US 20130240870A1

(19) United States

(12) Patent Application Publication

Kawato et al.

(10) Pub. No.: US 2013/0240870 A1

(43) Pub. Date: Sep. 19, 2013

(54) VAPOR DEPOSITION DEVICE, VAPOR DEPOSITION METHOD AND ORGANIC EL DISPLAY DEVICE

(75) Inventors: **Shinichi Kawato**, Osaka (JP); **Satoshi Inoue**, Osaka (JP); **Tohru Sonoda**, Osaka (JP)

(73) Assignee: **SHARP KABUSHIKI KAISHA**, Osaka-shi, Osaka (JP)

(21) Appl. No.: **13/989,757**

(22) PCT Filed: **Dec. 13, 2011**

(86) PCT No.: **PCT/JP2011/078749**

§ 371 (c)(1), (2), (4) Date: **May 24, 2013**

(30) **Foreign Application Priority Data**

Dec. 21, 2010 (JP) 2010-284940

Publication Classification

(51) **Int. Cl.**

H01L 51/56 (2006.01)

H01L 51/50 (2006.01)

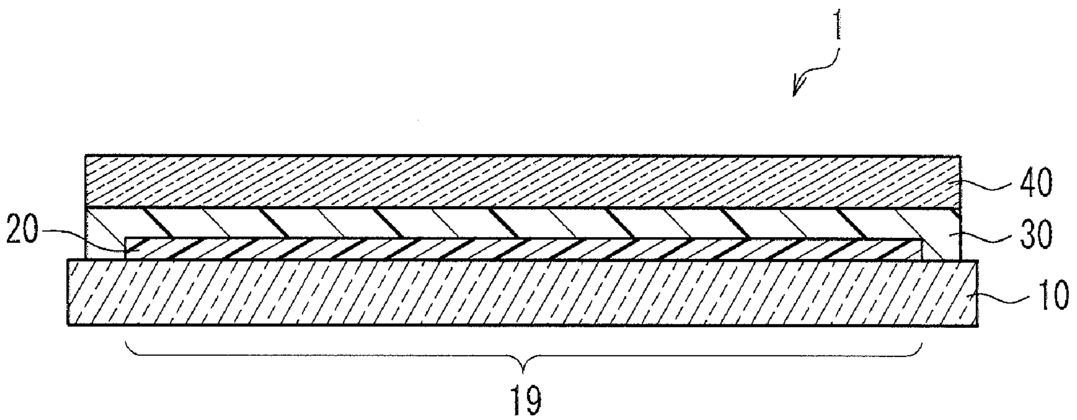
(52) **U.S. Cl.**

CPC ***H01L 51/56*** (2013.01); ***H01L 51/50*** (2013.01)

USPC **257/40**; 257/88; 118/720; 438/46

(57) **ABSTRACT**

A vapor deposition source (**60**), a limiting plate unit (**80**), and a vapor deposition mask (**70**) are disposed in this order. The limiting plate unit includes a plurality of limiting plates (**81**) disposed along a first direction. The side surfaces of the limiting plates defining a limiting space (**82**) in the first direction are configured such that a portion having a dimension in the first direction of the limiting space between the limiting plates neighboring in the first direction wider than a narrowest portion (**81***n*) having a narrowest dimension in the first direction of the limiting space is formed on at least the vapor deposition source side with respect to the narrowest portion. Accordingly, a coating film whose edge blur is suppressed can be formed at a desired position on a large-sized substrate.



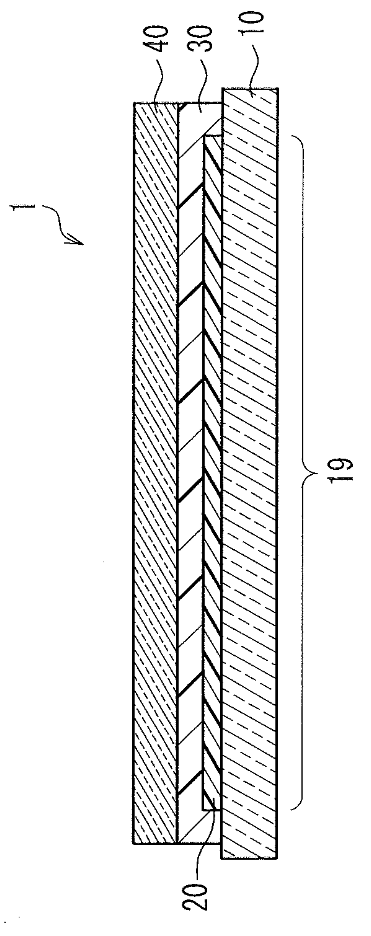


FIG. 1

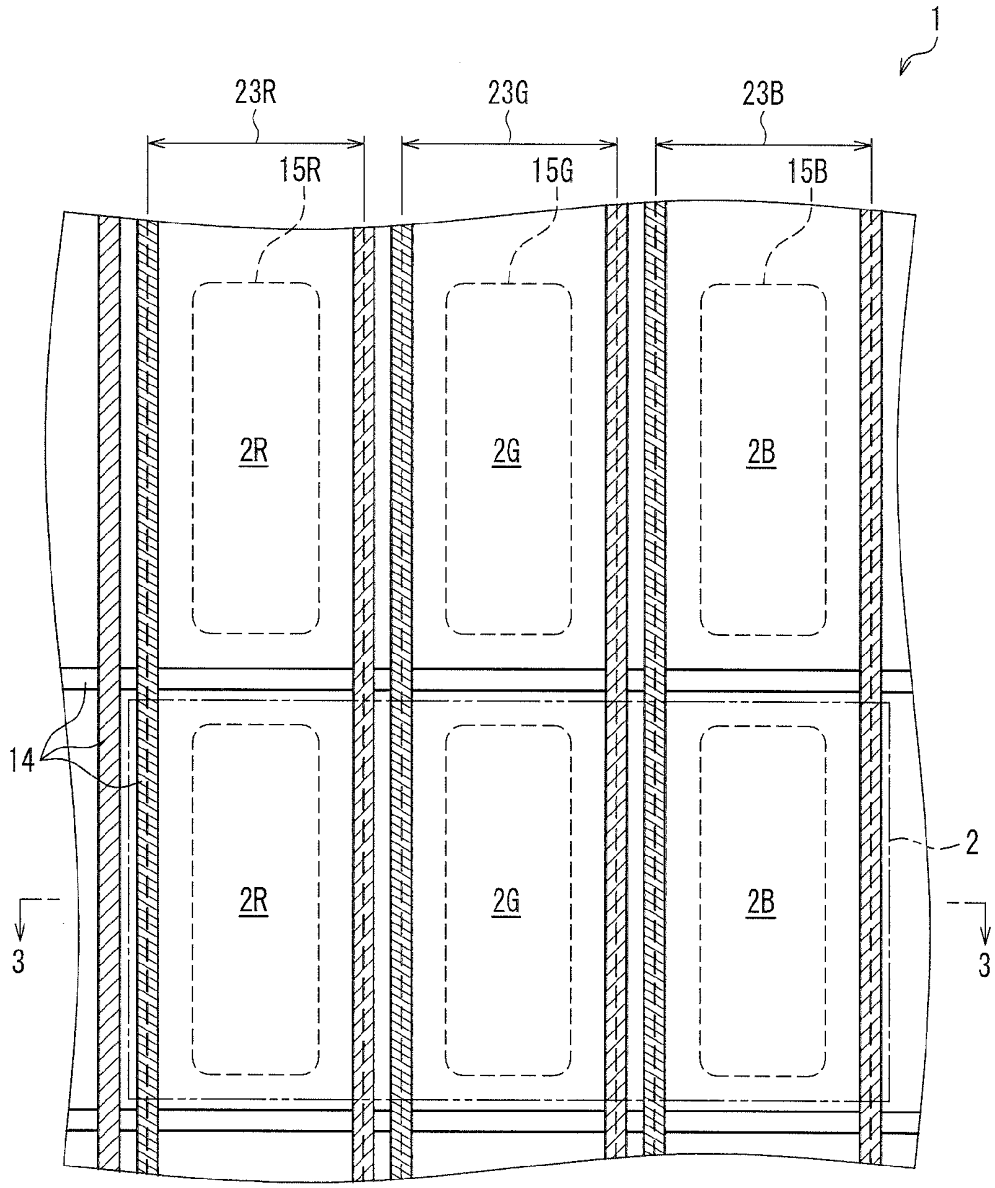


FIG. 2

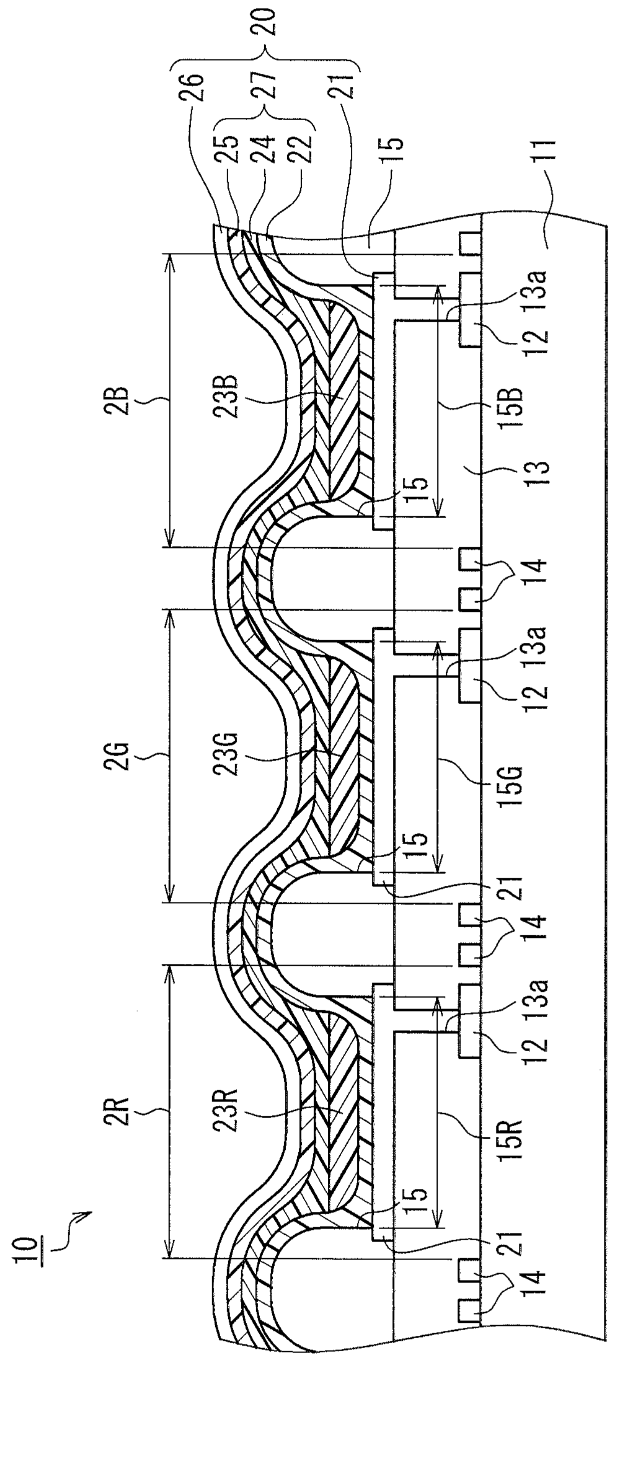

20
26
27
25
24
22
21
15
11
2B
23B
13a
12
15B
13
14
2G
23G
15G
2R
23R
15R
10

FIG. 3

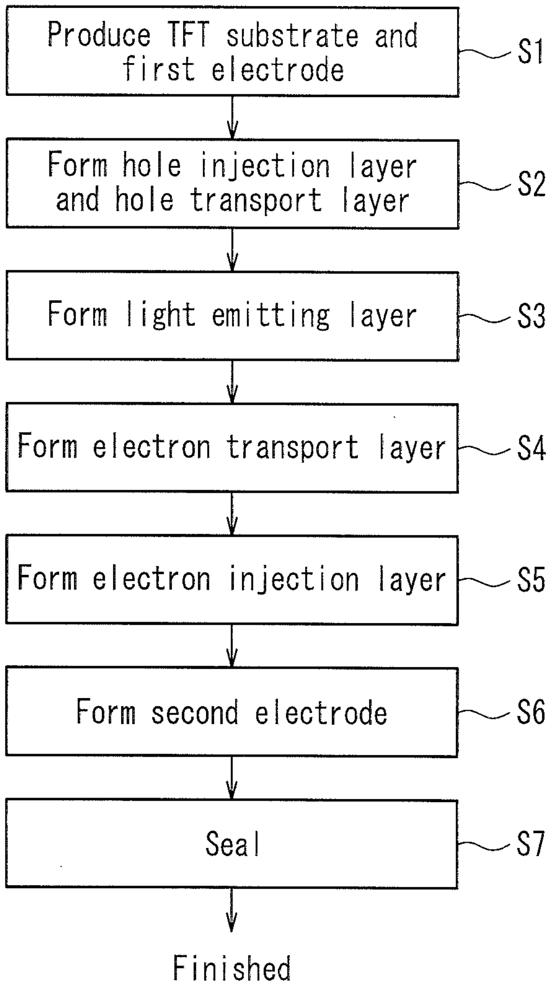

Produce TFT substrate and first electrode
S1
Form hole injection layer and hole transport layer
S2
Form light emitting layer
S3
Form electron transport layer
S4
Form electron injection layer
S5
Form second electrode
S6
Seal
S7
Finished

