0061]** Normally lit organic EL display device.

**[0062]** (b) Sample 2

**[0063]** An organic EL display device manufactured by manufacturing steps according to this embodiment. The device in which pixel defects caused by stainless steel type foreign matter (about 10 μm diameter) containing Fe, Ni, Cr, etc. are restored in the manufacturing steps.

**[0064]** (c) Sample 3

**[0065]** Organic EL display device in which the same foreign matter as that of Sample 2 was present in the thin organic EL film and, accordingly, the pixel defect was restored by directly irradiating the foreign matter region with a laser beam.

**[0066]** For the samples 1 to 3, a continuous current supply test was conducted with a DC current with the initial luminance being set at 1000 cd/$m^2$ and the change of the luminance in the course of the test was measured. The result is shown in **FIG. 8**.

**[0067]** It was found that the luminance of Sample 2 lowered moderately about at the same rate as the luminance of Sample 1, whereas the luminance of Sample 3 lowers abruptly just after starting the current supply since the foreign matter irradiated with laser constitutes a contamination source. For Sample 3, it was also found that the half-decay time of the luminance was extremely shorter than that of Sample 1 or 2.

**[0068]** Further, in the treatment for restoring the pixel defect of Sample 2, the laser irradiated region in the second electrode could be removed smoothly by the laser irradiation once, whereas the laser beam was absorbed by the stainless steel series foreign matter in the treatment for restoring the pixel defect of Sample 3 and the laser irradiated region in the second electrode could not be removed completely by the irradiation of the laser beam once. Therefore, it was necessary to irradiate the identical region with the laser beam three times.

**[0069]** From the result described above, it was confirmed that the foregoing effect could be obtained for the organic EL display to be a product by the manufacturing steps according to this embodiment.

**[0070]** In the embodiment, the rectangular band-like region 310 surrounding the foreign matter 300 is removed from the second electrode 250; however, the region to be removed from the second electrode may be any other shape so long as it is a shape easy for laser fabrication. For example, the region to be removed from the second electrode may also be a band-like or annular region along the profile of a polygonal shape other than the rectangular shape (refer to **FIG. 6B**), or a band-like region of a shape along the outer profile of the foreign matter 300 (refer to **FIG. 6C**).

**[0071]** Further, a laser beam M shaped into a rectangular form is irradiated several times; however, the laser beam M may be incident on the surface 210*b* of the glass substrate 210 in any manner so long as the contact region 250*a* with the foreign matters 300 can be isolated from the second electrode 250.

**[0072]** For example, as shown in **FIG. 6A**, a rectangular frame-like region 310 surrounding foreign matter 300 may be removed all at once from the second electrode 250 by irradiating once the surface 210*b* of the glass substrate 210 with a laser beam $M_1$ shaped to a rectangular frame-like form of a size in accordance with the size of the foreign matter 300 through an optical system such as a slit.

**[0073]** Further, as shown in **FIG. 6B**, a laser beam $M_1$ shaped to an annular form of a diameter in accordance with the size of the foreign matter 300 may be irradiated only for once to the surface 210*b* of the glass substrate 210 through an optical system such as a slit.

**[0074]** Further, as shown in **FIG. 6C**, a band-like region 310A along the outer shape of the foreign matter 300 may also be removed from the second electrode 250 by scanning a laser spot light along the outer shape of the foreign matter 300 within the surface 210*b* of the glass substrate 210.

**[0075]** By the way, the manufacturing conditions in the manufacturing steps described above give effects on the quality of the organic EL display as a completed product. Preferred manufacturing conditions are to be described below.

**[0076]** First, a description will be made of the shape and size for the region 310 to be removed from the second electrode.

**[0077]** Since the region 310 to be removed from the second electrode and a region surrounded therewith constitute a non-emission region in the thin organic EL film 240, the size of the region 310 to be removed from the second electrode gives an effect on user's visual sense. Then, to confirm the effect, a lighting test for pixels after restoration having the shape and size of the region 310 to be removed from the second electrode different from each other was conducted in the front elevational view from a predetermined distance.

