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(54) ORGANIC LIGHT-EMITTING PANEL, MANUFACTURING METHOD THEREOF, AND ORGANIC DISPLAY DEVICE

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H01L 51/56	(2006.01)

(52) **U.S. Cl.** **257/89**; 438/35; 257/E51.022

(57) ABSTRACT

A pixel in the panel includes sub-pixels **100***a*, **100***b*, and **100***c*. Non-light-emitting cells **100***d* and **100***e* are provided between the pixel and adjacent pixels on both sides thereof, respectively. The organic light-emitting layer of sub-pixel **100***a* and non-light-emitting cell **100***d* are separated by bank **105***a*. Similarly, the organic light-emitting layer of sub-pixel **100***c* and non-light-emitting cell **100***e* are separated by bank **105***d*; the organic light-emitting layers of sub-pixels **100***a* and **100***b* are separated by bank **105***b*; and the organic light-emitting layers of sub-pixels **100***b* and **100***c* are separated by bank **105***c*. Inclination angle θaa of sidewall **105***aa* of bank **105***a* adjacent to sib-pixel **100***a* and inclination angle θdc of sidewall **105***dc* of bank **105***d* adjacent to sib-pixel **100***c* are larger than other inclination angles θba, θbb, θcb, and θcc.

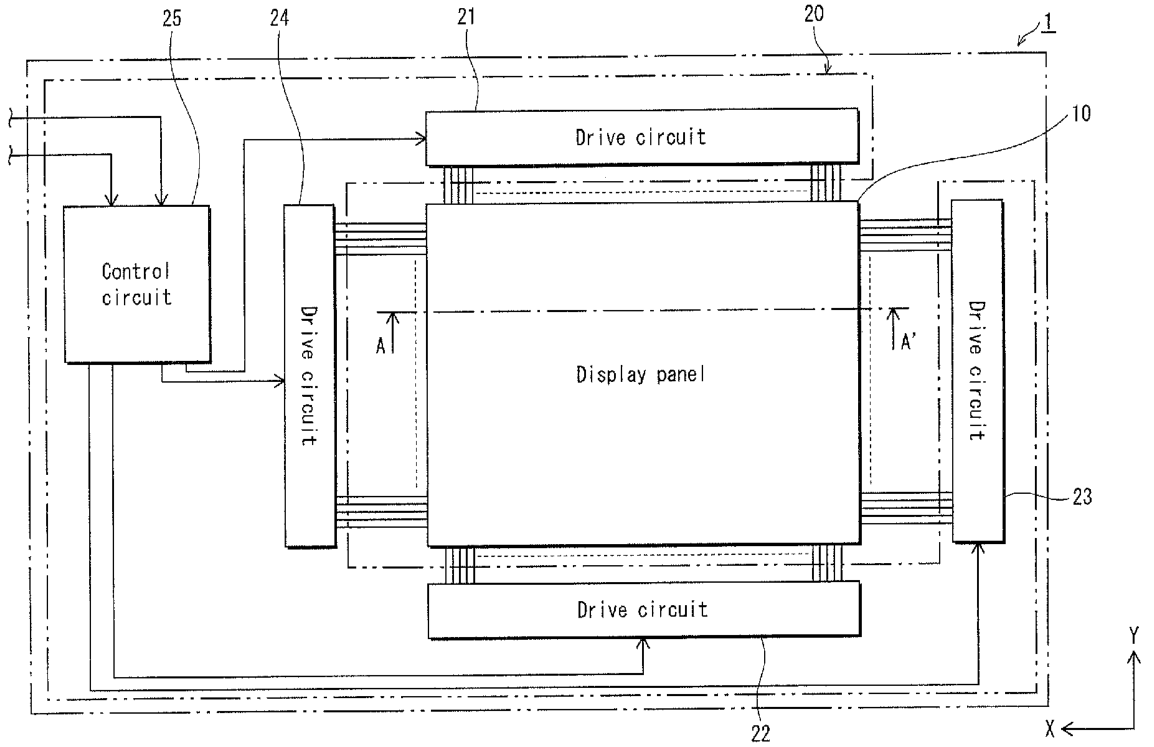


FIG. 1

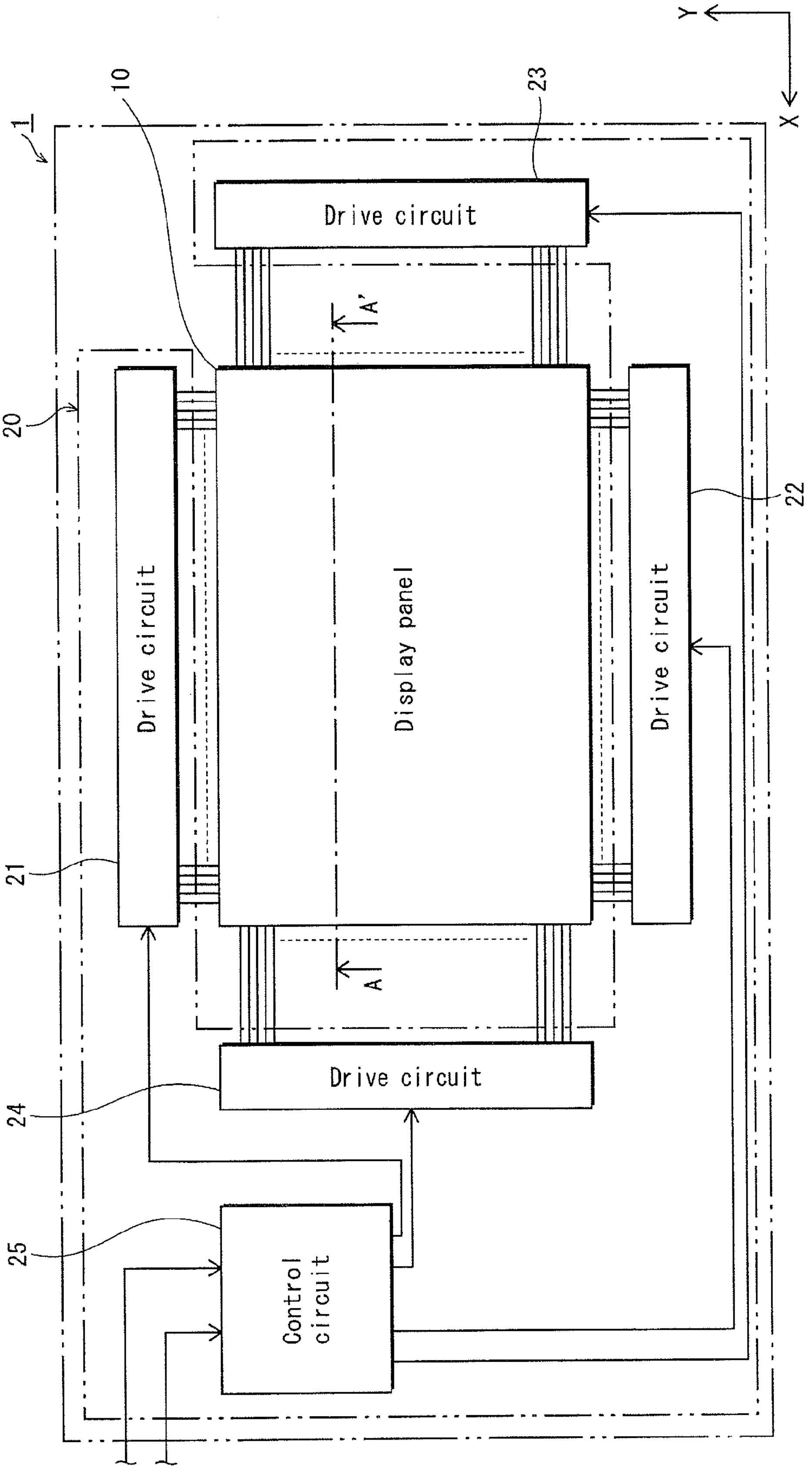

1
10
20
21
22
23
24
25
Drive circuit
Drive circuit
Drive circuit
Drive circuit
Display panel
Control circuit
A
A'
X
Y