FIG. 4

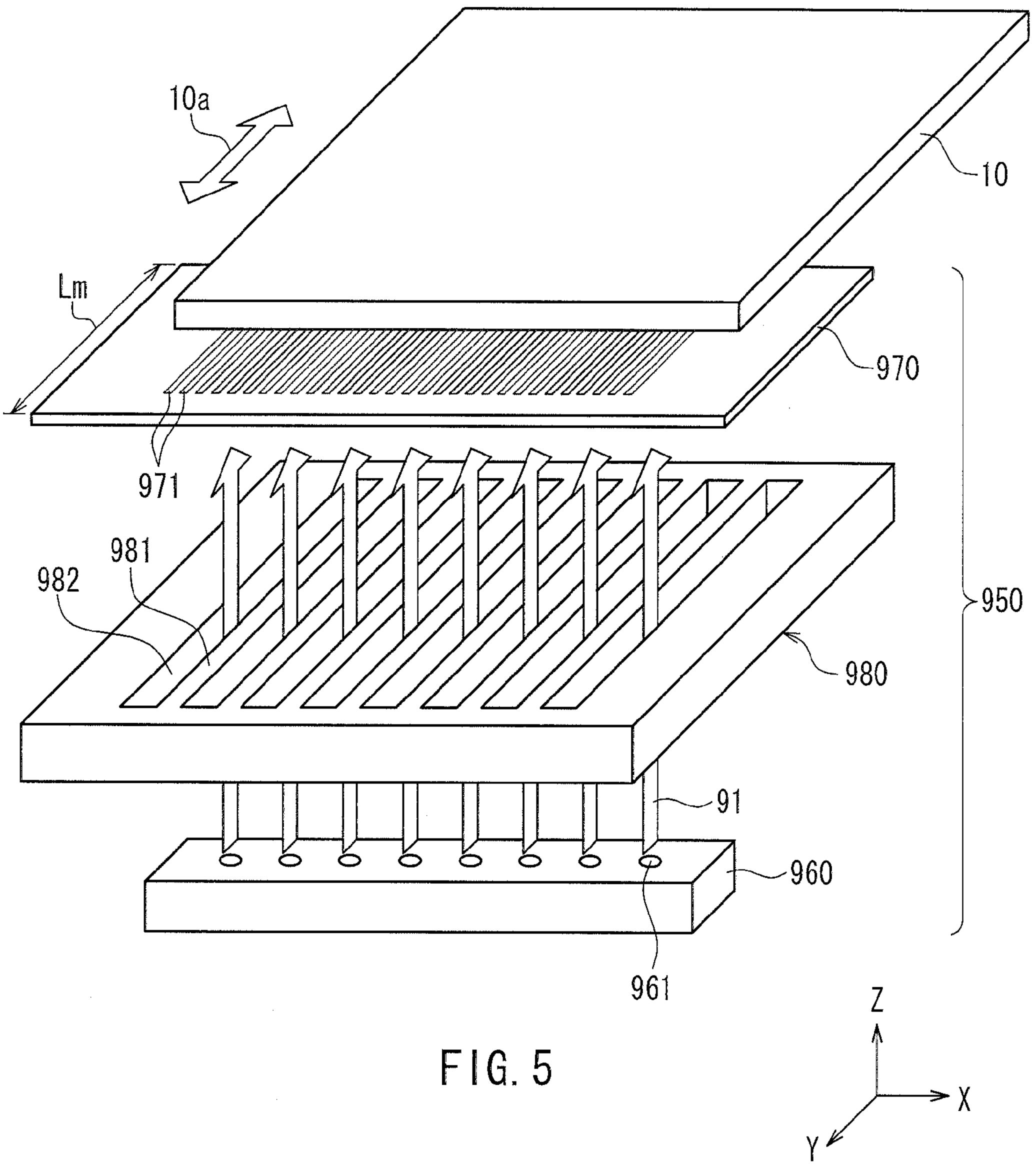


FIG. 5

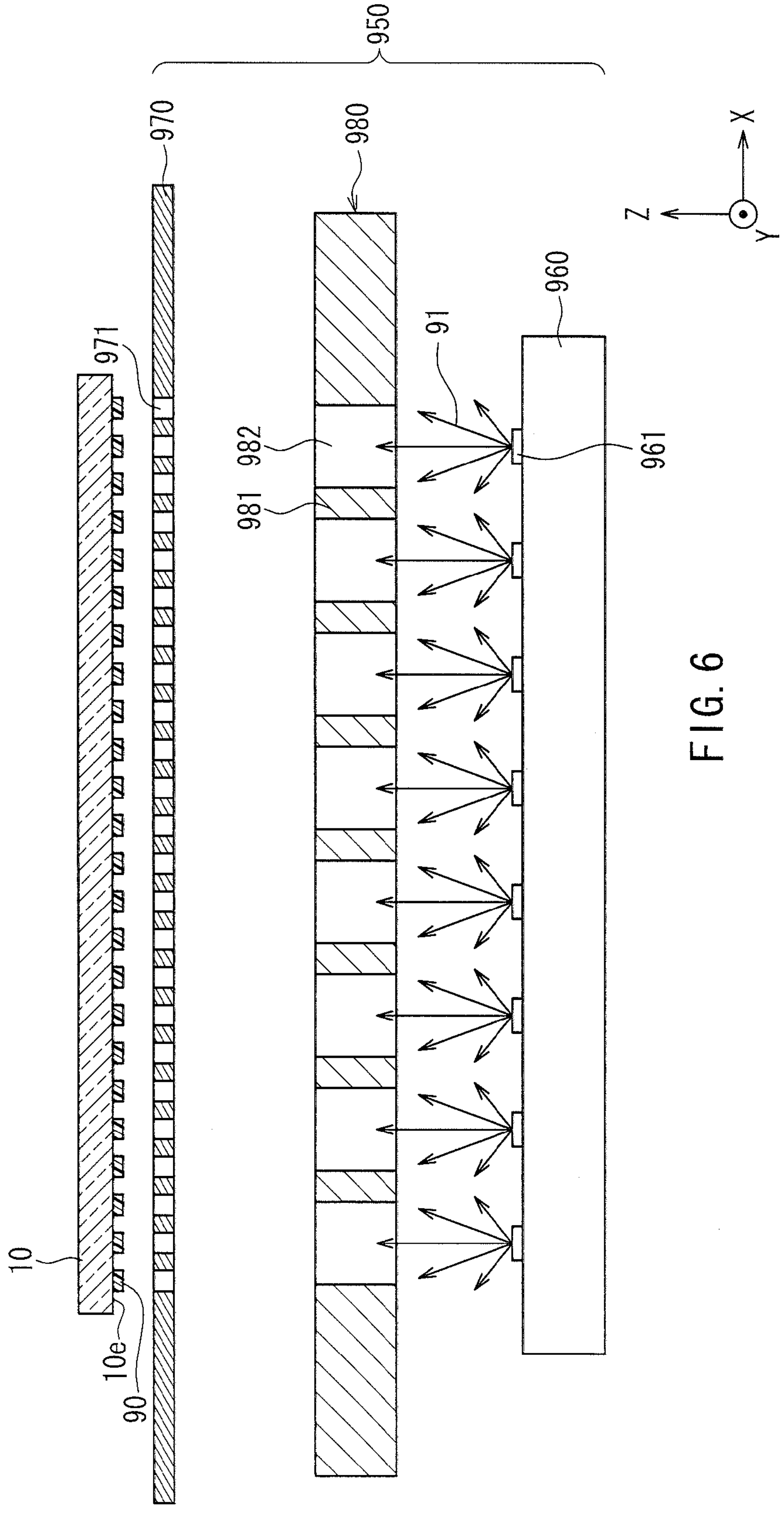


FIG. 6

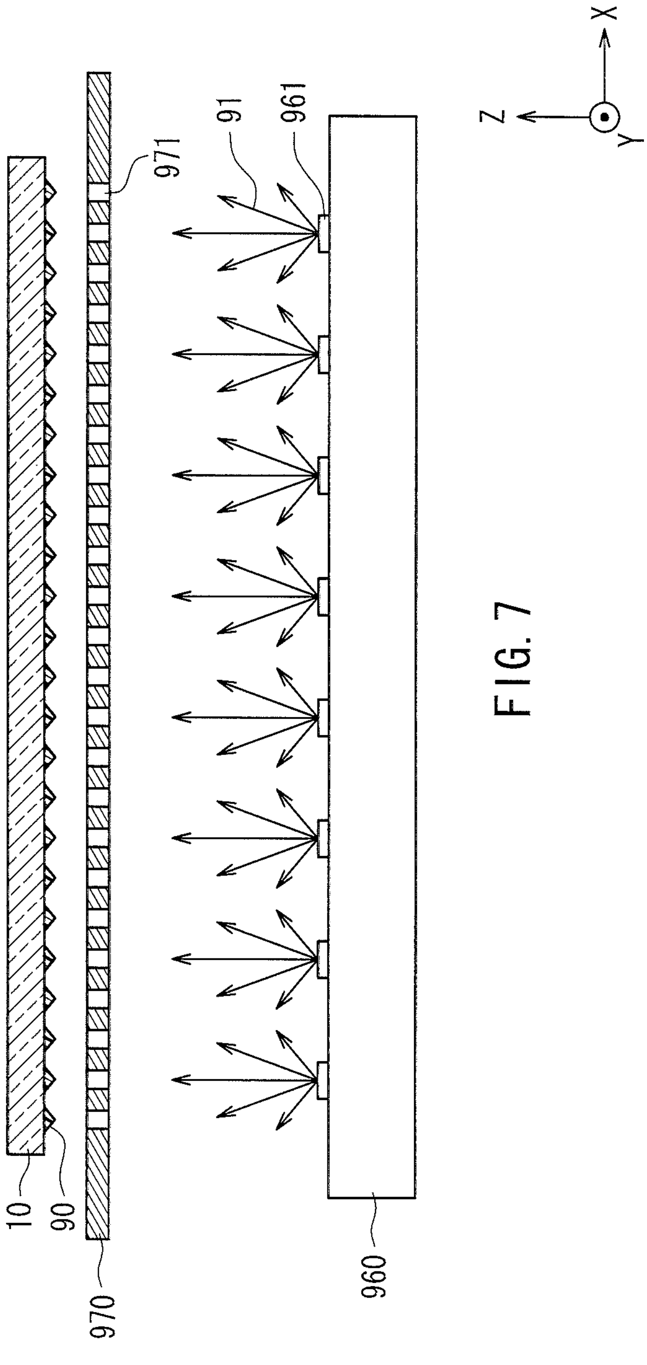


FIG. 7

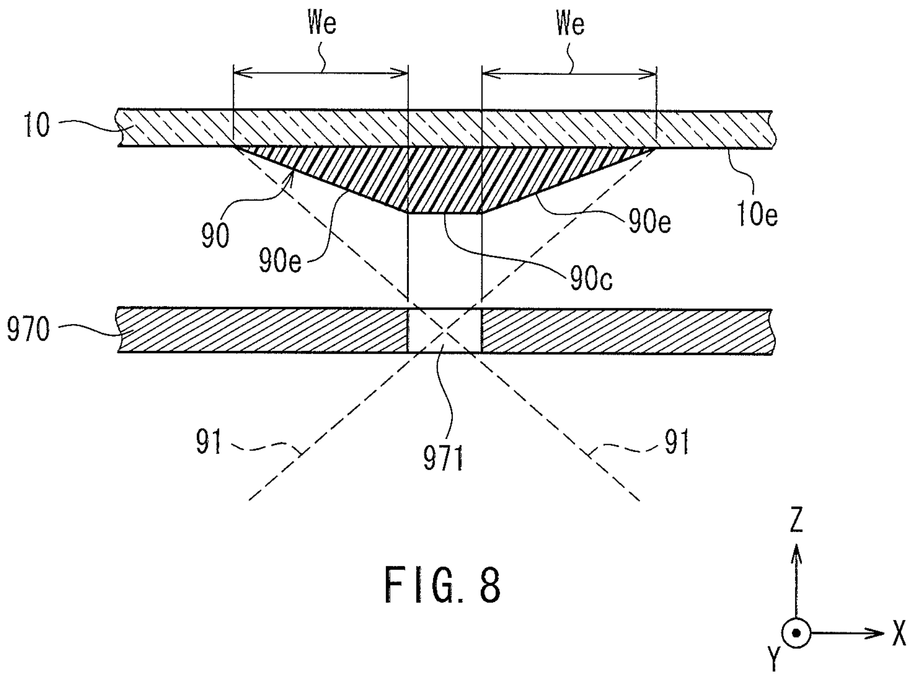


FIG. 8

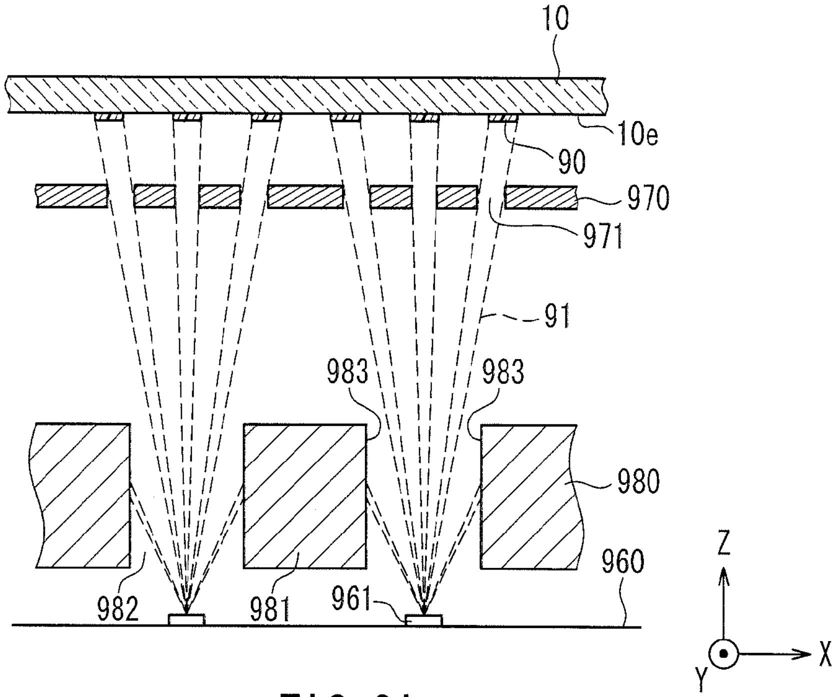

10
10e
90
970
971
91
983
983
980
960
982
981
961
Z
X
Y

FIG. 9A

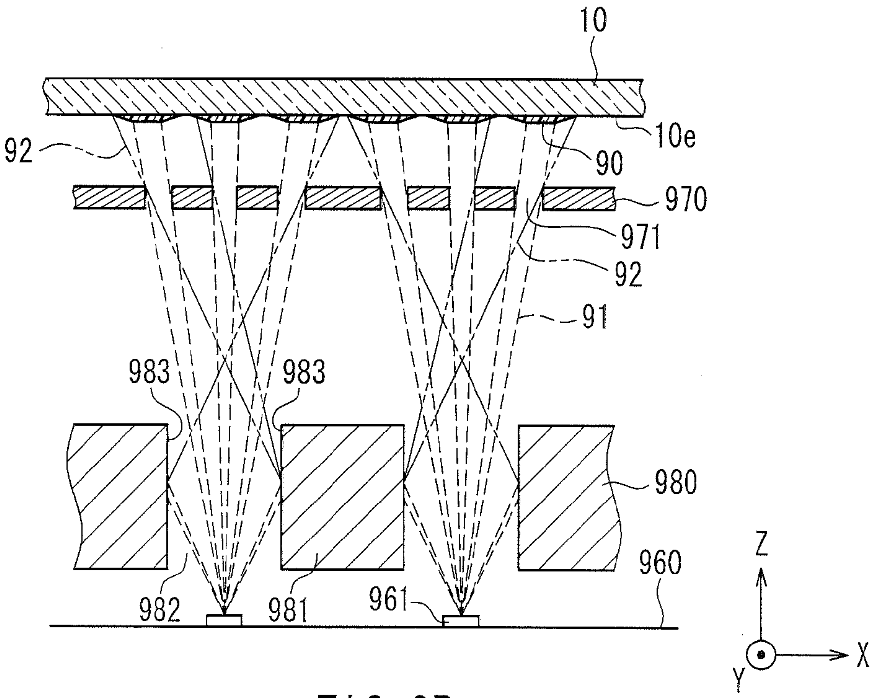

10
10e
92
90
970
971
92
91
983
983
980
960
982
981
961
Z
X
Y

FIG. 9B

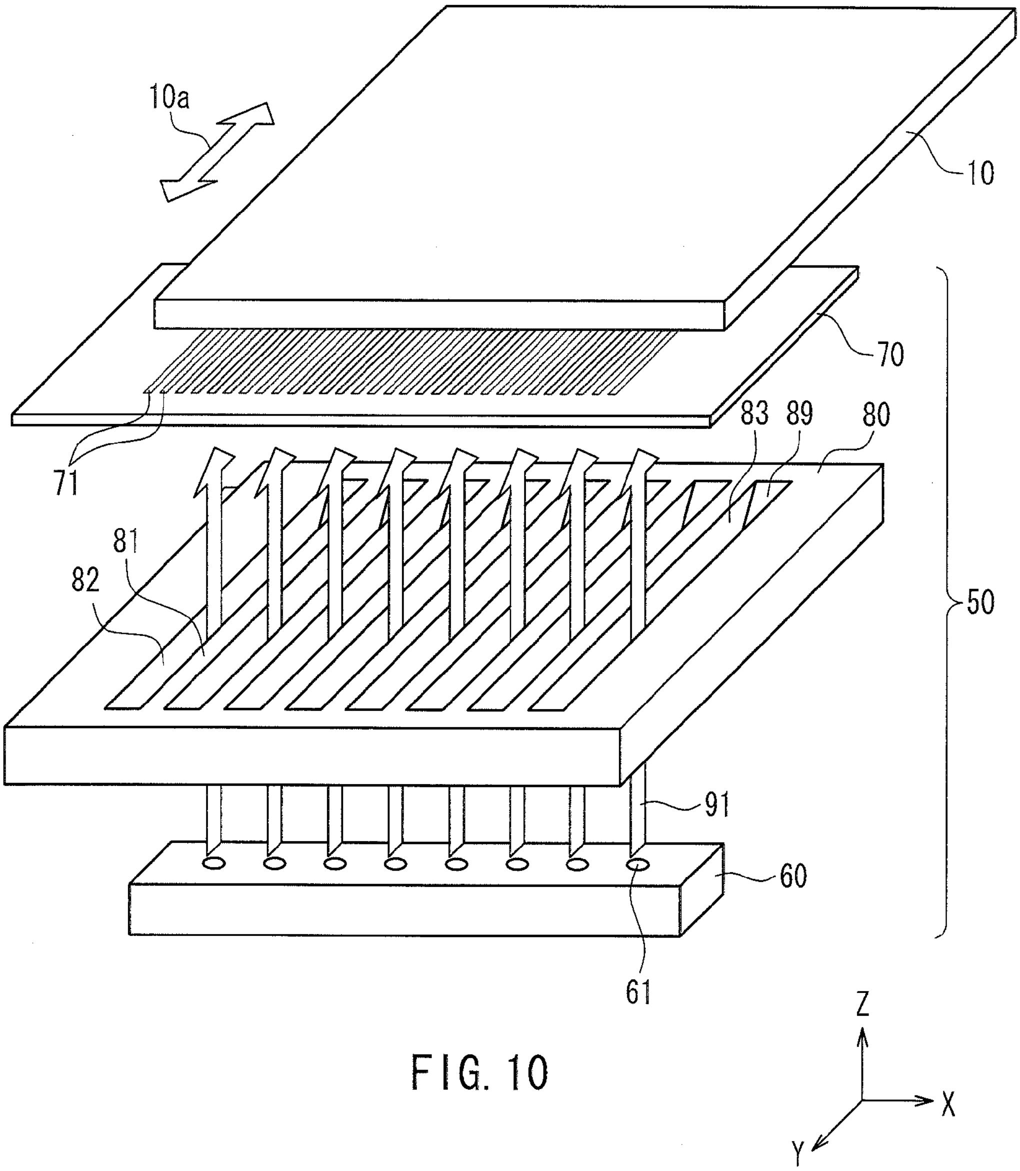


FIG. 10

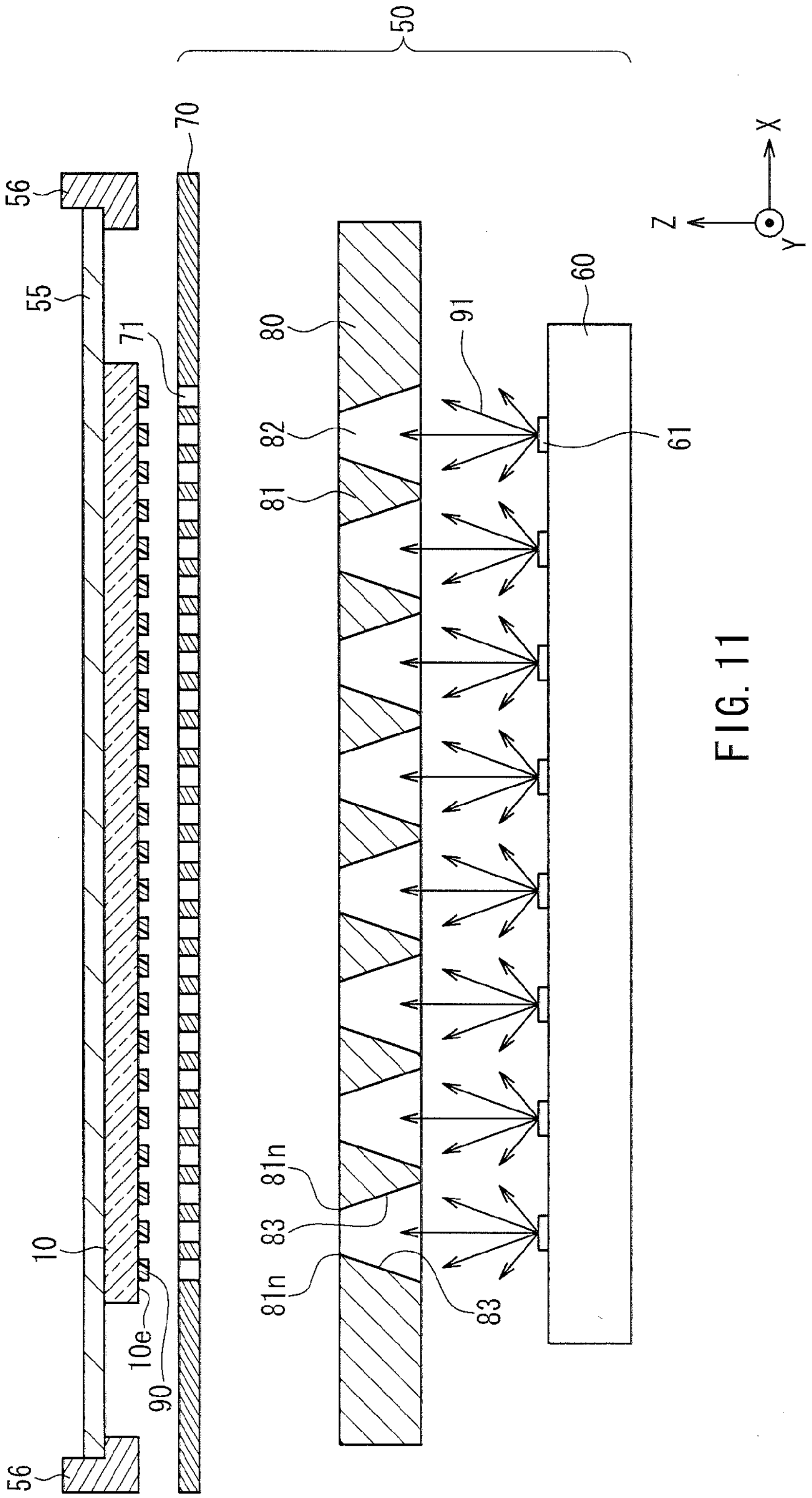


FIG. 11

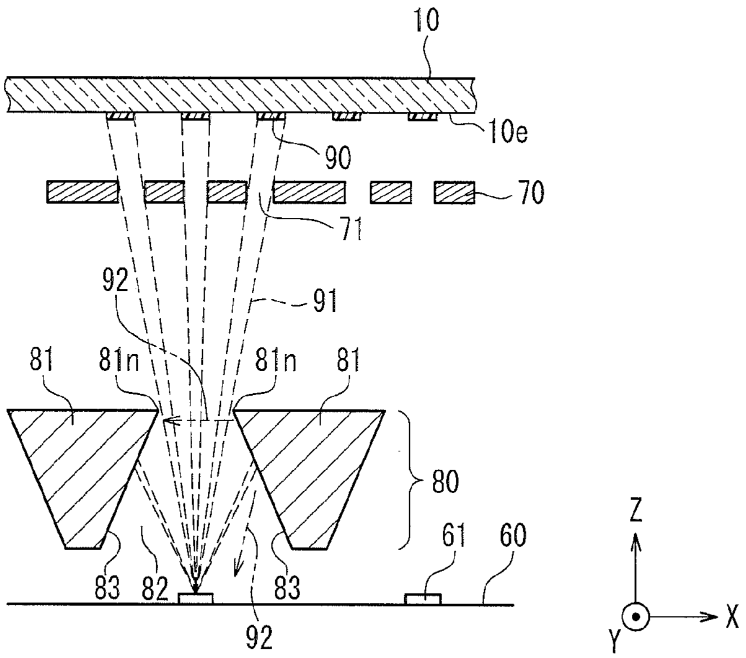

10
10e
90
70
71
92
91
81
81n
81n
81
80
Z
61
60
83
82
83
92
X
Y

FIG. 12

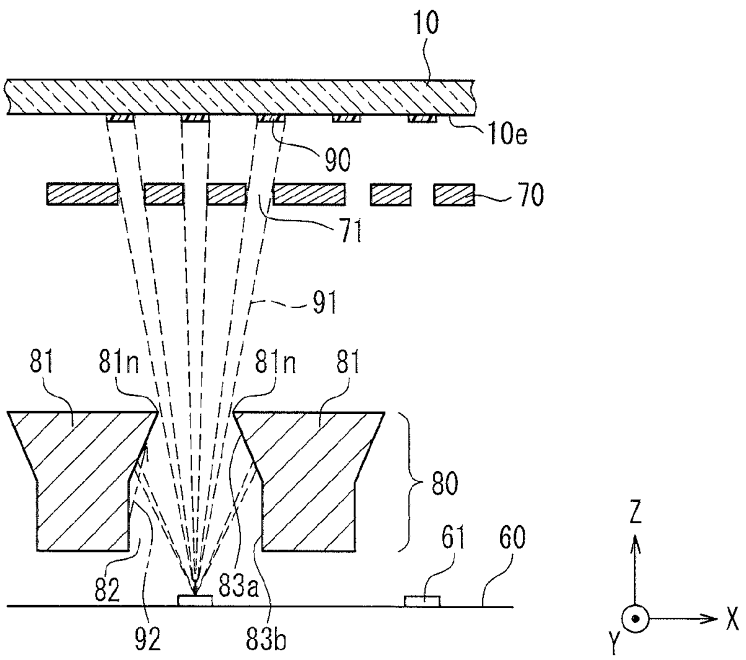

10
10e
90
70
71
91
81
81n
81n
81
80
Z
61
60
82
83a
92
83b
X
Y

FIG. 13

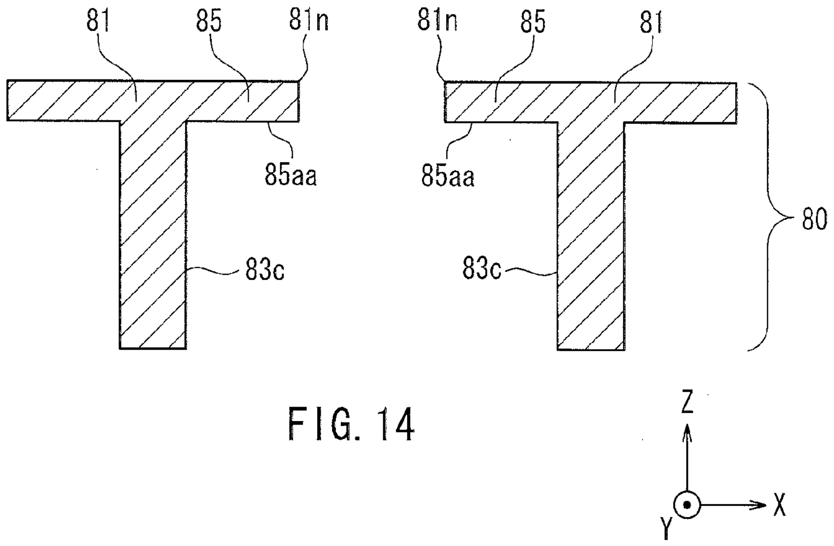

81
85
81n
81n
85
81
85aa
85aa
80
83c
83c
Z
Y
X

FIG. 14

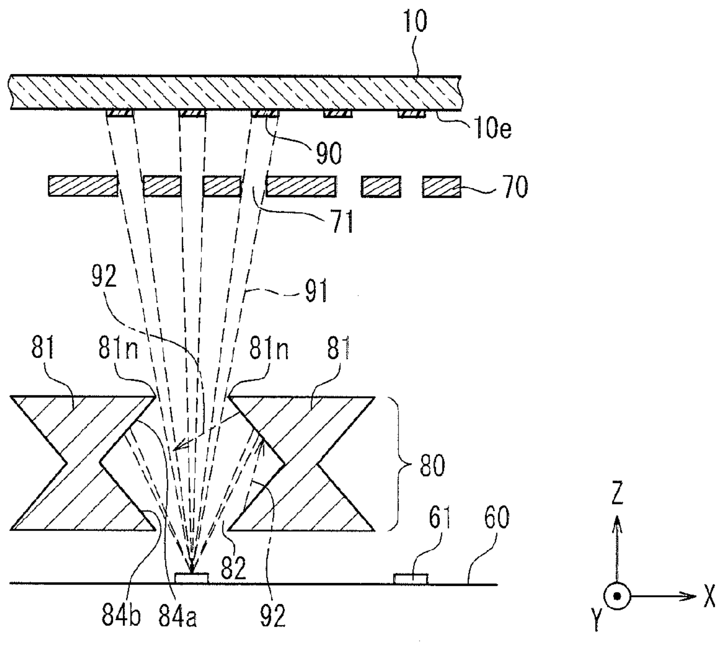

10
10e
90
70
71
92
91
81
81n
81n
81
80
61
60
Z
82
84b
84a
92
Y
X

FIG. 15

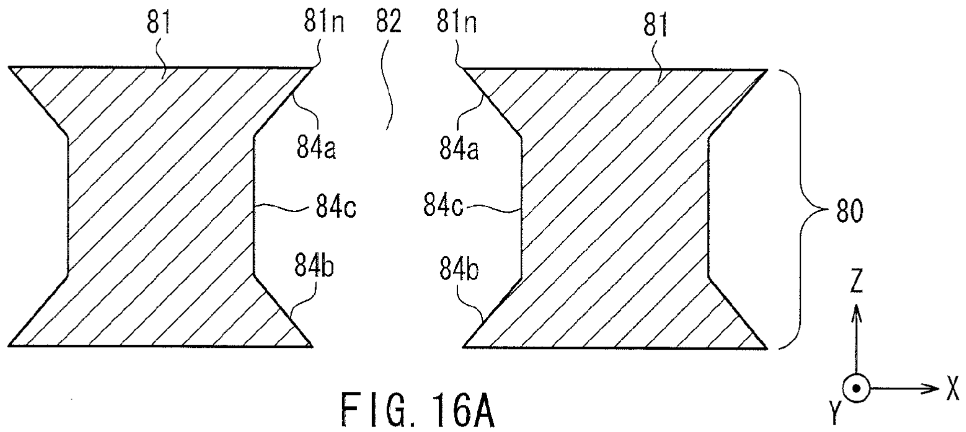


FIG. 16A

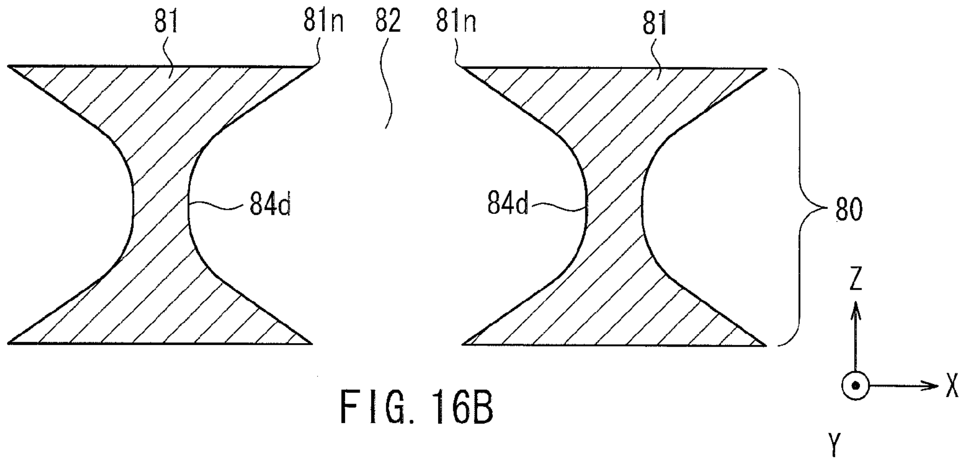


FIG. 16B

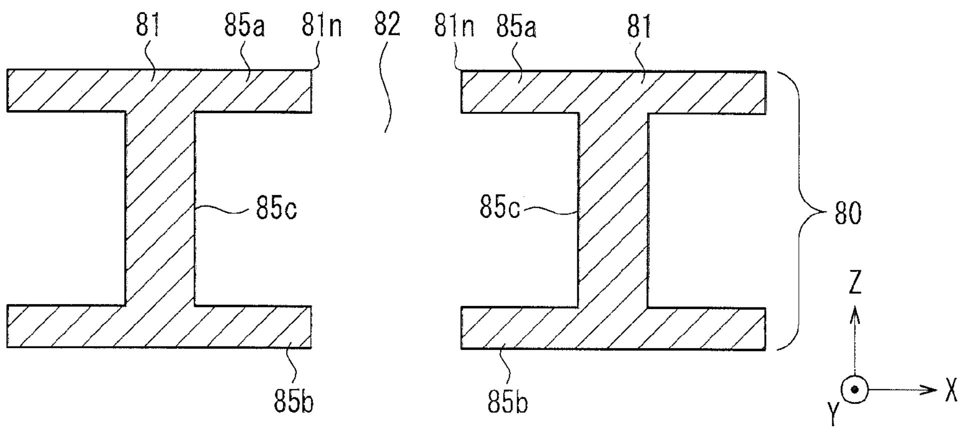


FIG. 16C

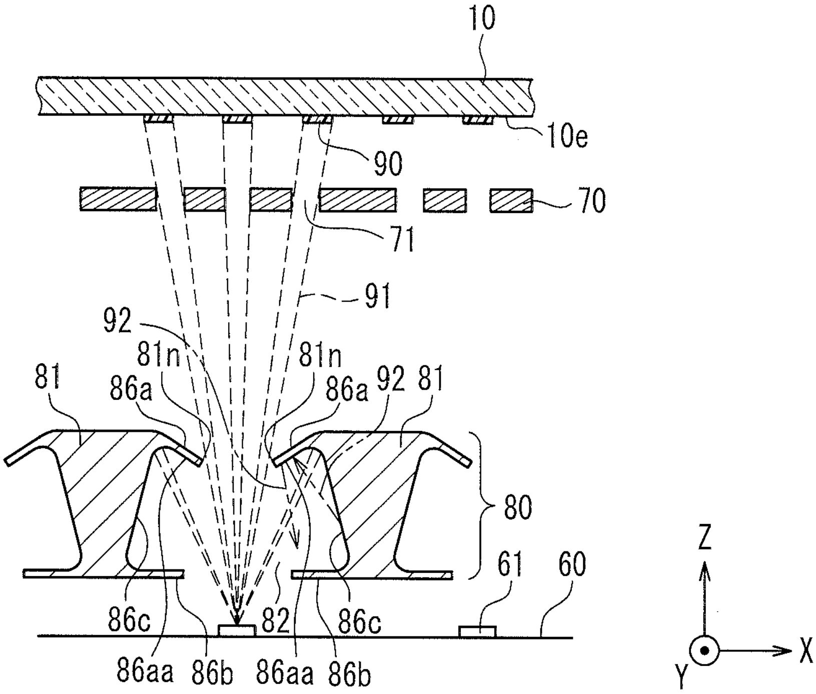

10
10e
90
70
71
91
92
81n