**[0078]** As a result, in a case where the region 310 to be removed from the second electrode was of a rectangular frame like form of about 50 μm×about 50 μm (area of the region 310 to be removed from the second electrode and a region surrounded therewith, that is, the area of non-emission region of about 2500 μ$m^2$), it gives no sense of discomfort to a user with naked eyes. However, in a case where the region 310 to be removed from the second electrode was a rectangular frame-like form of a greater size, for example, it was a rectangular frame-like form of 80 μm×80 μm (area of the non-emission region of about 6400 μ$m^2$), the user could recognize the non-emission region as a black spot.

[0079] Further, in a case where the region **310** to be removed from the second electrode had an annular shape with an outer diameter of about 60 μm (area for the non-emission region of about 2827 $\mu m^2$), it gave no sense of discomfort to the user with naked eyes. However, in a case where the region **310** to be removed from the second electrode was an annular shape with an outer diameter of about 80 μm (area of non-emission region of 5026 $\mu m^2$), the user could recognize the non-emission region as a black spot with naked eyes.

[0080] In view of the foregoing, it was confirmed that the size of the region **310** to be removed from the second electrode gave an effect on the visual sense of the user and it is preferred to determine the shape and size of the region **310** to be removed from the second electrode so that the area of the non-emission region is 2500 $\mu m^2$ or less in order to enable the display to be shipped as actual products.

[0081] Next, the effect given by the wavelength of the laser beam M used for restoration of the pixel is to be described.

[0082] As has been described above, it is preferred that the laser beam M used for the restoration of the pixel has a wavelength showing high transmittance for the material used to form the thin organic EL film **240**. This is because the laser beam M is irradiated from the side of the glass substrate **110** and reaches an object to be cut (second electrode **250**) after transmitting the driving circuit layer **220**, the first electrode **230** and the thin organic EL film **240**. In addition, accordingly, if it is absorbed greatly in the thin organic EL film **240**, not only the laser beam does not reach the second electrode **250**, but also the thin organic EL film **240** is melted by heat and the heat diffuses also in the in-plane direction of the substrate. Thus, possibly failing to obtain a desired fabrication shape.

[0083] Then, to examine the relationship between the material for forming the thin organic EL film **240** and the wavelength of the laser beam M, thin organic EL films having absorbing characteristics different from each other were prepared and the second electrode in contact with the thin organic EL films were put to cutting fabrication by laser beams at wavelengths different from each other.

[0084] In this case, second electrodes of pixels are used as objects to be cut by the three types of laser beams. The second electrodes of pixels have thin organic EL films formed of three types of light emitting materials showing absorption spectrum in **FIG. 9** (blue light emitting material, green light emitting material and red light emitting material). The three types of laser beams are obtained from Nd:YAG lasers (ultraviolet rays at a wavelength of 355 nm, a visible light (green) at a wavelength of 532 nm, near infrared light at a wavelength of 1064 nm). The absorbance shown in the drawings is a product of the film thickness of the thin organic EL film and the absorption coefficient of the thin organic EL film at each wavelength.

[0085] As shown in **FIG. 9A**, the absorbance of each of the three types of laser beams shows a value of 0.1 or less for the blue light emitting material. Further, as shown in **FIG. 9B**, for the green light emitting material, the absorbance of the laser beam with a wavelength of 532 nm and a wavelength of 1064 nm each shows a value of 0.1 or less, whereas the absorbance of the laser beam with a wavelength of 355 nm shows a value of about 0.25, among three types of the laser beams.

[0086] Further, as shown in **FIG. 9C**, for the red light emitting material, the absorbance of the laser beam with a wavelength of 1064 nm, shows a value of 0.1 or less, whereas the absorbance of the laser beams at a wavelength of 355 nm and at a wavelength of 532 nm respectively shows values of about 0.5 and about 0.4, among the three types of region light.

[0087] As a result of microscopic observation for the cut portion of each second electrode, the followings were confirmed for each of the light emitting materials.