FIG. 2

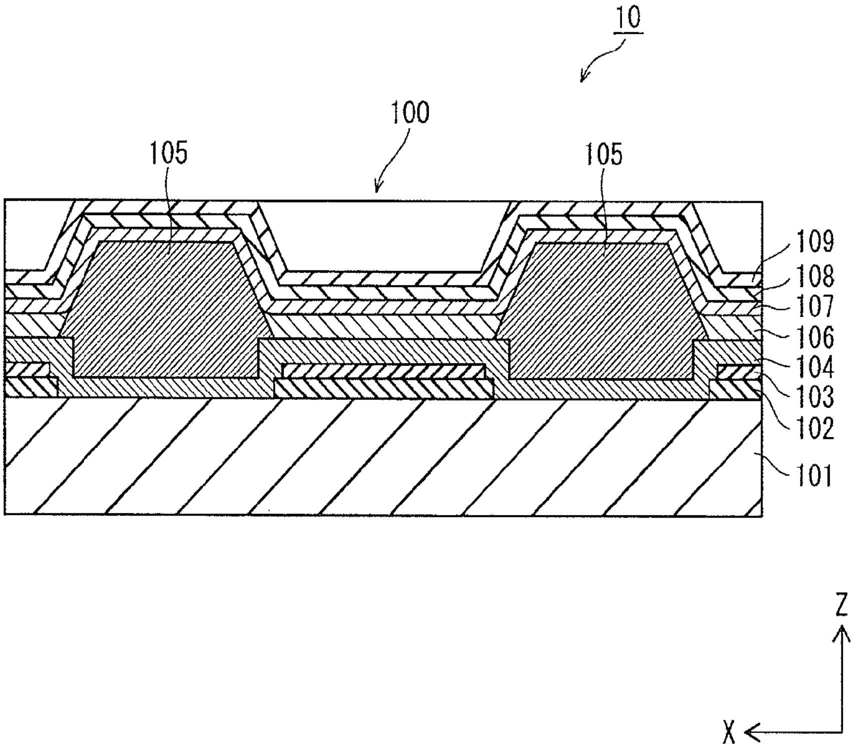


FIG. 3

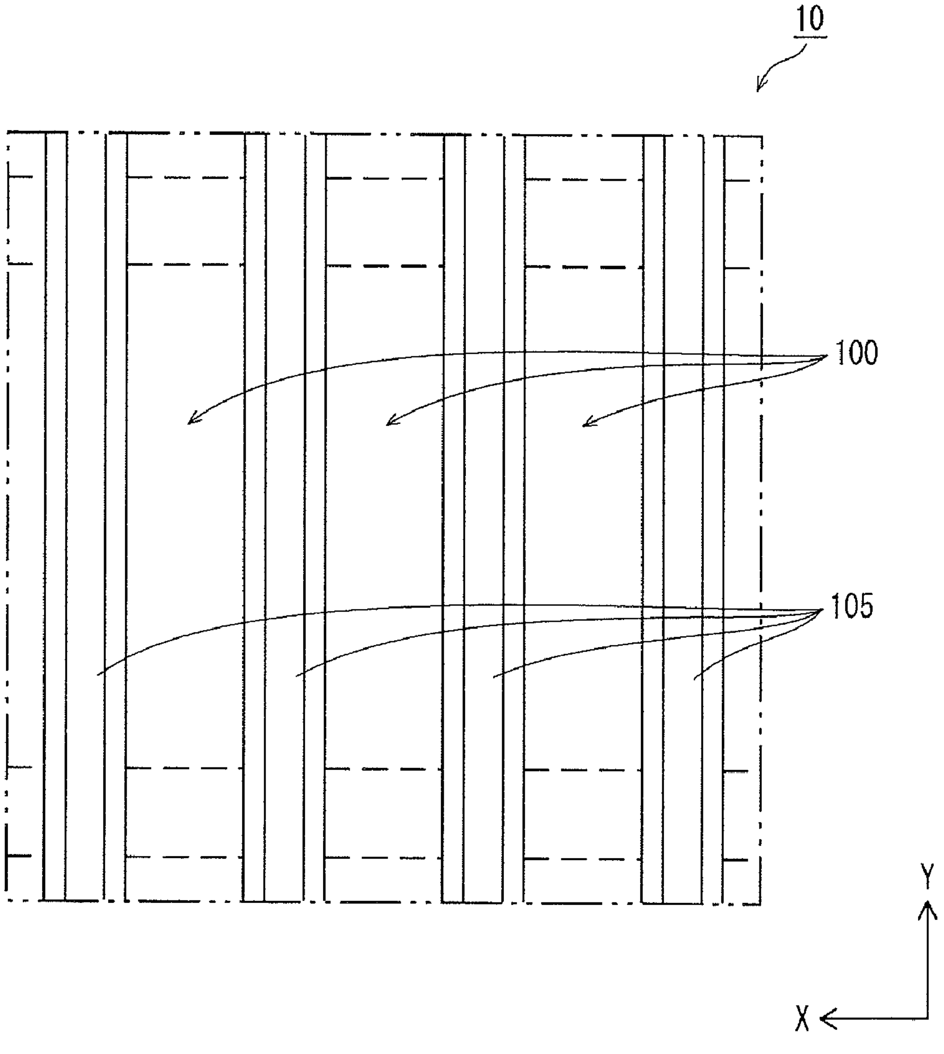
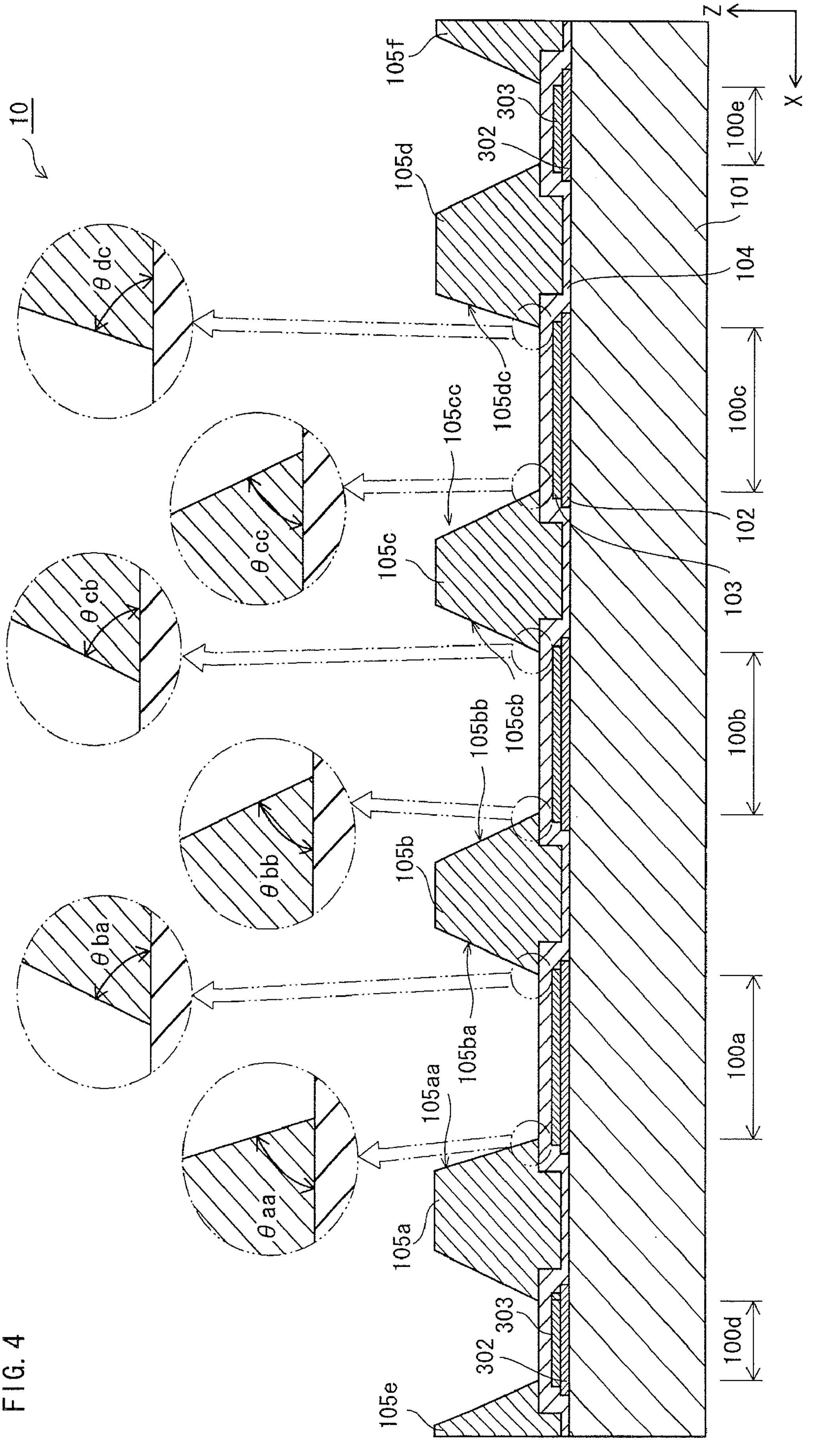


FIG. 4


10
Z
X
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303
302
100e
105d
101
104
θdc
105dc
100c
105cc
θcc
102
103
105c
θcb
105cb
100b
105bb
θbb
105b
θba
105ba
100a
105aa
θaa
105a
303
302
100d
105e