81n
81
86a
86a
92
81
80
Z
61
60
86c
82
86c
X
86aa
86b
86aa
86b
Y

FIG. 17

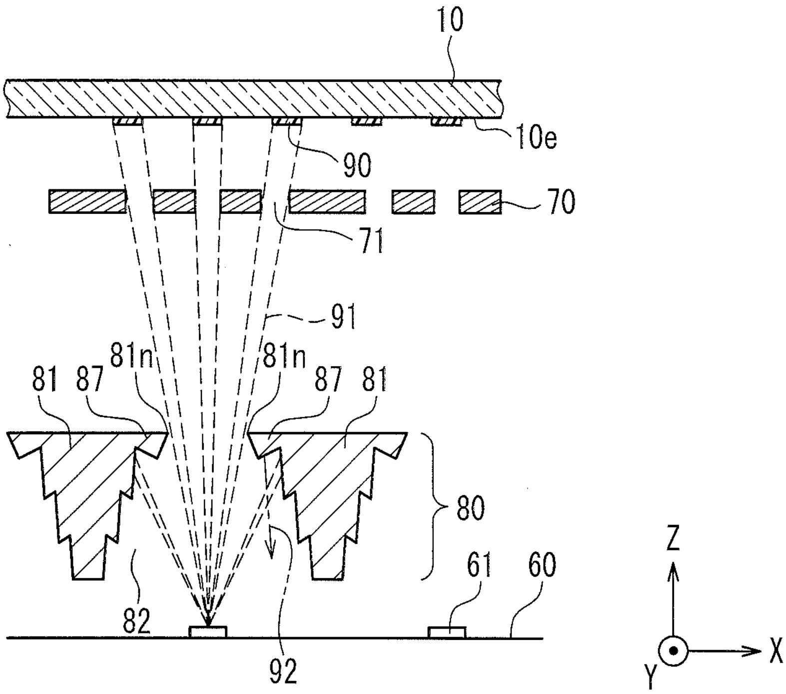


FIG. 18A

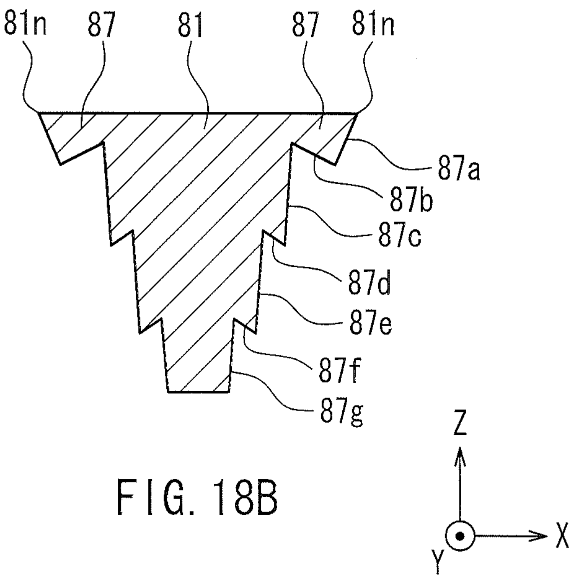


FIG. 18B

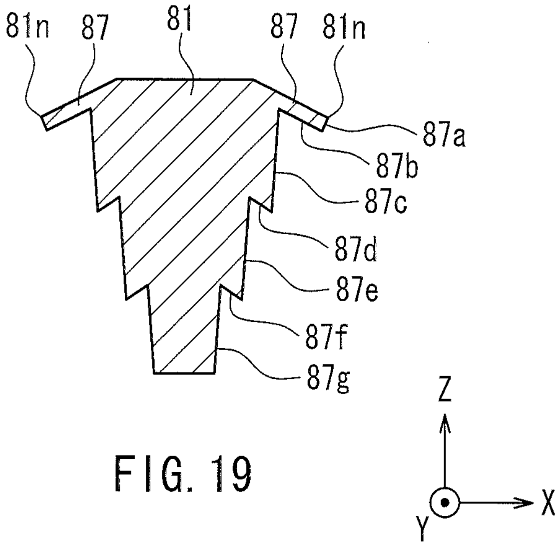


FIG. 19

VAPOR DEPOSITION DEVICE, VAPOR DEPOSITION METHOD AND ORGANIC EL DISPLAY DEVICE

TECHNICAL FIELD

[0001] The present invention relates to a vapor deposition device and a vapor deposition method for forming a coating film having a predetermined pattern on a substrate. The present invention also relates to an organic EL (Electro Luminescence) display device including a light emitting layer formed by vapor deposition.

BACKGROUND ART

[0002] In recent years, flat panel displays are used in various commodity products and fields, and thus flat panel displays are required to have a large size, high image quality and low power consumption.

[0003] Under the circumstances, organic EL display devices, which include an organic EL element that utilizes electro luminescence of an organic material, are attracting great attention as all-solid state flat panel displays that are excellent as having capability of low voltage operation, quick responsivity and light emission.