[0088] For the pixel having an thin organic EL film formed of the green light emitting material, as shown in **FIG. 10B**, the second electrode was cut favorably by the irradiation of a laser beam with a wavelength of 532 nm showing the absorbance, to the green light emitting material, of 0.1 or less and also the thin organic EL film was scarcely melted. The same result was obtained also in the irradiation of a laser beam with a wavelength of 1064 nm showing the absorbance, to the green light emitting material, of 0.1 or less.

[0089] On the contrary, as shown in **FIG. 10A**, the second electrode could not be cut completely by the irradiation of a laser beam with a wavelength of 355 nm showing the absorbance, to the green light emitting material, of about 0.25.

[0090] Further, for the pixel having a thin organic EL film of a red emission material, the second electrode could be favorably by the irradiation of a laser beam with a wavelength of 1064 nm showing an absorbance, to the red emission material, of 0.1 or less and also the thin organic EL film was scarcely melted. On the contrary, the second electrode could not be cut completely by the irradiation of a laser beam with a wavelength of 355 nm showing the absorbance, to the red emission material, of about 0.5 and by the irradiation of a laser beam with a wavelength of 532 nm showing the absorbance, to the red light emitting material, of about 0.4.

[0091] Further, for the pixel having an thin organic EL film formed of a blue emission material, the second electrode was cut favorably and also the thin organic EL film was scarcely melted by the irradiation of each of laser beams at the wavelengths of 355 nm, 532 nm and 1064 nm showing an absorbance, to the blue light emitting material, of 0.1 or less.

[0092] In view of the foregoings, it can be seen that the second electrode can be efficiently cut to a desired shape since the laser beam causes less absorption to the thin organic EL film so long as it has a wavelength showing an absorbance at a value of 0.1 or less to the material for forming the thin organic EL film. That is, it is confirmed that the second electrode can be cut favorably and efficiently without melting the thin organic EL film by selecting the wavelength of the laser beam used for the restoration of pixels in accordance with the material for forming thin organic EL film.

[0093] Among the wavelengths of 355 nm, 532 nm and 1064 nm, since the laser beam with the longest wavelength (1064 nm) gives a favorable result of fabrication to each of the light emitting materials, a laser beam with a wavelength of 1064 nm may be used generally for the restoration of pixels having thin organic EL films formed of the three kinds of light emitting materials described above. Further, since a laser beam with a shorter wavelength can reduce its diameter smaller, a laser beam with the shortest wavelength may be selected from laser beams at wavelengths providing favorable result of fabrication in a case where the size of the foreign matter is relatively larger in order to reduce the not-lit region of the pixel after restoration.

**[0094]** While we have shown and described several embodiments in accordance with our invention, it should be understood that disclosed embodiments are susceptible of changes and modifications without departing from the scope of the invention. Therefore, we do not intend to be bound by the details shown and described herein but intend to cover all such changes and modifications as fall within the ambit of the appended claims.

What is claimed is:

**1**. A method for manufacturing an organic electroluminescence display having an organic film and first and second electrode layers, the first and second electrode layers facing each other to interpose the organic film therebetween and allow the organic film to emit light passing through the first electrode layer, said method comprising the steps of:

inspecting whether the organic film emits light or not and, if the organic film does not emit light, detecting foreign matter in the organic film from a side of the first electrode layer; and

irradiating, if the foreign matter is detected, the second electrode layer with a laser beam capable of transmitting the first electrode layer and the organic film by way of an optical path not containing the foreign matter, so as to remove a band-like region surrounding a periphery of the foreign matter from the second electrode layer.

**2**. A method for manufacturing an organic electroluminescence display having an organic film and first and second electrode layers, the first and second electrode layers facing each other to interpose the organic film therebetween and allow the organic film to emit light passing through the first electrode layer, said method comprising the steps of:

inspecting whether the organic film emits light or not and, if the organic film does not emit light, detecting foreign matter in the organic film from a side of the first electrode layer; and

irradiating, if the foreign matter is detected, the second electrode layer with a laser beam capable of transmitting the first electrode layer and the organic film from the first electrode layer by way of a path passing the outside of the foreign matter in the organic film, cutting a band-like region surrounding the outside of the foreign matter, and cutting out from the second electrode layer a first region larger than a cross section of the foreign matter in view of the in-plane direction of the second electrode layer.