FIG. 5A

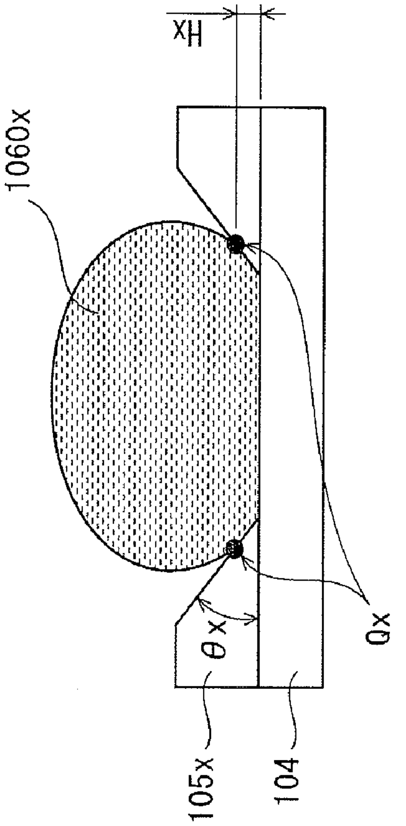


FIG. 5B

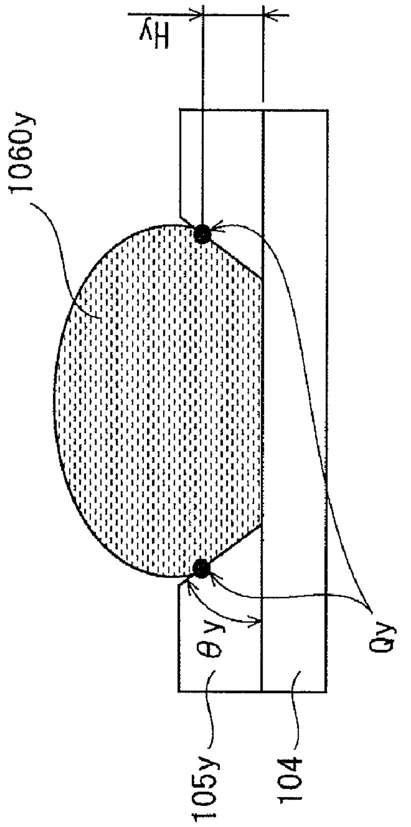


FIG. 5C

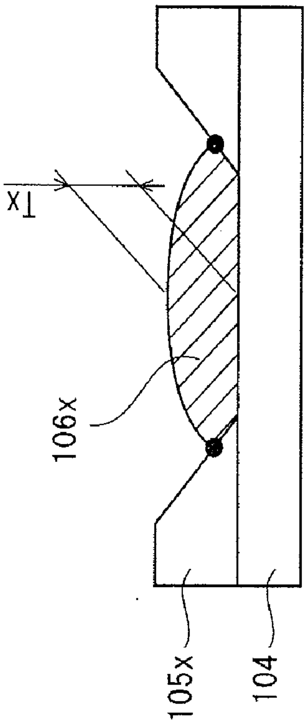


FIG. 5D

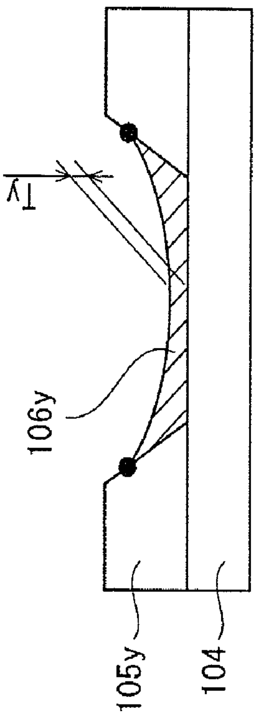


FIG. 6

Taper angle (θ)	Small ←→ Large
Pinning location (H)	Low ←→ High
Film thickness (T)	Thick ←→ Thin

FIG. 7

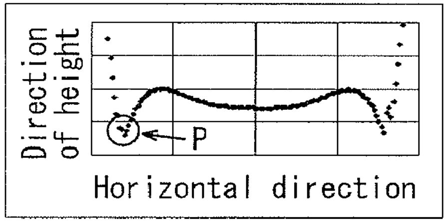
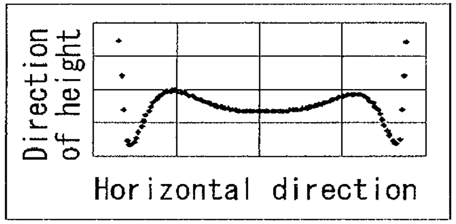
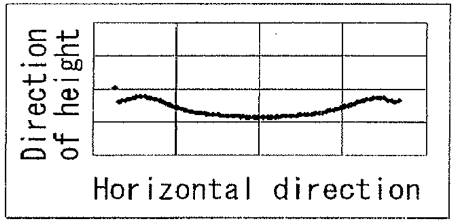
	Sample 1	Sample 2	Sample 3
Bank height [μm]	0.3	0.5	0.6
Contact angle [°]	—	55	44
Taper angle [°]	28	22	24
Film thickness distribution			