[0004] Active matrix type organic EL display devices, for example, are provided with a thin film-like organic EL element on a substrate having a TFT (thin film transistor). In the organic EL element, organic EL layers including a light emitting layer are laminated between a pair of electrodes. The TFT is connected to one of the pair of electrodes. Then, voltage is applied across the pair of electrodes so as to cause the light emitting layer to emit light, whereby an image is displayed.

[0005] In a full-color organic EL display device, generally, organic EL elements including light emitting layers of respective colors of red (R), green (G) and blue (B) are formed and arranged on a substrate as sub-pixels. By causing these organic EL elements to selectively emit light at the desired brightness by using the TFT, a color image is displayed.

[0006] In order to manufacture an organic EL display device, it is necessary to form a light emitting layer made of organic light emitting materials that emit respective colors in a predetermined pattern for each organic EL element.

[0007] Known methods for forming light emitting layers in a predetermined pattern are vacuum vapor deposition method, inkjet method and laser transfer method. For example, the vacuum vapor deposition method is often used for low molecular organic EL display devices (OLEDs).

[0008] In the vacuum vapor deposition method, a mask (also called a "shadow mask") having a predetermined pattern of openings is used. The deposition surface of a substrate having the mask closely fixed thereto is disposed so as to oppose a vapor deposition source. Then, vapor deposition particles (film forming material) from the vapor deposition source are deposited onto the deposition surface through the openings of the mask, whereby a predetermined pattern of a thin film is formed. Vapor deposition is performed for each color of the light emitting layer, which is referred to as "vapor deposition by color".

[0009] For example, Patent Documents 1 and 2 disclose a method for performing vapor deposition by color in which light emitting layers for respective colors are formed by sequentially moving a mask with respect to a substrate. With such a method, a mask having a size equal to that of a substrate is used, and the mask is fixed so as to cover the deposition surface of the substrate at the time of vapor deposition.

[0010] With conventional methods for performing vapor deposition by color as described above, as the substrate becomes larger, the mask needs to be large accordingly. However, when the mask is made large, a gap is likely to appear between the substrate and the mask by the mask being bent by its own weight or being extended. In addition, the size of the gap varies depending on the position of the deposition surface of the substrate. For this reason, it is difficult to perform highly accurate patterning, and it is therefore difficult to achieve high definition due to the occurrence of positional offset between the mask and the substrate during vapor deposition and the occurrence of color mixing.

[0011] Also, when the mask is made large, the mask as well as a frame or the like for holding the mask need to be gigantic, which increases the weight and makes handling thereof difficult. As a result, there is a possibility that productivity and safety might be compromised. Also, the vapor deposition device and devices that are used together therewith need to be made gigantic and complex as well, which makes device designing difficult and increases the installation cost.

[0012] For the reasons described above, the conventional methods for vapor deposition by color that are described in Patent Documents 1 and 2 are difficult to adapt to large-sized substrates, and it is difficult to perform vapor deposition by color on large-sized substrates such as those having a size exceeding 60 inches on a mass manufacturing level.

[0013] Patent Document 3 describes a vapor deposition method for causing vapor deposition particles discharged from a vapor deposition source to adhere to a substrate after causing the vapor deposition particles to pass through a mask opening of a vapor deposition mask while relatively moving the vapor deposition source and the vapor deposition mask with respect to the substrate. With this vapor deposition method, even in the case of large-sized substrates, it is not necessary to increase the size of the vapor deposition mask in accordance with the size of the substrates.

[0014] Patent Document 4 describes that a columnar-shaped or rectangle columnar-shaped vapor deposition beam direction adjustment plate having vapor deposition beam-pass-through holes formed therein whose diameter is approximately 0.1 mm to 1 mm is disposed between a vapor deposition source and a vapor deposition mask. By causing the vapor deposition particles discharged from the vapor deposition beam emission hole of the vapor deposition source to pass through the vapor deposition beam-pass-through holes formed in the vapor deposition beam direction adjustment plate, the directivity of vapor deposition beam can be increased.

CITATION LIST

Patent Document

[0015] Patent Document 1: JP H8-227276A
[0016] Patent Document 2: JP 2000-188179A
[0017] Patent Document 3: JP 2004-349101A
[0018] Patent Document 4: JP 2004-103269A

DISCLOSURE OF INVENTION

Problem to be Solved by the Invention

[0019] According to the vapor deposition method described in Patent Document 3, a vapor deposition mask smaller than the substrate can be used, and therefore vapor deposition can be easily performed on large-sized substrates.

[0020] However, because it is necessary to relatively move the vapor deposition mask with respect to the substrate, the substrate and the vapor deposition mask need to be spaced apart from each other. With Patent Document 3, vapor deposition particles that fly from various directions may enter the mask openings of the vapor deposition mask, and therefore the width of the coating film formed on the substrate is longer than the width of the mask opening, resulting blur at the edge of the coating film.

[0021] Patent Document 4 describes that the directivity of the vapor deposition beam entering the vapor deposition mask is improved by the vapor deposition beam direction adjustment plate.

[0022] However, in the actual vapor deposition step, the vapor deposition particles adhere to the inner circumferential surfaces of the vapor deposition beam-pass-through holes formed in the vapor deposition beam direction adjustment plate. Because the vapor deposition beam direction adjustment plate is disposed so as to oppose the vapor deposition source, it is heated by radiant heat from the vapor deposition source. Therefore, the vapor deposition particles that has adhered to the inner circumferential surfaces of the vapor deposition beam-pass-through holes are re-vaporized. A portion of the re-vaporized vapor deposition particles fly in a different direction from the penetration direction of the vapor deposition beam-pass-through holes, pass through the mask openings of the vapor deposition mask, and adhere to the substrate. In other words, even though the vapor deposition beam direction adjustment plate is provided in order to improve the directivity of the vapor deposition beam in Patent Document 4, it is difficult to control the directivity of the vapor deposition particles re-vaporized off the vapor deposition beam direction adjustment plate, as a result of which vapor deposition particles having undesired directivity adhere to the substrate. Therefore, if the substrate and the vapor deposition mask are spaced apart, the vapor deposition material adheres to an undesired portion of the substrate, and similarly to Patent Document 3 described above, blur occurs at the edge of the coating film formed on the substrate or an offset occurs in the formation position of the coating film.

[0023] It is an object of the present invention to provide a vapor deposition device and a vapor deposition method that are capable of forming a coating film in which edge blur is suppressed at a desired position on the substrate and that are applicable to large-sized substrates.

[0024] Also, it is an object of the present invention to provide a large-sized organic EL display device that has excellent reliability and display quality.

Means for Solving Problem

[0025] The vapor deposition device of the present invention is a vapor deposition device that forms a coating film having a predetermined pattern on a substrate, and the vapor deposition device includes a vapor deposition unit including a vapor deposition source having at least one vapor deposition source opening, a vapor deposition mask disposed between the at least one vapor deposition source opening and the substrate, and a limiting plate unit that is disposed between the vapor deposition source and the vapor deposition mask and that includes a plurality of limiting plates disposed along a first direction, and a moving mechanism that moves one of the substrate and the vapor deposition unit relative to the other along a second direction orthogonal to a normal line direction of the substrate and the first direction in a state in which the substrate and the vapor deposition mask are spaced apart at a fixed interval. The coating film is formed by causing vapor deposition particles that have been discharged from the at least one vapor deposition source opening and passed through a limiting space between the limiting plates neighboring in the first direction and a plurality of mask openings formed in the vapor deposition mask to adhere onto the substrate. Side surfaces of the limiting plates that define the limiting space in the first direction are configured such that a portion having a dimension in the first direction of the limiting space wider than a narrowest portion having a narrowest dimension in the first direction of the limiting space is formed on at least the vapor deposition source side with respect to the narrowest portion.

[0026] The vapor deposition method of the present invention is a vapor deposition method including a vapor deposition step of forming a coating film having a predetermined pattern on a substrate by causing vapor deposition particles to adhere onto the substrate, and the vapor deposition step is performed by using the above vapor deposition device of the present invention.

[0027] An organic EL display device according to the present invention includes a light emitting layer formed by using the above vapor deposition method of the present invention.

Effects of the Invention

[0028] According to the vapor deposition device and vapor deposition method of the present invention, the vapor deposition particles that have passed through the mask openings formed in the vapor deposition mask are caused to adhere to the substrate while one of the substrate and the vapor deposition unit is moved relative to the other, and therefore a vapor deposition mask that is smaller than the substrate can be used. It is therefore possible to form a coating film even on a large-sized substrate by vapor deposition.

[0029] The plurality of limiting plates provided between the vapor deposition source opening and the vapor deposition mask selectively capture the vapor deposition particles that have entered a limiting space between limiting plates neighboring in the first direction according to the incidence angle of the vapor deposition particles, and thus only the vapor deposition particles entering at a predetermined incidence angle or less enter the mask openings. As a result, the maximum incidence angle of the vapor deposition particles with respect to the substrate becomes small, and it is therefore possible to suppress blur that occurs at the edge of the coating film formed on the substrate.

[0030] Side surfaces of the limiting plates are configured such that a portion having a dimension in the first direction of the limiting space wider than a narrowest portion having a narrowest dimension in the first direction of the limiting space is formed on at least the vapor deposition source side with respect to the narrowest portion. Accordingly, most of the flight directions of the vapor deposition particles re-vaporized off the region of the side surfaces of the limiting plates on the vapor deposition source side with respect to the narrowest portion thereof can be caused to be pointed toward the opposite side to the substrate. Alternatively, it is possible to capture the vapor deposition particles re-vaporized off the region of the side surfaces of the limiting plates on the vapor deposition source side with respect to the narrowest portion thereof toward the substrate by causing the re-vaporized vapor deposition particles to collide with the side surfaces of the limiting plates before passing through the narrowest portion. Through these, the number of vapor deposition particles that are re-vaporized off the side surfaces of the limiting plates and adhere to the substrate can be reduced. As a result, a coating film in which edge blur is suppressed can be formed at a desired position on the substrate with high accuracy. Also, the need to frequently replace the limiting plate unit in order to reduce the amount of the vapor deposition material re-vaporized off the limiting plates is eliminated, and thus throughput at the time of mass production is improved, and productivity is improved.

[0031] The organic EL display device of the present invention includes a light emitting layer formed by using the vapor deposition method described above, and thus the positional offset of the light emitting layer and edge blur in the light emitting layer are suppressed. Accordingly, it is possible to provide an organic EL display device that has excellent reliability and display quality and that can be made in a large size.

BRIEF DESCRIPTION OF DRAWINGS

[0032] FIG. **1** is a cross-sectional view showing a schematic configuration of an organic EL display device.

[0033] FIG. **2** is a plan view showing a configuration of pixels that constitute the organic EL display device shown in FIG. **1**.

[0034] FIG. **3** is a cross-sectional view of a TFT substrate that constitutes the organic EL display device taken along the line **3-3** of FIG. **2**.

[0035] FIG. **4** is a flowchart illustrating the steps of a process for manufacturing an organic EL display device in order.

[0036] FIG. **5** is a perspective view showing the basic configuration of a vapor deposition device according to a new vapor deposition method.

[0037] FIG. **6** is a front cross-sectional view of the vapor deposition device shown in FIG. **5** as viewed in a direction parallel to the traveling direction of a substrate.

[0038] FIG. **7** is a front cross-sectional view of the vapor deposition device shown in FIG. **5** without a limiting plate unit.

[0039] FIG. **8** is a cross-sectional view illustrating the cause of blur generated at both edges of a coating film.

[0040] FIG. **9**A is an enlarged cross-sectional view showing how a coating film is formed on a substrate in the new vapor deposition method, and

[0041] FIG. **9**B is an enlarged cross-sectional view illustrating the cause of the problem encountered with the new vapor deposition method.

[0042] FIG. **10** is a perspective view showing the basic configuration of a vapor deposition device according to Embodiment 1 of the present invention.

[0043] FIG. **11** is a front cross-sectional view of the vapor deposition device shown in FIG. **10** as viewed in a direction parallel to the traveling direction of a substrate.

[0044] FIG. **12** is an enlarged cross-sectional view illustrating the function of the side surfaces of the limiting plates in a vapor deposition device according to Embodiment 1 of the present invention.

[0045] FIG. **13** is an enlarged cross-sectional view of the vapor deposition device according to Embodiment 1 of the present invention including limiting plates having another side surface shape.

[0046] FIG. **14** is an enlarged cross-sectional view of the limiting plates having still another side surface shape in the vapor deposition device according to Embodiment 1 of the present invention.

[0047] FIG. **15** is an enlarged cross-sectional view of a vapor deposition device according to Embodiment 2 of the present invention, as viewed in a direction parallel to the traveling direction of a substrate.

[0048] FIGS. **16**A to **16**C are enlarged cross-sectional views of the limiting plates having another side surface shape in the vapor deposition device according to Embodiment 2 of the present invention.

[0049] FIG. **17** is an enlarged cross-sectional view of a vapor deposition device according to Embodiment 3 of the present invention, as viewed in a direction parallel to the traveling direction of a substrate.

[0050] FIG. **18**A is an enlarged cross-sectional view of a vapor deposition device according to Embodiment 3 of the present invention, as viewed in a direction parallel to the traveling direction of a substrate, and

[0051] FIG. **18**B is an enlarged cross-sectional view of the limiting plate shown in FIG. **18**A.

[0052] FIG. **19** is an enlarged cross-sectional view of another limiting plate to be used in the vapor deposition device according to Embodiment 3 of the present invention.

DESCRIPTION OF THE INVENTION

[0053] The vapor deposition device of the present invention is a vapor deposition device that forms a coating film having a predetermined pattern on a substrate, and the vapor deposition device includes a vapor deposition unit including a vapor deposition source having at least one vapor deposition source opening, a vapor deposition mask disposed between the at least one vapor deposition source opening and the substrate, and a limiting plate unit that is disposed between the vapor deposition source and the vapor deposition mask and that includes a plurality of limiting plates disposed along a first direction, and a moving mechanism that moves one of the substrate and the vapor deposition unit relative to the other along a second direction orthogonal to a normal line direction of the substrate and the first direction in a state in which the substrate and the vapor deposition mask are spaced apart at a fixed interval. The coating film is formed by causing vapor deposition particles that have been discharged from the at least one vapor deposition source opening and passed through a limiting space between the limiting plates neighboring in the first direction and a plurality of mask openings formed in the vapor deposition mask to adhere onto the substrate. Side surfaces of the limiting plates that define the limiting space in the first direction are configured such that a portion having a dimension in the first direction of the limiting space wider than a narrowest portion having a narrowest dimension in the first direction of the limiting space is formed on at least the vapor deposition source side with respect to the narrowest portion.

[0054] It is preferable that in the above-described vapor deposition device of the present invention, the side surfaces of the limiting plates opposing in the first direction across the limiting space are in plane symmetry relationship. Accordingly, it is possible to simplify the design of the flight paths of the vapor deposition particles that are discharged from the vapor deposition source openings and adhere to the substrate to form the coating film.

[0055] It is preferable that the narrowest portion is provided at edges of the side surfaces of the limiting plates on the vapor deposition mask side. Accordingly, the number of vapor deposition particles that are re-vaporized off the side surfaces of the limiting plates and adhere to the substrate can be further reduced.

[0056] It is preferable that the side surface of each of the limiting plates has, on the vapor deposition source side with respect to the narrowest portion, a surface that is inclined such that the dimension in the first direction of the limiting space increases as the distance from the narrowest portion increases along the normal line direction of the substrate. Accordingly, the flight directions of the vapor deposition particles re-vaporized off the surface inclined in this manner can be caused to be pointed toward the side opposite to the substrate. Accordingly, the number of vapor deposition particles that are re-vaporized off the side surfaces of the limiting plates and adhere to the substrate can be further reduced.

[0057] It is preferable that a recess is formed in a region of the side surface of each of the limiting plates, the region being located on the vapor deposition source side with respect to the narrowest portion. Accordingly, the flight directions of the vapor deposition particles re-vaporized off the region on the vapor deposition mask side with respect to the deepest portion of the recess can be caused to be pointed toward the side opposite to the substrate. Also, the region on the vapor deposition mask side with respect to the deepest portion of the recess is capable of capturing the vapor deposition particles re-vaporized off the region on the vapor deposition source side by causing the re-vaporized vapor deposition particles to collide therewith. Accordingly, the number of vapor deposition particles that are re-vaporized off the side surfaces of the limiting plates and adhere to the substrate can be further reduced. Also, the region on the vapor deposition source side with respect to the deepest portion of the recess is capable of receiving the vapor deposition material separated from the region on the vapor deposition mask side so as not to let the vapor deposition material fall on the vapor deposition source.

[0058] It is preferable that a first overhang protruding toward the limiting space is formed on the side surface of each of the limiting plates, and the narrowest portion is provided at tip ends of the first overhangs. Accordingly, the vapor deposition particles re-vaporized off the region on the vapor deposition source side with respect to the first overhang can be captured by causing the vapor deposition particles to collide with the first overhang. Therefore, the number of vapor deposition particles that are re-vaporized off the side surfaces of the limiting plates and adhere to the substrate can be further reduced. There is no particular limitation on the shape of the first overhang, and the shape can be set to an arbitrary shape such as a thin plate shape having a fixed thickness, a shape having a substantially wedge-shaped cross section in which the thickness is reduced toward the tip end thereof, and the like.

[0059] It is preferable that in the above-described vapor deposition device, the first overhang has, on the vapor deposition source side, a surface that is inclined such that the surface of the first overhang is closer to the vapor deposition source as the distance to the tip end decreases. Accordingly, it is possible to substantially completely prevent the vapor deposition particles re-vaporized off the surface of the first overhang on the vapor deposition source side from adhering to the substrate.

[0060] It is preferable that the first overhang has, at the tip end thereof, a surface that is inclined such that the dimension in the first direction of the limiting space increases as the distance to the vapor deposition source decreases. Accordingly, the flight directions of the vapor deposition particles re-vaporized off the distal surface of the first overhang can be caused to be pointed toward the side opposite to the substrate. Therefore, the number of vapor deposition particles that are re-vaporized off the side surfaces of the limiting plates and adhere to the substrate can be further reduced.

[0061] It is preferable that a second overhang protruding toward the limiting space is formed on the side surface of each of the limiting plates at a position on the vapor deposition source side with respect to the narrowest portion. Accordingly, because the vapor deposition material separated from the region of the side surface of the limiting plate on the vapor deposition mask side with respect to the second overhang can be received by the second overhang, it is possible to prevent the separated vapor deposition material from falling on the vapor deposition source. There is also no particular limitation on the shape of the second overhang, and the shape can be set to an arbitrary shape such as a thin plate shape having a fixed thickness, a shape having a substantially wedge-shaped cross section in which the thickness is reduced toward the tip end thereof, and the like.