**3**. A method for manufacturing an organic electroluminescence display having an organic film between a first electrode layer permitting light from the organic film to transmit therethrough and a second electrode layer, the organic film emitting light by electric current supplied between the first and second electrode layers, said method comprising the steps of:

detecting foreign matter in contact with the second electrode layer from a side of the first electrode layer; and

separating, if the foreign matter is detected, the second electrode layer into a first region in contact with the foreign matter and a second region not in contact with the foreign matter.

**4**. A method for manufacturing an organic electroluminescence display having an organic film and first and second electrode layers, the first and second electrode layers facing each other to interpose the organic film therebetween and allow the organic film to emit light passing through the first electrode layer, said method comprising the steps of:

detecting foreign matter in contact with the second electrode layer form a side of the first electrode layer; and

irradiating, if the foreign matter is detected, the second electrode layer from a side of the first electrode layer with a laser beam capable of transmitting the first electrode layer and the organic film by way of a path passing the outside of the foreign matter in the organic film, cutting the second electrode layer at a band-like region surrounding a periphery of the foreign matter, and cutting out the first region including an entire portion in contact with the foreign matter from the second electrode layer.

**5**. A method for manufacturing an organic electroluminescence display having an organic film between a first electrode layer permitting light from the organic film to transmit therethrough and a second electrode layer, the organic film emitting light by electric current supplied between the first and second electrode layers, said method comprising the steps of:

detecting foreign matter in the organic film from a side of the first electrode layer; and

separating, if the foreign matter is detected, the second electrode layer into a first region of an area larger than foreign matter, on a side of the foreign matter opposite to the first electrode layer and a second region not in contact with the first region.

**6**. The method according to claim 1, wherein the laser beam is emitted such that the area of the band-like region and the region containing the foreign matter and remaining in the second electrode layer is 2500 $m^2$ or less.

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| 专利名称(译) | 制造有机电致发光显示器的方法 | | |
| 公开(公告)号 | [US20050215163A1](US20050215163A1) | 公开(公告)日 | 2005-09-29 |
| 申请号 | US10/878550 | 申请日 | 2004-06-29 |
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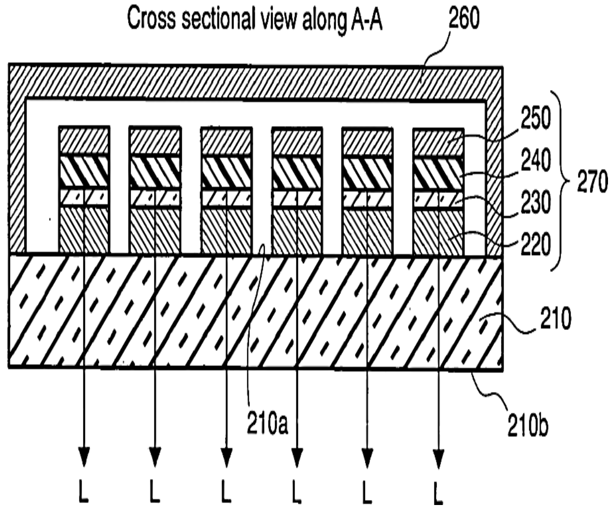
| IPC分类号 | H05B33/10 G09F9/30 H01J9/00 H01L51/50 H05B33/12 H05B33/14 H05B33/22 H05B33/26 | | |
| CPC分类号 | H01L2251/568 H01L51/56 | | |
| 优先权 | 2004087527 2004-03-24 JP | | |
| 其他公开文献 | US7258586 | | |
| 外部链接 | Espacenet USPTO | | |


**摘要(译)**

当在第一电极和第二电极之间具有有机EL层的有机EL显示器中没有点亮任何像素时，观察到像素的有机层。如果像素的有机层包含异物，则第二电极被分离成与异物接触的区域和不与接触区域和异物接触的区域。因此，尽可能少地减少未点亮的显示区域，使得可以制造显示性能优异的有机EL显示器。



Cross sectional view along A-A
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