FIG. 8

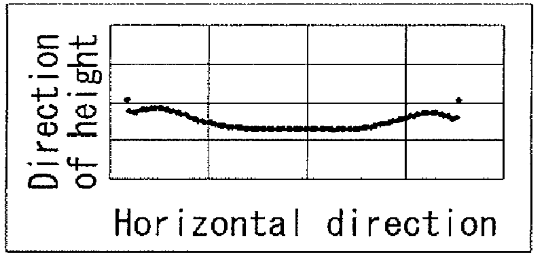
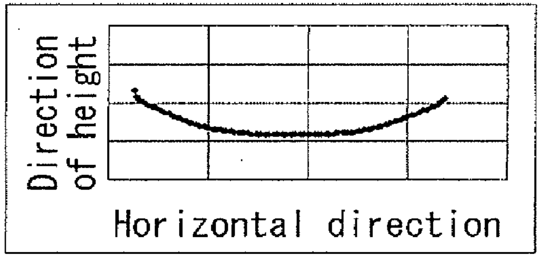
	Sample 4	Sample 5
Bank height [μm]	0.7	1.0
Contact angle [°]	43	47
Taper angle [°]	28	50
Film thickness distribution		

FIG. 9A

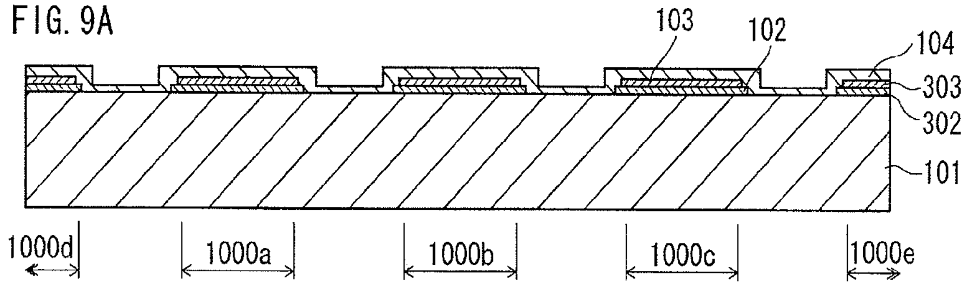


FIG. 9B

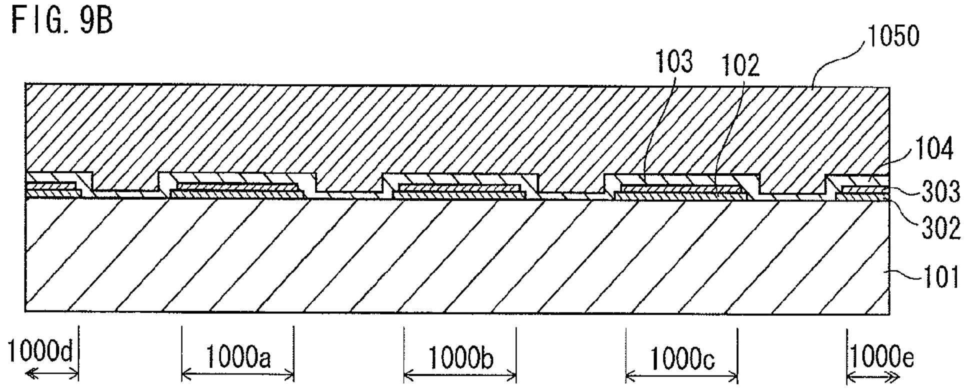


FIG. 9C

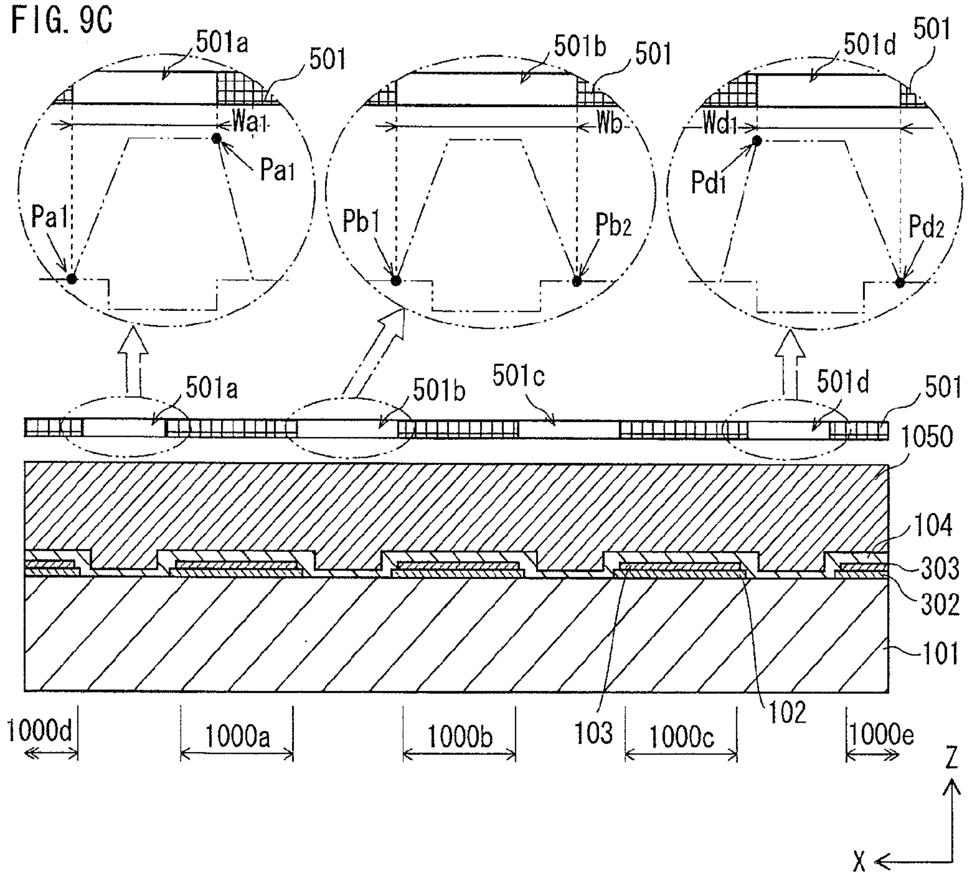


FIG. 10A

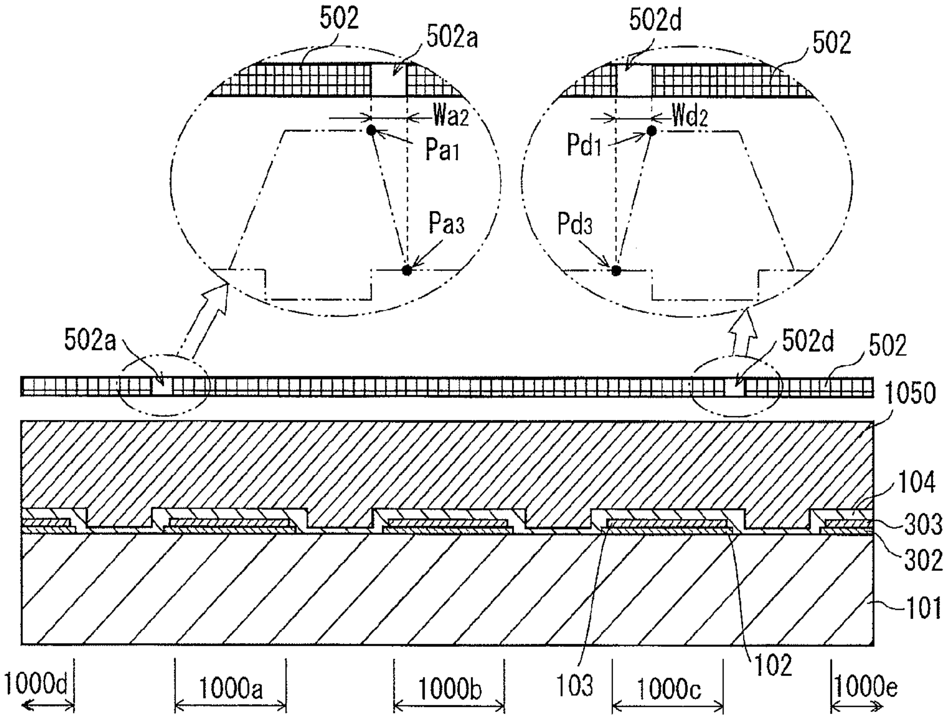
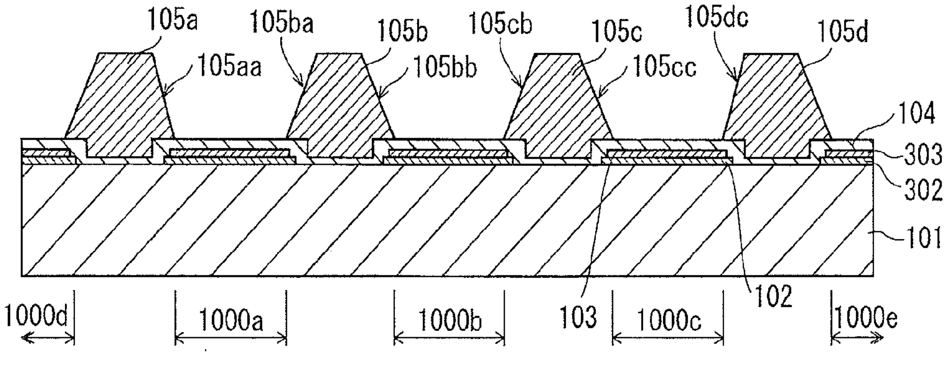