[0062] It is preferable that each of the side surfaces of the limiting plates has a plurality of steps in a stepwise arrangement. Accordingly, the number of vapor deposition particles that are re-vaporized off the side surfaces of the limiting plates and adhere to the substrate can be further reduced.

[0063] It is preferable that side surfaces of the limiting plate unit that define the limiting space in the second direction are configured such that a portion having a dimension in the second direction of the limiting space wider than a second narrowest portion having a narrowest dimension in the second direction of the limiting space is formed on at least the vapor deposition source side with respect to the second narrowest portion. Accordingly, the number of vapor deposition particles that are re-vaporized off the side surfaces of the limiting plate unit and adhere to the substrate. can be reduced

[0064] It is preferable that the various preferred configurations to be applied to the side surfaces of the limiting plates can also be applied to the side surfaces of the limiting plate unit.

[0065] Hereinafter, the present invention will be described in detail by showing preferred embodiments. It should be noted, however, that the present invention is not limited to the following embodiments. For the sake of convenience of the description, the drawings referred to hereinafter show only the principal members required to describe the present invention in simplified form among the constituent members of the embodiments of the present invention. Accordingly, the present invention may include optional constituent members that are not shown in the following drawings. Also, the dimensions of the members in the drawings do not faithfully represent the actual dimensions or dimensional proportions of the constituent members.

[0066] (Configuration of Organic EL Display Device)

[0067] An example of an organic EL display device that can be manufactured by applying the present invention will be described. This organic EL display device is a bottom emission type organic EL display device in which light is extracted from the TFT substrate side and that displays full color images by controlling light emission of red (R), green (G) and blue (B) pixels (sub-pixels).

[0068] First, the overall configuration of the organic EL display device will be described below.

[0069] FIG. **1** is a cross-sectional view showing a schematic configuration of the organic EL display device. FIG. **2** is a plan view showing a configuration of pixels that constitute the organic EL display device shown in FIG. **1**. FIG. **3** is a cross-sectional view of a TFT substrate that constitutes the organic EL display device, taken along the line III-III of FIG. **2**.

[0070] As shown in FIG. **1**, the organic EL display device **1** has a configuration in which, on a TFT substrate **10** provided with a TFT **12** (see FIG. **3**), an organic EL element **20** connected to the TFT **12**, an adhesive layer **30** and a sealing substrate **40** are provided in this order. A display region **19** in which images are displayed is located in the center of the organic EL display device **1**, and the organic EL element **20** is disposed within the display region **19**.

[0071] The organic EL element **20** is enclosed between a pair of substrates, namely, the TFT substrate **10** and the sealing substrate **40**, by the TFT substrate **10** having the organic EL element **20** laminated thereon being bonded to the sealing substrate **40** with the use of the adhesive layer **30**. By the organic EL element **20** being enclosed between the TFT substrate **10** and the sealing substrate **40** as described above, oxygen and moisture are prevented from entering the organic EL element **20** from the outside.

[0072] As shown in FIG. **3**, the TFT substrate **10** includes, as a support substrate, a transparent insulating substrate **11** such as a glass substrate, for example. In the case of a top emission type organic EL display device, however, the insulating substrate **11** is not necessarily transparent.

[0073] As shown in FIG. **2**, on the insulating substrate **11**, a plurality of wires **14** are provided that include a plurality of gate lines provided in the horizontal direction and a plurality of signal lines intersecting the gate lines and provided in the vertical direction. A gate line driving circuit (not shown) that drives the gate lines is connected to the gate lines, and a signal line driving circuit (not shown) that drives the signal lines are connected to the signal lines. On the insulating substrate **11**, red (R), green (G) and blue (B) sub-pixels **2**R, **2**G and **2**B made of the organic EL element **20** are disposed in a matrix in their respective regions surrounded by the wires **14**.

[0074] The sub-pixels **2**R emit red light, the sub-pixels **2**G emit green light, and the sub-pixels **2**B emit blue light. Sub-pixels of the same color are disposed in a column direction (up-down direction in FIG. **2**) and a repeating unit consisting of sub-pixels **2**R, **2**G and **2**B is repeatedly disposed in a row direction (right-left direction in FIG. **2**). The sub-pixels **2**R, **2**G and **2**B constituting a repeating unit in the row direction constitute a pixel **2** (specifically, a single pixel).

[0075] The sub-pixels **2**R, **2**G and **2**B respectively include light emitting layers **23**R, **23**G and **23**B that emit respective colors. The light emitting layers **23**R, **23**G and **23**B are provided to extend in stripes in the column direction (up-down direction in FIG. **2**).

[0076] A configuration of the TFT substrate **10** will be described.

[0077] As shown in FIG. **3**, the TFT substrate **10** includes, on the transparent insulating substrate **11** such as a glass substrate, the TFT **12** (switching element), the wires **14**, an inter-layer film **13** (interlayer insulating film, planarized film), an edge cover **15**, and so on.

[0078] The TFT **12** functions as a switching element that controls light emission of the sub-pixels **2**R, **2**G and **2**B, and is provided for each of the sub-pixels **2**R, **2**G and **2**B. The TFT **12** is connected to the wires **14**.

[0079] The inter-layer film **13** also functions as a planarized film, and is laminated over the display region **19** of the insulating substrate **11** so as to cover the TFT **12** and the wires **14**.

[0080] A first electrode **21** is formed on the inter-layer film **13**. The first electrode **21** is electrically connected to the TFT **12** via a contact hole **13***a* formed in the inter-layer film **13**.

[0081] The edge cover **15** is formed on the inter-layer film **13** so as to cover pattern ends of the first electrode **21**. The edge cover **15** is an insulating layer for preventing short-circuiting between the first electrode **21** and a second electrode **26** that constitute the organic EL element **20** caused by an organic EL layer **27** becoming thin or the occurrence of electric field concentration at the pattern ends of the first electrode **21**.

[0082] The edge cover **15** has openings **15**R, **15**G and **15**B for the sub-pixels **2**R, **2**G and **2**B. The openings **15**R, **15**G and **15**B of the edge cover **15** serve as light emitting regions of the sub-pixels **2**R, **2**G and **2**B. To rephrase, the sub-pixels **2**R, **2**G and **2**B are partitioned by the edge cover **15** that is insulative. The edge cover **15** also functions as an element separation film.

[0083] The organic EL element **20** will be described.

[0084] The organic EL element **20** is a light emitting element capable of emitting highly bright light by low voltage direct current driving, and includes the first electrode **21**, the organic EL layer **27** and the second electrode **26** in this order.

[0085] The first electrode **21** is a layer having a function of injecting (supplying) holes into the organic EL layer **27**. As described above, the first electrode **21** is connected to the TFT **12** via the contact hole **13***a*.

[0086] As shown in FIG. **3**, the organic EL layer **27** includes, between the first electrode **21** and the second electrode **26**, a hole injection and transport layer **22**, the light emitting layers **23**R, **23**G, **23**B, an electron transport layer **24** and an electron injection layer **25** in this order from the first electrode **21** side.

[0087] In the present embodiment, the first electrode **21** serves as a positive electrode and the second electrode **26** serves as a negative electrode, but the first electrode **21** may serve as a negative electrode and the second electrode **26** may serve as a positive electrode. In this case, the order of the layers constituting the organic EL layer **27** is reversed.

[0088] The hole injection and transport layer **22** functions both as a hole injection layer and a hole transport layer. The hole injection layer is a layer having a function of enhancing the efficiency of injecting holes into the organic EL layer **27**. The hole transport layer is a layer having a function of enhancing the efficiency of transporting holes to the light emitting layers **23**R, **23**G and **23**B. The hole injection and transport layer **22** is formed uniformly over the display region **19** in the TFT substrate **10** so as to cover the first electrode **21** and the edge cover **15**.

[0089] In the present embodiment, the hole injection and transport layer **22** in which a hole injection layer and a hole transport layer are integrated together is provided, but the present invention is not limited thereto, and the hole injection layer and the hole transport layer may be formed as independent layers.

[0090] On the hole injection and transport layer **22**, the light emitting layers **23**R, **23**G and **23**B are formed correspondingly to the columns of the sub-pixels **2**R, **2**G and **2**B so as to cover the openings **15**R, **15**G and **15**B of the edge cover **15**, respectively. The light emitting layers **23**R, **23**G and **23**B are layers having a function of emitting light by recombining holes injected from the first electrode **21** side and electrons injected from the second electrode **26** side. The light emitting layers **23**R, **23**G and **23**B each contain a material having a high light-emission efficiency such as a low-molecular fluorescent dye or a metal complex.

[0091] The electron transport layer **24** is a layer having a function of enhancing the efficiency of transporting electrons from the second electrode **26** to the light emitting layers **23**R, **23**G and **23**B.

[0092] The electron injection layer **25** is a layer having a function of enhancing the efficiency of injecting electrons from the second electrode **26** to the organic EL layer.

[0093] The electron transport layer **24** is formed uniformly over the display region **19** in the TFT substrate **10** such that it is on the light emitting layers **23**R, **23**G and **23**B and the hole injection and transport layer **22** so as to cover the light emitting layers **23**R, **23**G and **23**B and the hole injection and transport layer **22**. Likewise, the electron injection layer **25** is formed uniformly over the display region **19** in the TFT substrate **10** such that it is on the electron transport layer **24** so as to cover the electron transport layer **24**.

[0094] In the present embodiment, the electron transport layer **24** and the electron injection layer **25** are provided as independent layers, but the present invention is not limited thereto, and they may be provided as a single layer (specifically, an electron transport and injection layer) in which the electron transport layer **24** and the electron injection layer **25** are integrated together.

[0095] The second electrode **26** is a layer having a function of injecting electrons into the organic EL layer **27**. The second electrode **26** is formed uniformly over the display region **19** in the TFT substrate **10** such that it is on the electron injection layer **25** so as to cover the electron injection layer **25**.

[0096] An organic layer other than the light emitting layers **23**R, **23**G and **23**B is not essential to the organic EL layer **27**, and may be selected or omitted according to the characteristics required of the organic EL element **20**. The organic EL layer **27** may further include a carrier blocking layer if necessary. By adding a hole blocking layer serving as a carrier blocking layer between the electron transport layer **24** and the light emitting layer **23**R, **23**G, **23**B, for example, it is possible to prevent holes from escaping to the electron transport layer **24**, whereby light-emission efficiency can be improved.

[0097] (Manufacturing Method for Organic EL Display Device)

[0098] A method for manufacturing an organic EL display device **1** will be described below.

[0099] FIG. **4** is a flowchart illustrating the steps of a process for manufacturing the above-described organic EL display device **1** in order.

[0100] As shown in FIG. **4**, the method for manufacturing an organic EL display device **1** according to the present embodiment includes, for example, a TFT substrate/first electrode producing step S**1**, a hole injection layer/hole transport layer forming step S**2**, a light emitting layer forming step S**3**, an electron transport layer forming step S**4**, an electron injection layer forming step S**5**, a second electrode forming step S**6** and a sealing step S**7** in this order.

[0101] Each step of FIG. **4** will be described below. It should be noted, however, that the dimensions, materials and shapes of the constituent elements described below are merely examples, and the present invention is not limited thereto. Also, in the present embodiment, the first electrode **21** is used as a positive electrode and the second electrode **26** is used as a negative electrode, but in the case where the first electrode **21** is used as a negative electrode and the second electrode **26** is used as a positive electrode, the order of the layers laminated in the organic EL layer is reversed from that discussed below. Likewise, the materials for constituting the first electrode **21** and the second electrode **26** are also reversed from those discussed below.

[0102] First, a TFT **12**, wires **14** and the like are formed on an insulating substrate **11** by a known method. As the insulating substrate **11**, for example, a transparent glass substrate, plastic substrate or the like can be used. As an example, a rectangular glass plate having a thickness of about 1 mm and longitudinal and transverse dimensions of 500×400 mm can be used as the insulating substrate **11**.

[0103] Next, a photosensitive resin is applied onto the insulating substrate **11** so as to cover the TFT **12** and the wires **14**, and patterning is performed using a photolithography technique to form an inter-layer film **13**. As a material for the inter-layer film **13**, for example, an insulating material such as acrylic resin or polyimide resin can be used. Generally, polyimide resin is not transparent but colored. For this reason, when manufacturing a bottom emission type organic EL display device **1** as shown FIG. **3**, it is preferable to use a transparent resin such as acrylic resin for the inter-layer film **13**. There is no particular limitation on the thickness of the inter-layer film **13** as long as irregularities in the upper surface of the TFT **12** can be eliminated. As an example, an inter-layer film **13** having a thickness of about 2 μm can be formed by using acrylic resin.

[0104] Next, contact holes **13***a* for electrically connecting the first electrode **21** to the inter-layer film **13** are formed.

[0105] Next, a first electrode **21** is formed on the inter-layer film **13**. Specifically, a conductive film (electrode film) is formed on the inter-layer film **13**. Next, a photoresist is applied onto the conductive film and patterning is performed by using a photolithography technique, after which the conductive film is etched using ferric chloride as an etching solution. After that, the photoresist is stripped off using a resist stripping solution, and the substrate is washed. A first electrode **21** in a matrix is thereby obtained on the inter-layer film **13**.

[0106] Examples of conductive film-forming materials that can be used for the first electrode **21** include transparent conductive materials such as ITO (indium tin oxide), IZO (indium zinc oxide) and gallium-added zinc oxide (GZO); and metal materials such as gold (Au), nickel (Ni) and platinum (Pt).

[0107] As the method for laminating conductive films, it is possible to use a sputtering method, a vacuum vapor deposition method, a CVD (chemical vapor deposition) method, a plasma CVD method, a printing method or the like can be used.

[0108] As an example, a first electrode **21** having a thickness of about 100 nm can be formed by a sputtering method using ITO.

[0109] Next, an edge cover **15** having a predetermined pattern is formed. The edge cover **15** can be formed by, for example, patterning performed in the same manner as performed for the inter-layer film **13**, using the same insulating materials as those listed for the edge cover **15**. As an example, an edge cover **15** having a thickness of about 1 μm can be formed using acrylic resin.

[0110] Through the above processing, the TFT substrate **10** and the first electrode **21** are produced (Step S**1**).

[0111] Next, the TFT substrate **10** that has undergone step S**1** is baked under reduced pressure for the purpose of dehydration and then subjected to an oxygen plasma treatment in order to wash the surface of the first electrode **21**.

[0112] Next, on the TFT substrate **10**, a hole injection layer and a hole transport layer (in the present embodiment, a hole injection and transport layer **22**) is formed over the display region **19** in the TFT substrate **10** by a vapor deposition method (S**2**).

[0113] Specifically, an open mask having an opening corresponding to the entire display region **19** is closely fixed to the TFT substrate **10**. Materials for forming a hole injection layer and a hole transport layer are deposited over the display region **19** in the TFT substrate **10** through the opening of the open mask while the TFT substrate **10** and the open mask are rotated together.

[0114] As noted above, the hole injection layer and the hole transport layer may be integrated into a single layer, or may be independent layers. Each layer has a thickness of, for example, 10 to 100 nm.

[0115] Examples of materials for the hole injection layer and the hole transport layer include benzine, styryl amine, triphenyl amine, porphyrin, triazole, imidazole, oxadiazole, polyarylalkane, phenylene diamine, arylamine, oxazole, anthracene, fluorenone, hydrazone, stilbene, triphenylene, azatriphenylene and derivatives thereof, heterocyclic or linear conjugated monomers, oligomers or polymers, such as polysilane-based compounds, vinylcarbazole-based compounds, thiophene-based compounds, aniline-based compounds and the like.

[0116] As an example, a hole injection and transport layer **22** having a thickness of 30 nm can be formed using 4,4'-bis [N-(1-naphthyl)-N-phenylamino]biphenyl (α-NPD).

[0117] Next, on the hole injection and transport layer **22**, light emitting layers **23**R, **23**G and **23**B are formed in stripes so as to cover openings **15**R, **15**G and **15**B in the edge cover **15** (S3). The light emitting layers **23**R, **23**G and **23**B are deposited such that respective colors, namely, red, green and blue are applied to corresponding predetermined regions (vapor deposition by color).

[0118] As materials for the light emitting layers **23**R, **23**G and **23**B, materials having a high light-emission efficiency such as low-molecular fluorescent dyes or metal complexes can be used. Examples thereof include anthracene, naphthalene, indene, phenanthrene, pyrene, naphthacene, triphenylene, anthracene, perylene, picene, fluoranthene, acephenanthrylene, pentaphene, pentacene, coronene, butadiene, coumarin, acridine, stilbene and derivatives thereof, tris(8-quinolinolato)aluminum complex, bis(benzoquinolinato)beryllium complex, tri(dibenzoylmethyl)phenanthroline europium complex, ditolyl vinyl biphenyl and the like.

[0119] The light emitting layers **23**R, **23**G and **23**B can have a thickness of, for example, 10 to 100 nm.

[0120] The vapor deposition method and the deposition device of the present invention can be used particularly suitably in vapor deposition by color for forming light emitting layers **23**R, **23**G and **23**B. The method for forming light emitting layers **23**R, **23**G and **23**B using the present invention will be described later in detail.

[0121] Next, an electron transport layer **24** is formed over the display region **19** in the TFT substrate **10** so as to cover the hole injection and transport layer **22** and the light emitting layers **23**R, **23**G and **23**B by a vapor deposition method (S**4**). The electron transport layer **24** can be formed in the same manner as in the hole injection layer/hole transport layer forming step (S2) described above.

[0122] Next, an electron injection layer **25** is formed over the display region **19** in the TFT substrate **10** so as to cover the electron transport layer **24** by a vapor deposition method (S**5**). The electron injection layer **25** can be formed in the same manner as in the hole injection layer/hole transport layer forming step (S2) described above.

[0123] Examples of materials for the electron transport layer **24** and the electron injection layer **25** include quinoline, perylene, phenanthroline, bisstyryl, pyrazine, triazole, oxazole, oxadiazole, fluorenone, and derivatives and metal complexes thereof, LiF (lithium fluoride) and the like.

[0124] As noted above, the electron transport layer **24** and the electron injection layer **25** may be formed as a single layer in which these layers are integrated together, or may be formed as independent layers. Each layer has a thickness of, for example, 1 to 100 nm. The total thickness of the electron transport layer **24** and the electron injection layer **25** is, for example, 20 to 200 nm.

[0125] As an example, an electron transport layer **24** having a thickness of 30 nm can be formed using Alq (tris(8-hydroxyquinoline)aluminum), and an electron injection layer **25** having a thickness of 1 nm can be formed using LiF (lithium fluoride).

[0126] Next, a second electrode **26** is formed over the display region **19** in the TFT substrate **10** so as to cover the electron injection layer **25** by a vapor deposition method (S**6**). The second electrode **26** can be formed in the same manner as in the hole injection layer/hole transport layer forming step (S2) described above. The material (electrode material) for the second electrode **26** is preferably a metal having a small work function, or the like. Examples of such electrode materials include magnesium alloy (MgAg and the like), aluminum alloy (AlLi, AlCa, AlMg and the like), metal calcium, and the like. The second electrode **26** has a thickness of, for example, 50 to 100 nm. As an example, a second electrode **26** having a thickness of 50 nm can be formed using aluminum.

[0127] On the second electrode **26**, a protective film may be formed so as to cover the second electrode **26**, in order to prevent oxygen and moisture from entering the organic EL element **20** from the outside. As the material for the protective film, an insulating or conductive material can be used. Examples thereof include silicon nitride and silicon oxide. The protective film has a thickness of, for example, 100 to 1000 nm.

[0128] Through the above processing, the organic EL element **20** including the first electrode **21**, the organic EL layer **27** and the second electrode **26** can be formed on the TFT substrate **10**.

[0129] Next, as shown in FIG. **1**, the TFT substrate **10** having the organic EL element **20** formed thereon is bonded to a sealing substrate **40** by using an adhesive layer **30** so as to enclose the organic EL element **20**. As the sealing substrate **40**, for example, an insulating substrate, such as a glass substrate or a plastic substrate, having a thickness of 0.4 to 1.1 mm can be used.

[0130] In this manner, an organic EL display device **1** is obtained.

[0131] In the organic EL display device **1**, when the TFT **12** is turned on by input of signals from the wires **14**, holes are injected from the first electrode **21** into the organic EL layer **27**. On the other hand, electrons are injected from the second electrode **26** into the organic EL layer **27**. The holes and the electrons are recombined in the light emitting layers **23**R, **23**G and **23**B and emit predetermined color light when deactivating energy. By controlling emitting brightness of each of the sub-pixels 2R, 2G and 2B, a predetermined image can be displayed on the display region **19**.

[0132] Hereinafter, S3, which is the step of forming light emitting layers **23**R, **23**G and **23**B by vapor deposition by color, will be described.

[0133] (New Vapor Deposition Method)

[0134] The present inventors investigated, as the method for forming light emitting layers **23**R, **23**G and **23**B by vapor deposition by color, a new vapor deposition method (hereinafter referred to as the "new vapor deposition method") in which vapor deposition is performed while a substrate is moved with respect to a vapor deposition source and a vapor deposition mask, instead of the vapor deposition method as disclosed in Patent Documents 1 and 2 in which a mask having the same size as a substrate is fixed to the substrate at the time of vapor deposition.

[0135] FIG. **5** is a perspective view showing the basic configuration of the vapor deposition device according to the new vapor deposition method. FIG. **6** is a front cross-sectional view of the vapor deposition device shown in FIG. **5**.

[0136] A vapor deposition source **960**, a vapor deposition mask **970**, and a limiting plate unit **980** disposed therebetween constitute a vapor deposition unit **950**. The relative positions of the vapor deposition source **960**, the limiting plate unit **980**, and the vapor deposition mask **970** are constant. The substrate **10** moves along an arrow **10***a* at a constant speed with respect to the vapor deposition mask **970** on the opposite side from the vapor deposition source **960**. For the sake of convenience of the description given below, an XYZ orthogonal coordinate system is set in which a horizontal axis parallel to the movement direction **10***a* of the substrate **10** is defined as the Y axis, a horizontal axis perpendicular to the Y axis is defined as the X axis, and a vertical axis perpendicular to the X axis and the Y axis is defined as the Z axis. The Z axis is parallel to the normal line direction of the deposition surface **10***e* of the substrate **10**.

[0137] A plurality of vapor deposition source openings **961** that discharge vapor deposition particles **91** are formed on the upper surface of the vapor deposition source **960**. The plurality of vapor deposition source openings **961** are arranged at a fixed pitch along a straight line parallel to the X axis.

[0138] The limiting plate unit **980** has a plurality of limiting plates **981**. The major surface (the surface having the largest area) of each of the limiting plates **981** is parallel to the YZ plane. The plurality of limiting plates **981** are arranged parallel to the direction in which the plurality of vapor deposition source openings **961** are arranged (that is, the X axis direction), at a fixed pitch. A space between limiting plates **981** neighboring in the X axis direction that penetrates the limiting plate unit **980** in the Z axis direction is referred to as a limiting space **982**.

[0139] A plurality of mask openings **971** are formed in the vapor deposition mask **970**. The plurality of mask openings **971** are arranged along the X axis direction.

[0140] The vapor deposition particles **91** discharged from the vapor deposition source openings **961** pass through the limiting spaces **982**, further pass through the mask openings **971**, and adhere to the substrate **10** to form a stripe-shaped coating film **90** parallel to the Y axis. Vapor deposition is repeatedly performed for each color of light emitting layers **23**R, **23**G and **23**B, whereby vapor deposition by color for forming light emitting layers **23**R, **23**G and **23**B can be performed.

[0141] According to this new vapor deposition method, a dimension Lm of the vapor deposition mask **970** in the movement direction **10***a* of the substrate **10** can be set irrespective of a dimension of the substrate **10** in the same direction. This enables the use of a vapor deposition mask **970** that is smaller than the substrate **10**. Accordingly, even if the substrate **10** is made large, the vapor deposition mask **970** does not need to be made large, and therefore the problem in that the vapor deposition mask **970** is bent by its own weight or being extended does not occur. Also, the vapor deposition mask **970** and a frame or the like for holding the vapor deposition mask **970** do not need to be made big and heavy. Accordingly, the problems encountered with the conventional vapor deposition methods disclosed in Patent Documents 1 and 2 are solved, and large-sized substrates can be subjected to vapor deposition by color.

[0142] Effects of the new vapor deposition method on the limiting plate unit **980** are now described.

[0143] FIG. **7** is a cross-sectional view showing the vapor deposition device according to the new vapor deposition method similar to FIG. **6** except that the limiting plate unit **980** is omitted.

[0144] As shown in FIG. **7**, the vapor deposition particles **91** from each vapor deposition source opening **961** are discharged with a certain spread (directivity). Specifically, in FIG. **7**, the number of vapor deposition particles **91** discharged from each vapor deposition source opening **961** is the greatest in a direction upward from the vapor deposition source opening **961** (the Z axis direction) and gradually decreases as the angle (departure angle) formed with respect to the straight upward direction increases. The vapor deposition particles **91** discharged from the vapor deposition source openings **961** travel straight in their discharged directions. In FIG. **7**, the flow of vapor deposition particles **91** discharged from the vapor deposition source openings **961** is conceptually indicated by arrows. The length of the arrows corresponds to the number of vapor deposition particles. Accordingly, each mask opening **971** mostly receives, but not necessarily limited thereto, the vapor deposition particles **91** discharged from the vapor deposition source opening **961** located directly below the mask opening **971** and also receives the vapor deposition particles **91** discharged from the vapor deposition source openings **961** located obliquely downward.

[0145] FIG. **8** is a cross-sectional view of a coating film **90** formed on a substrate **10** with vapor deposition particles **91** that have passed through a mask opening **971** in the vapor deposition device of FIG. **7**, as viewed in a plane perpendicular to the Y axis as in FIG. **7**. As described above, the vapor deposition particles **91** coming from various directions pass through the mask opening **971**. The number of vapor deposition particles **91** that reach a deposition surface **10***e* of the substrate **10** is the greatest in a region directly above the mask opening **971** and gradually decreases as the position gets farther away therefrom. Accordingly, as shown in FIG. **8**, on the deposition surface **10***e* of the substrate **10**, a coating film main portion **90***c* having a large and substantially constant thickness is formed in the region where the mask opening **971** is projected onto the substrate **10** from directly above, and blur portions **90***e* that are gradually thinner as the position gets farther away from the coating film main portion **90***c* are formed on both sides of the coating film main portion **90***c*. Then, the blur portions **90***e* cause blur at the edge of the coating film **90**.

[0146] In order to reduce the width We of the blur portion **90***e*, a space between the vapor deposition mask **970** and the substrate **10** needs only be reduced. However, because it is necessary to move the substrate **10** relative to the vapor deposition mask **970**, it is not possible to reduce the space between the vapor deposition mask **970** and the substrate **10** to zero.

[0147] If the blur portion **90***e* extends to the neighboring light emitting layer region having a different color due to an increase in the width We of the blur portion **90***e*, it causes "color mixing" or degradation of the characteristics of the organic EL element. In order to prevent the blur portion **90***e* from extending to the neighboring light emitting layer region having a different color, so as to not cause color mixing, it is necessary to reduce the opening width of pixels (the pixels referring to the sub-pixels **2**R, **2**G and **2**B shown in FIG. **2**) or to increase the pixel pitch so as to increase the non-light-emitting region. However, if the opening width of the pixels is reduced, the light-emitting region will be small, causing a reduction in brightness. If the current density is increased in order to obtain the required brightness, the organic EL element will have a short service life and easily be damaged, causing a reduction in reliability. If, on the other hand, the pixel pitch is increased, display of high definition images cannot be achieved, reducing the quality of display.

[0148] In contrast, with a new vapor deposition method, as shown in FIG. **6**, the limiting plate unit **980** is provided between the vapor deposition source **960** and the vapor deposition mask **970**.

[0149] FIG. **9**A is an enlarged cross-sectional view showing how the coating film **90** is formed on the substrate **10** in the new vapor deposition method. In the present example, one vapor deposition source opening **961** is disposed for one limiting space **982**, and the vapor deposition source opening **961** is disposed at the central position of a pair of the limiting plates **981** in the X axis direction. The representative flight paths of the vapor deposition particles **91** discharged from the vapor deposition source openings **961** are indicated by dashed lines. Among the vapor deposition particles **91** discharged from the vapor deposition source opening **961** with a certain spread (directivity), those passing through the limiting space **982** directly above the vapor deposition source opening **961** and then passing through the mask opening **971** adhere to the substrate **10** so as to form the coating film **90**. On the other hand, the vapor deposition particles **91** having a large speed vector component in the X axis direction collide with and adhere to side surfaces **983** of the limiting plates **981** that define the limiting space **982**, and therefore cannot pass through limiting spaces **982** and cannot reach the mask openings **971**. That is, the limiting plates **981** limit the incidence angle of the vapor deposition particles **91** entering the mask openings **971**. As used herein, "incidence angle" of the vapor deposition particles **91** with respect to a mask opening **971** is defined as the angle formed between the flight direction of the vapor deposition particles **91** entering the mask opening **971** and the Z axis on a projection onto the XZ plane.

[0150] As described above, the directivity of the vapor deposition particles **91** in the X axis direction can be improved by using the limiting plate unit **980** including the plurality of limiting plates **981**. Accordingly, the width We of the blur portion **90***e* can be reduced.

[0151] With the above-described conventional vapor deposition method described in Patent Document 3, a member corresponding to the limiting plate unit **980** of the new vapor deposition method is not used. Also, vapor deposition particles are discharged from a single slot-shaped opening of the vapor deposition source that extends along the direction orthogonal to the relative movement direction of the substrate. With this configuration, the incidence angle of the vapor deposition particles with respect to the mask opening becomes larger than that in the new vapor deposition method, and therefore detrimental blur occurs at the edge of the coating film.

[0152] As described above, according to the new vapor deposition method, the width We of the blur portion **90***e* at the edge of the coating film **90** to be formed on the substrate **10** can be reduced. Therefore, vapor deposition by color for forming light emitting layers **23**R, **23**G and **23**B using the new vapor deposition method can prevent color mixing from occurring. Accordingly, the pixel pitch can be reduced, and in this case, it is possible to provide an organic EL display device that is capable of displaying high definition images. Meanwhile, the light-emitting region may be enlarged without changing the pixel pitch, and in this case, it is possible to provide an organic EL display device that is capable of displaying high definition images. Also, because it is not necessary to increase the current density in order to increase the brightness, the organic EL element does not have a short service life and is not easily damaged, and a reduction in reliability can be prevented.

[0153] However, as a result of examinations, the present inventors found that the new vapor deposition method is problematic in that when the coating film **90** is formed on the substrate **10** actually using the new vapor deposition method, the width We of the blur portion **90***e* at the edge of the coating film **90** cannot be reduced as assumed. Also, the inventors found that there is a problem in that the vapor deposition material adheres to an undesired portion of the deposition surface **10***e* of the substrate **10**. Moreover, they found that these problems are caused by the vapor deposition material that has adhered to the side surfaces **983** of the limiting plate unit **980** being re-vaporized.

[0154] This will be described below.

[0155] FIG. **9**B is an enlarged cross-sectional view illustrating the cause of the above-described problems in the new vapor deposition method. As shown in FIG. **9**B, the limiting plate unit **980** is disposed in the vicinity of the vapor deposition source **960** that is kept at high temperature so as to oppose the vapor deposition source **960**, and thus is heated from receiving the radiant heat from the vapor deposition source **960**. Therefore, depending on the conditions such as the amount of the vapor deposition material adhering to the side surfaces **983** of the limiting plates **981**, the degree of vacuum in the periphery, and the like, the vapor deposition material that has adhered to the side surfaces **983** may be re-vaporized as vapor deposition particles. There are various flight directions of the re-vaporized vapor deposition particles, and a portion of the vapor deposition particles **92** pass through the mask openings **971** and adhere to an undesired position on the deposition surface **10***e* of the substrate **10**, as indicated by double-dot-dashed lines in FIG. **9**B. As a result, blur may occur at the edge of the coating film **90**, and an offset may occur in the formation position of the coating film.

[0156] In order to reduce the re-vaporization of the vapor deposition material off the limiting plates **981**, the limiting plate unit **980** need only be frequently replaced. However, this leads to an increase in the frequency of maintenance, a drop in the throughput at the time of mass production, and a drop in the productivity.

[0157] The problem of the new vapor deposition method is the same as the problem encountered with the vapor deposition device of Patent Document 4 described above, in terms of the principle of the occurrence.

[0158] The present inventors conducted an in-depth investigation to solve the above problems encountered with the new vapor deposition method and the present invention has been accomplished. Hereinafter, the present invention will be described using preferred embodiments.

Embodiment 1

[0159] FIG. **10** is a perspective view showing the basic configuration of a vapor deposition device according to Embodiment 1 of the present invention. FIG. **11** is a front cross-sectional view of the vapor deposition device shown in FIG. **10**.

[0160] A vapor deposition source **60**, a vapor deposition mask **70**, and a limiting plate unit **80** disposed therebetween constitute a vapor deposition unit **50**. The substrate **10** moves along an arrow **10***a* at a constant speed with respect to the vapor deposition mask **70** on the opposite side from the vapor deposition source **60**. For the sake of convenience of the description given below, an XYZ orthogonal coordinate system is set in which a horizontal axis parallel to the movement direction **10***a* of the substrate **10** is defined as the Y axis, a horizontal axis perpendicular to the Y axis is defined as the X axis, and a vertical axis perpendicular to the X axis and the Y axis is defined as the Z axis. The Z axis is parallel to the normal line direction of the deposition surface **10***e* of the substrate **10**. To facilitate the description, the side to which the arrow indicating the Z axis points (the upper side of FIG. **11**) is referred to the "upper side".

[0161] The vapor deposition source **60** has a plurality of vapor deposition source openings **61** in its upper surface (the surface opposing the vapor deposition mask **70**). The plurality of vapor deposition source openings **61** are arranged at a fixed pitch along a straight line parallel to the X axis direction. Each vapor deposition source opening **61** has a nozzle shape that is upwardly open parallel to the Z axis and discharges vapor deposition particles **91**, which are a light emitting layer-forming material, toward the vapor deposition mask **70**.

[0162] The vapor deposition mask **70** is a plate-shaped piece that has a major surface (the surface having the largest area) parallel to the XY plane and in which a plurality of mask openings **71** are formed along the X axis direction at different positions in the X axis direction. The mask openings **71** are through holes that penetrate the vapor deposition mask **70** in the Z axis direction. In the present embodiment, each mask opening **71** has an opening shape having a slot shape that is parallel to the Y axis, but the present invention is not limited thereto. All of the mask openings **71** may have the same shape and dimensions, or may have different shapes and dimensions. The pitch in the X axis direction of the mask openings **71** may be constant or different.

[0163] It is preferable that vapor deposition mask **70** is held by a mask tension mechanism (not shown). The mask tension mechanism prevents the occurrence of bending or extension of the vapor deposition mask **70** due to its own weight, by applying tension to the vapor deposition mask **70** in a direction parallel to the major surface thereof.

[0164] The limiting plate unit **80** is disposed between the vapor deposition source openings **61** and the vapor deposition mask **70**. The limiting plate unit **80** includes a plurality of limiting plates **81** arranged at a constant pitch along the X axis direction. The space between the limiting plates **81** neighboring in the X axis direction is a limiting space **82** through which the vapor deposition particles **91** pass.

[0165] In the present embodiment, one vapor deposition source opening **61** is disposed at the center of limiting plates **81** neighboring in the X axis direction. Accordingly, one vapor deposition source opening **61** corresponds to one limiting space **82**. However, the present invention is not limited to this, and the plurality of limiting spaces **82** may be configured to correspond to one vapor deposition source opening **61**, or one limiting space **82** may be configured to correspond to the plurality of vapor deposition source openings **61**. In the present invention, "the limiting space **82** corresponding to the vapor deposition source opening **61**" refers to the limiting space **82** that is designed to allow the passage of the vapor deposition particles **91** discharged from the vapor deposition source opening **61**.

[0166] In FIGS. **10** and **11**, although the number of vapor deposition source openings **61** and the number of limiting spaces **82** are eight, the present invention is not limited to this and the number may be larger or smaller than this.

[0167] In the present embodiment, the limiting plate unit **80** is formed into a substantially rectangular parallelepiped object (or thick plate-like object) by forming through holes penetrating in the Z axis direction at a constant pitch in the X axis direction. Each through hole serves as the limiting space **82**, and each wall between neighboring through holes serves as the limiting plate **81**. However, the method for manufacturing the limiting plate unit **80** is not limited thereto. For example, the plurality of limiting plates **81** having the same dimension may be made separately and fixed to a holding body at a constant pitch by means of welding or the like.

[0168] A cooling device for cooling the limiting plates **81**, or a temperature adjustment device for maintaining the limiting plates **81** at a fixed temperature may be provided on the limiting plate unit **80**.

[0169] The vapor deposition source opening **61** and the plurality of limiting plates **81** are spaced apart from each other in the Z axis direction, and the plurality of limiting plates **81** and the vapor deposition mask **70** are spaced apart from each other in the Z axis direction. It is preferably that the relative position between the vapor deposition source **60**, the limiting plate unit **80**, and the vapor deposition mask **70** is substantially constant at least during vapor deposition by color.

[0170] The substrate **10** is held by a holding device **55**. As the holding device **55**, for example, an electrostatic chuck that holds the surface of the substrate **10** opposite to the deposition surface **10***e* of the substrate **10** with electrostatic force can be used. The substrate **10** can thereby be held substantially without the substrate **10** being bent by its own weight. However, the holding device **55** for holding the substrate **10** is not limited to an electrostatic chuck and may be any other device.

[0171] The substrate **10** held by the holding device **55** is scanned (moved) in the Y axis direction at a constant speed by a moving mechanism **56** with respect to the vapor deposition mask **70** on the opposite side from the vapor deposition source **60**, with the substrate **10** being spaced apart from the vapor deposition mask **70** at a fixed interval.

[0172] The vapor deposition unit **50**, the substrate **10**, the holding device **55** for holding the substrate **10** and the moving mechanism **56** for moving the substrate **10** are housed in a vacuum chamber (not shown). The vacuum chamber is a hermetically sealed container, with its internal space being vacuumed and maintained to a predetermined low pressure state.

[0173] The vapor deposition particles **91** discharged from the vapor deposition source openings **61** pass through a limiting space **82** of the limiting plate unit **80**, and a mask opening **71** of the vapor deposition mask **70** in this order. The deposition particles **91** adhere to the deposition surface (specifically, the surface of the substrate **10** opposing the vapor deposition mask **70**) **10***e* of the substrate **10** traveling in the Y axis direction to form a coating film **90**. The coating film **90** has a stripe shape extending in the Y axis direction.

[0174] The vapor deposition particles **91** that form the coating film **90** necessarily pass through the limiting space **82** and the mask opening **71**. The limiting plate unit **80** and the vapor deposition mask **70** are designed so as to prevent a situation in which the vapor deposition particles **91** discharged from a vapor deposition source opening **61** reach the deposition surface **10***e* of the substrate **10** without passing through the limiting spaces **82** and the mask openings **71**, and if necessary, a shielding plate (not shown) or the like that prevents flight of the vapor deposition particles **91** may be installed.

[0175] By performing vapor deposition three times by changing the vapor deposition material **91** for each color, namely, red, green and blue (vapor deposition by color), stripe-shaped coating films **90** (specifically, light emitting layers **23**R, **23**G and **23**B) that correspond to the respective colors of red, green and blue can be formed on the deposition surface **10***e* of the substrate **10**.

[0176] As with the limiting plates **981** of the new vapor deposition method shown in FIGS. **5** and **6**, the limiting plates **81** limit the incidence angle of the vapor deposition particles **91** entering the mask openings **71** on a projection onto the XZ plane by causing the vapor deposition particles **91** having a large speed vector component in the X axis direction to collide with and adhere to the limiting plates **81**. As used herein, "incidence angle" of the vapor deposition particles **91** with respect to a mask opening **71** is defined as the angle formed between the flight direction of the vapor deposition particles **91** entering the mask opening **71** and the Z axis on a projection onto the XZ plane. As a result, the amount of the vapor deposition particles **91** that pass through a mask opening **71** at a large incidence angle is reduced. Accordingly, the width We of the blur portion **90***e* shown in FIG. **8** is reduced, and thus the occurrence of blur at both edges of the stripe-shaped coating film **90** can be suppressed significantly.

[0177] In order to limit the incidence angle at the vapor deposition particles **91** enter the mask opening **71**, the limiting plates **81** are used in the present embodiment. The dimension in the X axis direction of a limiting space **82** can be large, and the dimension in the Y axis direction can be set to substantially any value. Accordingly, the opening area of the limiting space **82** viewed from the vapor deposition source openings **61** is increased, and thus the amount of vapor deposition particles that adhere to the limiting plate unit **80** can be reduced, as a result of which the wasted vapor deposition material can be reduced. Also, clogging caused as a result of the vapor deposition material adhering to the limiting plates **81** is unlikely to occur, enabling continuous use for a long period of time and improving the mass productivity of the organic EL display device. Furthermore, because the opening area of the limiting plate **82** is large, the vapor deposition material that has adhered to the limiting plates **81** can be easily washed off, enabling simple maintenance and reducing the losses resulting from a stop of mass production, as a result of which the mass productivity can be further improved.

[0178] In the present embodiment, as shown in FIG. **11**, side surfaces (hereinafter also referred to simply as "limiting plate side surfaces") **83** of the limiting plates **81** that define limiting spaces **82** in the X axis direction are inclined such that the dimension in the X axis direction (or in other words, the interval between each pair of limiting plates **81** opposing in the X axis direction) of the limiting space **82** becomes smaller as the distance to the vapor deposition mask **70** decreases. That is, a narrowest portion **81***n* having the narrowest dimension in the X axis direction of the limiting space **82** is at the upper (on the vapor deposition mask **70** side) edges of the side surfaces **83**, and the dimension in the X axis direction of the limiting space **82** becomes wider as the distance from the narrowest portion **81***n* to the vapor deposition source **60** increases. A pair of side surfaces **83** opposing in the X axis direction across the limiting space **82** are in plane symmetry relationship.

[0179] FIG. **12** is an enlarged cross-sectional view of the vapor deposition device of Embodiment 1. The function of the side surfaces **83** of the limiting plates **81** will be described with reference to FIG. **12**.

[0180] As described with reference to FIG. **9**B, in the present embodiment as well, the limiting plate unit **980** receives radiant heat from the vapor deposition source **960** maintained at a high temperature and thus is heated. Accordingly, the vapor deposition material that has adhered to the side surfaces **83** may be re-vaporized as vapor deposition particles. The double-dot-dashed lines shown in FIG. **12** illustratively indicate the flight trajectories of re-vaporized vapor deposition particles **92**. The arrows at the tip end of the double-dot-dashed lines indicate the flight directions of the vapor deposition particles **92**. The vapor deposition particles **92** re-vaporized off the side surfaces **83** fly in various directions, but generally have a distribution in which the amount of vapor deposition particles flying in the normal line direction of the side surfaces **83** is the largest. In the present embodiment, the side surfaces **83** are inclined as shown in FIG. **12**, and thus the normal line direction of the side surfaces **83** points toward the vapor deposition source **60**, and not toward the substrate **10**. Accordingly, the number of vapor deposition particles traveling toward the substrate **10** among the re-vaporized vapor deposition particles is much smaller than that in FIG. **9**B in which the side surfaces **983** are substantially parallel to the Z axis direction. Thus, the number of vapor deposition particles that pass through the mask openings **71** and adhere to the deposition surface **10***e* of the substrate **10** is further reduced. As a result, it is possible to solve the problems encountered with Patent Document 4 and the new vapor deposition method, which was described with reference to FIG. **9**B, such as the vapor deposition material adhering to an undesired position on the substrate and causing a blur at the edge of the coating film, or causing an offset in the formation position of the coating film.

[0181] As described above, according to Embodiment 1, a coating film **90** in which the edge blur is suppressed can be formed at a desired position on the substrate **10** by performing pattern vapor deposition with high accuracy. As a result, in the organic EL display device, the need to increase the width of the non-light-emitting region between light-emitting regions so as to not cause color mixing is eliminated. Accordingly, it is possible to achieve display of high definition and high brightness images. In addition, the need to increase the current density in the light emitting layers in order to enhance brightness is also eliminated, and thus a long service life can be achieved and reliability can be improved.

[0182] Furthermore, the need to frequently replace the limiting plate unit **80** in order to reduce re-vaporization of vapor deposition material from the limiting plates **81** can be eliminated. Accordingly, the frequency of maintenance is reduced, throughput at the time of mass production is improved, and productivity is improved. Therefore, vapor deposition cost is reduced, and thus an inexpensive organic EL display device can be provided.

[0183] In Embodiment 1, there is no particular limitation on the angle of inclination of the side surfaces **83** with respect to the Z axis direction. The angle of inclination of the side surfaces **83** with respect to the Z axis direction is preferably large because the number of vapor deposition particles traveling toward the substrate **10** among the vapor deposition particles re-vaporized off the side surfaces **83** is reduced as the angle of inclination is increased (or in other words, as the normal line direction of the side surfaces **83** points more toward the vapor deposition source **60**).

[0184] In the example described above, each of the side surfaces **83** of the limiting plates **81** is a single inclined surface, but the present invention is not limited to this configuration. For example, as shown in FIG. **13**, it is also possible to provide first surfaces **83***a* inclined similarly to the side surfaces **83** shown in FIG. **12** on the vapor deposition mask **70** side in the Z axis direction, and provide second surfaces **83***b* that are substantially parallel to the Z axis direction on the vapor deposition source **60** side in the Z axis direction. In this case, the upper ends of the first surfaces **83***a* form the narrowest portion **81***n*. The first surfaces **83***a* are inclined similarly to the side surfaces **83** shown in FIG. **12**, and thus the number of vapor deposition particles re-vaporized off the first surfaces **83***a* toward the substrate **10** is very small. On the other hand, as with the vapor deposition particles **92** re-vaporized off the side surfaces **983** shown in FIG. 9B, the vapor deposition particles **92** that fly toward the substrate **10** may be re-vaporized off the second surfaces **83***b*, but it is highly likely that such vapor deposition particles **92** will collide with and be captured by the first surfaces **83***a* that are disposed closer to the substrate **10** than the second surfaces **83***b* are. Accordingly, as in the case of FIG. **12**, a coating film **90** in which the edge blur is suppressed can be formed at a desired position on the substrate **10**. Also, the frequency of replacement of the limiting plate unit **80** can be reduced, and thus throughput at the time of mass production can be improved and productivity can be improved.

[0185] In FIG. **13**, the second surfaces **83***b* do not need to be surfaces that are parallel to the Z axis, and may be inclined surfaces whose normal line points toward the substrate **10** or the vapor deposition source **60**. The side surface of each limiting plate **81** may be configured with more surfaces.

[0186] Furthermore, as shown in FIG. **14**, an overhang (or brim or flange) **85** projecting toward the limiting space **82** may be formed at an edge of the side surface of each limiting plate **81**, the edge being on the vapor deposition mask **70** side. In this case, the tip ends of the overhangs **85** form the narrowest portion **81***n*. The normal line direction of an undersurface (the surface opposing the vapor deposition source **60**) **85***aa* of the overhang **85** is substantially parallel to the Z axis, and thus there are almost no vapor deposition particles re-vaporized off the undersurface **85***aa* toward the substrate **10**. On the other hand, the vapor deposition particles re-vaporized off a surface **83***c* located below the overhang **85** (on the vapor deposition source **60** side) toward the substrate **10** will collide with and be captured by the undersurface **85***aa* of the overhang **85**. Accordingly, with the configuration of FIG. **14**, a coating film **90** in which the edge blur is further suppressed as compared with FIGS. **12** and **13** can be formed at a desired position on the substrate **10**. Also, the frequency of replacement of the limiting plate unit **80** can be further reduced, and thus throughput at the time of mass production can be improved and productivity can be improved.

[0187] In FIG. **14**, the surface **83***c* is a flat surface that is substantially parallel to the Z axis direction, but the configuration is not limited thereto, and the surface **83***c* may be a flat surface inclined with respect to the Z axis direction or may have any shape such as a curved surface. Also, in FIG. **14**, the overhangs **85** are thin plates having a substantially constant thickness, but the configuration is not limited thereto, and the overhangs **85** may have, for example, a substantially wedge-shaped cross section that becomes thinner toward the tip end thereof.

Embodiment 2

[0188] FIG. **15** is an enlarged cross-sectional view of a vapor deposition device according to Embodiment 2 of the present invention, as viewed in a direction parallel to the movement direction of the substrate **10**. In FIG. **15**, members that are the same as those shown in FIGS. **10** to **12** showing the vapor deposition device of Embodiment 1 are given the same reference numerals, and descriptions thereof are omitted here. Hereinafter, Embodiment 2 will be described, focusing on the difference from Embodiment 1.

[0189] Embodiment 2 is different from Embodiment 1 in the cross-sectional shape along the XZ plane of the limiting plates **81** of the limiting plate unit **80**.

[0190] Specifically, as shown in FIG. **15**, the side surfaces of the limiting plates **81** that define a limiting space **82** in the X axis direction each have two ends in the vertical direction (Z axis direction) protruding toward the limiting space **82**, and a region between the two ends is recessed. In FIG. **15**, the side surfaces of the limiting plates **81** each have, on the vapor deposition mask **70** side in the Z axis direction, a first surface **84***a* that is inclined similarly to the side surface **83** shown in FIG. **12**, and have, on the vapor deposition source **60** side in the Z axis direction, a second surface **84***b* that is inclined in a direction opposite to the inclination of the first surface **84***a*. The normal line direction of the first surface **84***a* points toward the vapor deposition source **60**, and the normal line direction of the second surface **84***b* points toward the substrate **10**. The upper ends of the first surfaces **84***a* form the narrowest portion **81***n*. The double-dot-dashed lines shown in FIG. **12** illustratively indicate the flight trajectories of re-vaporized vapor deposition particles **92**. The arrows at the tip end of the double-dot-dashed lines indicate the flight directions of the vapor deposition particles **92**.

[0191] According to Embodiment 2, even if the vapor deposition material that has adhered to the first surface **84***a* is re-vaporized, the first surface **84***a* is inclined in the same direction as the side surface **83** of Embodiment 1 shown in FIG. **12**, and thus as in the case described with reference to FIG. **12**, the number of vapor deposition particles traveling toward the substrate **10** among the re-vaporized vapor deposition particles **92** is very small.

[0192] In addition, according to Embodiment 2, as compared with the side surface **83** (see FIG. **12**) or the first surface **83***a* (see FIG. **13**) of Embodiment 1, the first surface **84***a* can be inclined more steeply so as to oppose the vapor deposition source **60**, without increasing the dimension in the Z axis direction of the limiting plates **81**. Accordingly, the number of vapor deposition particles **92** re-vaporized off the first surface **84***a* toward the substrate **10** can be further reduced as compared with Embodiment 1.

[0193] On the other hand, the second surface **84***b* is inclined so as to oppose the vapor deposition mask **70**, and thus usually the vapor deposition particles **91** are less likely to adhere to the second surface **84***b*, as compared with the second surface **83***b* shown in FIG. **13**. Accordingly, the amount of vapor deposition material re-vaporized off the second surface **84***b* is relatively smaller than that in Embodiment 1. However, the vapor deposition particles **91** discharged from a vapor deposition source opening **61** located far away from the second surface **84***b* may adhere to the second surface **84***b*, depending on the inclination of the second surface **84***b* or the relative position of the second surface **84***b* with respect to the vapor deposition source opening **61**. In this case, even if the vapor deposition material that has adhered to the second surface **84***b* is re-vaporized, it is highly likely that the re-vaporized vapor deposition particles **92** will collide with and be captured by the first surface **84***a* that is disposed closer to the substrate **10** than the second surface **84***b* is, as with the vapor deposition particles **92** re-vaporized off the second surface **83***b* shown in FIG. **13**.

[0194] Therefore, according to Embodiment 2, a coating film **90** in which the edge blur is further suppressed as compared with Embodiment 1 can be formed at a desired position on the substrate **10**. Also, the frequency of replacement of the limiting plate unit **80** can be further reduced, and thus throughput at the time of mass production can be improved and productivity can be improved.

[0195] Furthermore, according to Embodiment 2, the second surface **84***b* is formed below (on the vapor deposition source **60** side) the first surface **84***a*, and thus even if a large amount of vapor deposition material that has adhered to the first surface **84***a* separates and falls from the first surface **84***a*, the vapor deposition material will fall onto and be captured by the second surface **84***b*. As a result, the possibility that the vapor deposition material will fall onto the vapor deposition source **60** can be reduced. If the vapor deposition material separated from the limiting plates **81** falls onto the vapor deposition source **60** and is re-vaporized, the vapor deposition particles will adhere to an undesired position on the substrate **10**. Also, if the vapor deposition material separated from the limiting plates **81** falls onto the vapor deposition source openings **61**, the vapor deposition source openings **61** will be clogged. As a result, the coating film will not be formed at a desired position on the substrate **10**. According to Embodiment 2, the possibility of the occurrence of such a disadvantage can be reduced.

[0196] In the above example, the side surface of each limiting plate **81** is constituted by a first surface **84***a* and a second surface **84***b* that are inclined in opposite directions to each other, but the present invention is not limited to this configuration.

[0197] For example, as shown in FIG. **16**A, a third surface **84***c* that is substantially parallel to the Z axis direction may be provided between the first surface **84***a* and the second surface **84***b* that are inclined similarly to the first surface **84***a* and the second surface **84***b* shown in FIG. **15**. Although illustration is omitted, two or more surfaces that are inclined in different directions may be provided between the first surface **84***a* and the second surface **84***b*.

[0198] Alternatively, as shown in FIG. **16**B, the side surfaces of the limiting plates **81** each may be a concavely curved surface **84***d*. The curved surface **84***d* can be, for example, a part of a cylindrical surface or any concavely curved surface. Each of the side surfaces of the limiting plates **81** does not need to be a single curved surface **84***d* as shown in FIG. **16**B, and may be, for example, a combination of a plurality of curved surfaces whose curvature changes discontinuously or a combination of a curved surface and a flat surface.

[0199] Alternatively, as shown in FIG. **16**C, overhangs (or brims or flanges) **85***a* and **85***b* protruding toward the limiting space **82** may be formed at two edges in the vertical direction (Z axis direction) of the side surface of each limiting plate **81**. The tip ends of the first overhangs **85***a* located on the upper side (on the vapor deposition mask **70** side) form the narrowest portion **81***n*. As with the overhang **85** shown in FIG. **14**, the first overhang **85***a* captures the vapor deposition particles re-vaporized off a region below the first overhang **85***a* of the limiting plate **81** toward the substrate **10**. On the other hand, the second overhang **85***b* located on the lower side (on the vapor deposition source **60** side) prevents the vapor deposition particles from adhering to a connecting surface **85***c* between the first overhang **85***a* and the second overhang **85***b*. The upper surface of the second overhang **85***b* is substantially parallel to the XY plane. This is effective particularly to, even if the vapor deposition material accumulated on the undersurface of the first overhang **85***a* and the connecting surface **85***c* separates therefrom, receive the vapor deposition material and prevent the vapor deposition material from falling on the vapor deposition source **60** side. In FIG. **16**C, the connecting surface **85***c* is a flat surface that is substantially parallel to the Z axis direction, but the present invention is not limited to this configuration. For example, the connecting surface **85***c* may be a flat surface whose normal line is inclined toward the substrate **10** or the vapor deposition source **60**. Alternatively, the connecting surface **85***c* may be, instead of the flat surface **85***c*, an arbitrary curved surface (preferably a concavely curved surface).

Embodiment 3

[0200] FIG. **17** is an enlarged cross-sectional view of a vapor deposition device according to Embodiment 3 of the present invention, as viewed in a direction parallel to the movement direction of the substrate **10**. In FIG. **17**, members that are the same as those shown in FIGS. **10** to **12** showing the vapor deposition device of Embodiment 1 are given the same reference numerals, and descriptions thereof are omitted here. Hereinafter, Embodiment 3 will be described, focusing on the difference from Embodiments 1 and 2.

[0201] Embodiment 3 is different from Embodiments 1 and 2 in the cross-sectional shape along the XZ plane of the limiting plates **81** of the limiting plate unit **80**.

[0202] Specifically, as shown in FIG. **17**, overhangs (or brims or flanges) **86***a* and **86***b* protruding toward the limiting space **82** are formed at two edges in the vertical direction (Z axis direction) of the side surface of each limiting plate **81** defining the limiting space **82** in the X axis direction. The tip ends of the first overhangs **86***a* located on the upper side (on the vapor deposition mask **70** side) form the narrowest portion **81***n*. Unlike the overhang **85** shown in FIG. **14** and the first overhang **85***a* shown in FIG. **16**C, the first overhang **86***a* is inclined such that the first overhang **86***a* is closer to the vapor deposition source **60** as the distance to the tip end (the narrowest portion **81***n*) decreases. The first overhang **86***a* is a thin plate having a substantially uniform thickness, and therefore the undersurface (the surface opposing the vapor deposition source **60**) **86***aa* of the first overhang **86***a* is also inclined similarly to the first overhang **86***a*. That is, the normal line direction of the undersurface **86***aa* of the first overhang **86***a* points to the limiting plate **81** itself (more specifically, the connecting surface **86***c* between the first overhang **86***a* and the second overhang **86***b*). Accordingly, there are substantially no vapor deposition particles that are re-vaporized off the undersurface **86***aa* of the first overhang **86***a*, pass through a space between the first overhangs **86***a* of neighboring limiting plates **81** and travel toward the substrate **10**.

[0203] Also, the connecting surface **86***c* between the first overhang **86***a* and the second overhang **86***b* is inclined such that the dimension in the X axis direction of the limiting space **82** becomes larger as the distance to the vapor deposition source **60** decreases, as with the side surface **83** shown in FIG. **12**. Accordingly, the number of vapor deposition particles traveling toward the substrate **10** among the vapor deposition particles re-vaporized off the connecting surface **86***c* is very small. Even if vapor deposition particles **92** are re-vaporized off the connecting surface **86***c* toward the substrate **10**, the vapor deposition particles **92** will collide with and be captured by the undersurface **86***aa* of the first overhang **86***a*.

[0204] Accordingly, a coating film **90** in which the edge blur is further suppressed as compared with FIG. **16**C can be formed at a desired position on the substrate **10**. Also, the frequency of replacement of the limiting plate unit **80** can be further reduced, and thus throughput at the time of mass production can be improved and productivity can be improved.

[0205] As with the second overhang **85***b* shown in FIG. **16**C, the second overhang **86***b* on the lower side (on the vapor deposition source **60** side) prevents vapor deposition particles from adhering to the connecting surface **86***c*, as well as receiving the vapor deposition material separated from the undersurface **86***aa* of the first overhang **86***a* and the connecting surface **85***c* and preventing the vapor deposition material from falling onto the vapor deposition source **60**.

Embodiment 4

[0206] FIG. **18**A is an enlarged cross-sectional view of a vapor deposition device according to Embodiment 4 of the present invention, as viewed in a direction parallel to the movement direction of the substrate **10**. FIG. **18**B is an enlarged cross-sectional view of a limiting plate **81** shown in FIG. **18**A. In FIGS. **18**A and **18**B, members that are the same as those shown in FIGS. **10** to **12** showing the vapor deposition device of Embodiment 1 are given the same reference numerals, and descriptions thereof are omitted here. Hereinafter, Embodiment 4 will be described, focusing on the difference from Embodiments 1 to 3.

[0207] Embodiment 4 is different from Embodiments 1 to 3 in the cross-sectional shape along the XZ plane of the limiting plates **81** of the limiting plate unit **80**.

[0208] Specifically, as shown in FIGS. **18**A and **18**B, the side surface of each limiting plate **81** defining the limiting space **82** in the X axis direction has a plurality of steps in a substantially stepwise arrangement (substantially saw-like arrangement). The steps are formed by surfaces **87***a*, **87***b*, **87***c*, **87***d*, **87***e*, **87***f* and **87***g* that are disposed in order from the vapor deposition mask **70** toward the vapor deposition source **60**. An overhang (or brim or flange) **87** protruding toward the limiting space **82** is formed at an upper edge of the limiting plate **81**. The surface **87***a* constitutes a distal surface of the overhang **87**. The narrowest portion **81***n* is located at an upper end of the surface **87***a*.

[0209] The positions in the X axis direction of surfaces **87***a*, **87***c*, **87***e* and **87***g* are successively shifted so that the dimension in the X axis direction of the limiting space **82** is increased as the distance to the vapor deposition source **60** decreases. The surfaces **87***a*, **87***c*, **87***e* and **87***g* are successively connected by surfaces **87***b*, **87***d* and **87***f*. Accordingly, as viewed macroscopically, the side surface of the limiting plate **81** having a plurality of steps in a substantially stepwise arrangement is inclined such that the dimension in the X axis direction of the limiting space **82** becomes larger as the distance to the vapor deposition source **60** decreases.

[0210] The surfaces **87***a*, **87***c*, **87***e* and **87***g* are inclined such that the dimension in the X axis direction of the limiting space **82** is increased as the distance to the vapor deposition source **60** decreases, as with the side surface **83** shown in FIG. **12**. Accordingly, the number of vapor deposition particles traveling toward the substrate **10** among the vapor deposition particles re-vaporized off the surfaces **87***a*, **87***c*, **87***e* and **87***g* is very small. Even if vapor deposition particles are re-vaporized off the surfaces **87***c*, **87***e* and **87***g* toward the substrate **10**, the vapor deposition particles will collide with and be captured by the surfaces **87***b*, **87***d* and **87***f*.

[0211] Also, the surfaces **87***b*, **87***d* and **87***f* are inclined in the same direction as the undersurface **86***aa* of the first overhang **86***a* shown in FIG. **17**, and thus there are substantially no vapor deposition particles that are re-vaporized off the surfaces **87***b*, **87***d* and **87***f*, pass through a space between the overhangs **87** of neighboring limiting plates **81** and travel toward the substrate **10**.

[0212] Therefore, according to the present embodiment, a coating film **90** in which the edge blur is further suppressed can be formed at a desired position on the substrate **10**. Also, the frequency of replacement of the limiting plate unit **80** can be further reduced, and thus throughput at the time of mass production can be improved and productivity can be improved.

[0213] The direction of inclination of the surfaces **87***b*, **87***d* and **87***f* is not limited to that described above. For example, the surfaces **87***b*, **87***d* and **87***f* may be surfaces whose normal line direction is parallel to the Z axis.

[0214] The direction of inclination of the surfaces **87***a*, **87***c*, **87***e* and **87***g* is not limited to that described above, either. For example, the surfaces **87***a*, **87***c*, **87***e* and **87***g* may be surfaces parallel to the Z axis direction. However, in order to reduce the number of vapor deposition particles re-vaporized off the surface **87***a* toward the substrate **10**, the distal surface **87***a* of the overhang **87** is preferably inclined in the direction shown in FIGS. **18**A and **18**B.

[0215] The number of inclined surfaces that form the steps in a substantially stepwise arrangement of the side surface of the limiting plate **81** can be any number, and may be either greater or less than that shown in FIGS. **18**A and **18**B.

[0216] As shown in FIG. **19**, the overhang **87** may be formed by using a thin plate so that the upper surface of the overhang **87** is parallel to the surface **87***b*. This configuration can reduce the area of the distal surface **87***a* of the overhang **87**, as a result of which the vapor deposition particles re-vaporized off the surface **87***a* can be reduced. Accordingly, the number of vapor deposition particles re-vaporized toward the substrate **10** can be reduced as well. Alternatively, in order to further reduce the area of the distal surface **87***a* of the overhang **87**, the cross-sectional shape of the overhang **87** may be formed in a substantially wedge shape that becomes thinner toward the distal surface **87***a*.

[0217] In Embodiment 4, a second overhang similar to the second overhang **85***b* shown in FIG. **16**C or the second overhang **86***b* shown in FIG. **17** may be formed at the lower edges of the side surface of the limiting plate **81**. In this case, the same effects as those of the second overhangs **85***b* and **86***b* can be obtained.

[0218] Embodiments 1 to 4 described above are merely illustrative. The present invention is not limited to Embodiments 1 to 4 described above and can be modified as appropriate.

[0219] Embodiments 1 to 4 given above described the side surfaces of the limiting plates **81** defining the limiting spaces **82** in the X axis direction, but in addition to this, the side surfaces **89** (see FIG. **10**) of the limiting plate unit **80** that define the limiting spaces **82** in the Y axis direction may have the same configuration as the side surfaces of the limiting plates **81** described in Embodiments 1 to 4 given above. There is a possibility that the vapor deposition material that has adhered to the side surfaces **89** will also be re-vaporized. In this case, it is difficult to control the flight directions (the components thereof in the X axis direction in particular) of the re-vaporized vapor deposition particles. Accordingly, by configuring the side surfaces **89** in the same manner as the side surfaces of the limiting plates **81**, it is possible to suppress a situation in which the vapor deposition material adheres to an undesired position on the substrate due to the vapor deposition particles re-vaporized off the side surfaces **89**.

[0220] In Embodiments 1 to 4 described above, the vapor deposition source **60** has a plurality of the nozzle-shaped vapor deposition source openings **61** arranged at equal pitch in the X axis direction, but the shapes of the vapor deposition source openings are not limited to this in the present invention. For example, the vapor deposition source openings may have a slot shape extending in the X axis direction. In this case, a single slot-shaped vapor deposition source opening may be disposed so as to correspond to a plurality of the limiting spaces **82**.

[0221] If the substrate **10** has a large dimension in the X axis direction, a plurality of vapor deposition units **50** as shown in the above-described embodiments may be arranged at different positions in the X axis direction and in the Y axis direction.

[0222] In Embodiments 1 to 4 described above, the substrate **10** is moved relative to the vapor deposition unit **50** that is stationary, but the present invention is not limited thereto. It is sufficient that one of the vapor deposition unit **50** and the substrate **10** is moved relative to the other. For example, it may be possible to fix the position of the substrate **10** and move the vapor deposition unit **50**. Alternatively, both the vapor deposition unit **50** and the substrate **10** may be moved.

[0223] In Embodiments 1 to 4 described above, the substrate **10** is disposed above the vapor deposition unit **50**, but the relative positional relationship between the vapor deposition unit **50** and the substrate **10** is not limited thereto. It may be possible to, for example, dispose the substrate **10** below the vapor deposition unit **50** or dispose the vapor deposition unit **50** and the substrate **10** so as to oppose each other in the horizontal direction.

INDUSTRIAL APPLICABILITY

[0224] There is no particular limitation on the fields to which the vapor deposition device and vapor deposition method of the present invention can be applied, and the present invention is preferably used to form light emitting layers for use in organic EL display devices.

DESCRIPTION OF SYMBOLS

[0225] **10** Substrate
[0226] **10***e* Deposition Surface
[0227] **20** Organic EL Element
[0228] **23**R, **23**G, **23**B Light Emitting Layer
[0229] **50** Vapor Deposition Unit
[0230] **56** Moving Mechanism
[0231] **60** Vapor Deposition Source
[0232] **61** Vapor Deposition Source Opening
[0233] **70** Vapor Deposition Mask
[0234] **71** Mask Opening
[0235] **80** Limiting Plate Unit
[0236] **81** Limiting Plate
[0237] **81***n* Narrowest Portion of Limiting Space
[0238] **82** Limiting Space
[0239] **83** Side Surface
[0240] **83***a*,**84***a* First Surface
[0241] **83***b*,**84***b* Second Surface
[0242] **84***c* Third Surface
[0243] **84***d* Curved Surface
[0244] **83***c* Surface
[0245] **85**,**87** Overhang
[0246] **85***a*,**86***a* First Overhang
[0247] **85***b*,**86***b* Second Overhang
[0248] **85***c*,**86***c* Connecting Surface
[0249] **87***a*,**87***b*,**87***c*,**87***d*,**87***e*,**87***f*,**87***g* Surface
[0250] **89** Side Surface of Limiting Plate Unit
[0251] **91** Vapor Deposition Particles
[0252] **92** Re-Vaporized Vapor Deposition Particles

1. A vapor deposition device that forms a coating film having a predetermined pattern on a substrate, the vapor deposition device comprising:

a vapor deposition unit including a vapor deposition source having at least one vapor deposition source opening, a vapor deposition mask disposed between the at least one vapor deposition source opening and the substrate, and a limiting plate unit that is disposed between the vapor deposition source and the vapor deposition mask and that includes a plurality of limiting plates disposed along a first direction; and a moving mechanism that moves one of the substrate and the vapor deposition unit relative to the other along a second direction orthogonal to a normal line direction of the substrate and the first direction in a state in which the substrate and the vapor deposition mask are spaced apart at a fixed interval,

wherein the coating film is formed by causing vapor deposition particles that have been discharged from the at least one vapor deposition source opening and passed through a limiting space between the limiting plates neighboring in the first direction and a plurality of mask openings formed in the vapor deposition mask to adhere onto the substrate, and

side surfaces of the limiting plates that define the limiting space in the first direction are configured such that a portion having a dimension in the first direction of the limiting space wider than a narrowest portion having a narrowest dimension in the first direction of the limiting space is formed on at least the vapor deposition source side with respect to the narrowest portion.

2. The vapor deposition device according to claim **1**,

wherein the side surfaces of the limiting plates opposing in the first direction across the limiting space are in plane symmetry relationship.

3. The vapor deposition device according to claim **1**,

wherein the narrowest portion is provided at edges of the side surfaces of the limiting plates on the vapor deposition mask side.

4. The vapor deposition device according to claim **1**,

wherein the side surface of each of the limiting plates has, on the vapor deposition source side with respect to the narrowest portion, a surface that is inclined such that the dimension in the first direction of the limiting space increases as the distance from the narrowest portion increases along the normal line direction of the substrate.

5. The vapor deposition device according to claim **1**,

wherein a recess is formed in a region of the side surface of each of the limiting plates, the region being located on the vapor deposition source side with respect to the narrowest portion.

6. The vapor deposition device according to claim **1**,

wherein a first overhang protruding toward the limiting space is formed on the side surface of each of the limiting plates, and

the narrowest portion is provided at tip ends of the first overhangs.

7. The vapor deposition device according to claim **6**,

wherein the first overhang has, on the vapor deposition source side, a surface that is inclined such that the surface of the first overhang is closer to the vapor deposition source as the distance to the tip end decreases.

8. The vapor deposition device according to claim **6**,

wherein the first overhang has, at the tip end thereof, a surface that is inclined such that the dimension in the first direction of the limiting space increases as the distance to the vapor deposition source decreases.

9. The vapor deposition device according to claim **1**,

wherein a second overhang protruding toward the limiting space is formed on the side surface of each of the limiting plates at a position on the vapor deposition source side with respect to the narrowest portion.

10. The vapor deposition device according to claim **1**,

wherein each of the side surfaces of the limiting plates has a plurality of steps in a stepwise arrangement.

11. The vapor deposition device according to claim **1**,

wherein side surfaces of the limiting plate unit that define the limiting space in the second direction are configured such that a portion having a dimension in the second direction of the limiting space wider than a second narrowest portion having a narrowest dimension in the second direction of the limiting space is formed on at least the vapor deposition source side with respect to the second narrowest portion.

12. A vapor deposition method comprising a vapor deposition step of forming a coating film having a predetermined pattern on a substrate by causing vapor deposition particles to adhere onto the substrate,

wherein the vapor deposition step is performed by using the vapor deposition device according to claim **1**.

13. The vapor deposition method according to claim **12**,

wherein the coating film is a light emitting layer for an organic EL element.

14. An organic EL display device comprising a light emitting layer formed by using the vapor deposition method according to claim **12**.

* * * * *

专利名称(译)	蒸气沉积装置，蒸气沉积方法和有机EL显示装置		
公开(公告)号	US20130240870A1	公开(公告)日	2013-09-19
申请号	US13/989757	申请日	2011-12-13
[标]申请(专利权)人(译)	川户SHINICHI 井上聪 园田彻		
申请(专利权)人(译)	川户，SHINICHI 井上聪 园田，彻		
当前申请(专利权)人(译)	夏普株式会社		
[标]发明人	KAWATO SHINICHI INOUE SATOSHI SONODA TOHRU		
发明人	KAWATO, SHINICHI INOUE, SATOSHI SONODA, TOHRU		
IPC分类号	H01L51/56 H01L51/50		
CPC分类号	C23C14/042 C23C14/12 H01L51/50 H01L51/0011 H01L51/56 C23C14/243 C23F1/02 H01L27/3251 H01L27/3274 H01L51/001		
优先权	2010284940 2010-12-21 JP		
外部链接	Espacenet USPTO		

摘要(译)

气相沉积源（60），限制板单元（80）和气相沉积掩模（70）按此顺序设置。限制板单元包括沿第一方向设置的多个限制板（81）。限定板在第一方向上限定限制空间（82）的侧表面构造成使得在第一方向上相邻的限制板之间的限制空间的第一方向上的尺寸比最窄部分宽的部分（在极限空间的第一方向上具有最窄尺寸的81n）至少在气相沉积源侧相对于最窄部分形成。因此，可以在大尺寸基板上的期望位置处形成抑制边缘模糊的涂膜。