FIG. 10B



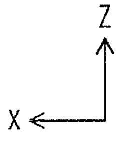
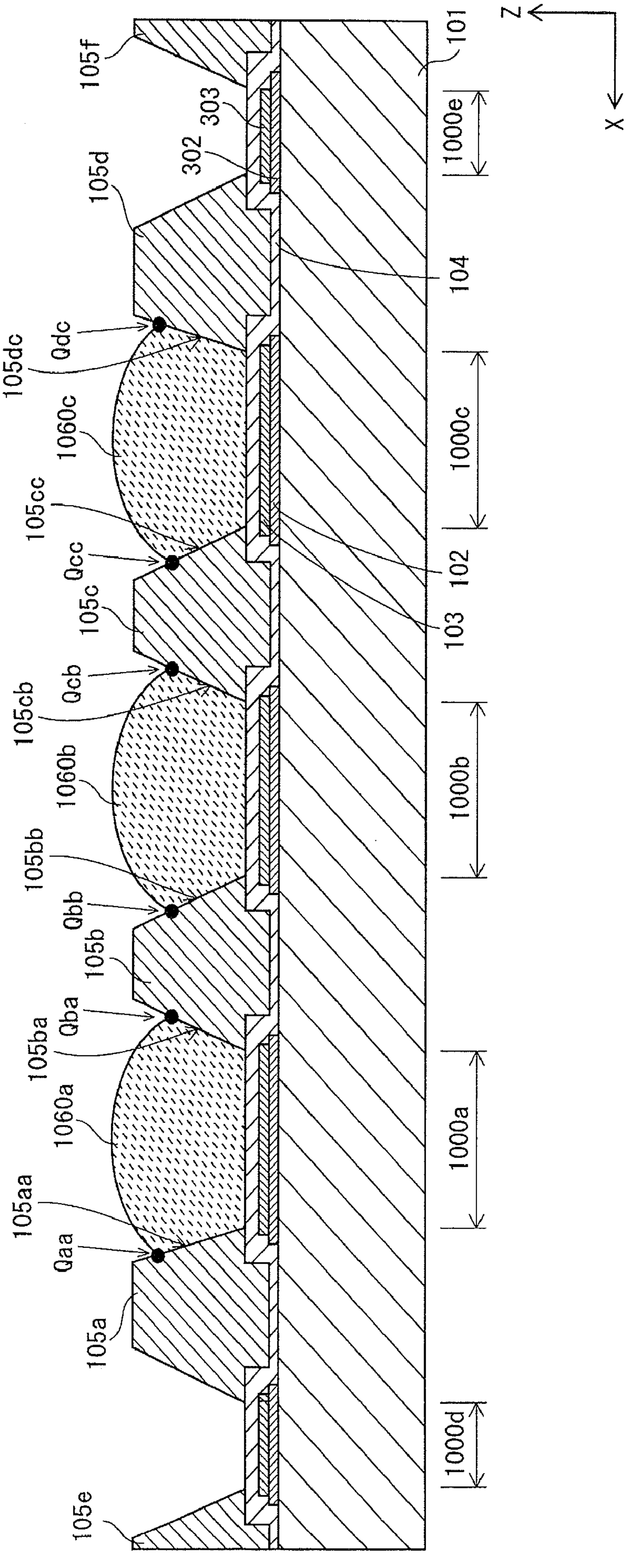


FIG. 11


Z
X
101
105f
303
1000e
302
105d
104
Qdc
105dc
1060c
1000c
105cc
102
Qcc
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105c
Qcb
105cb
1060b
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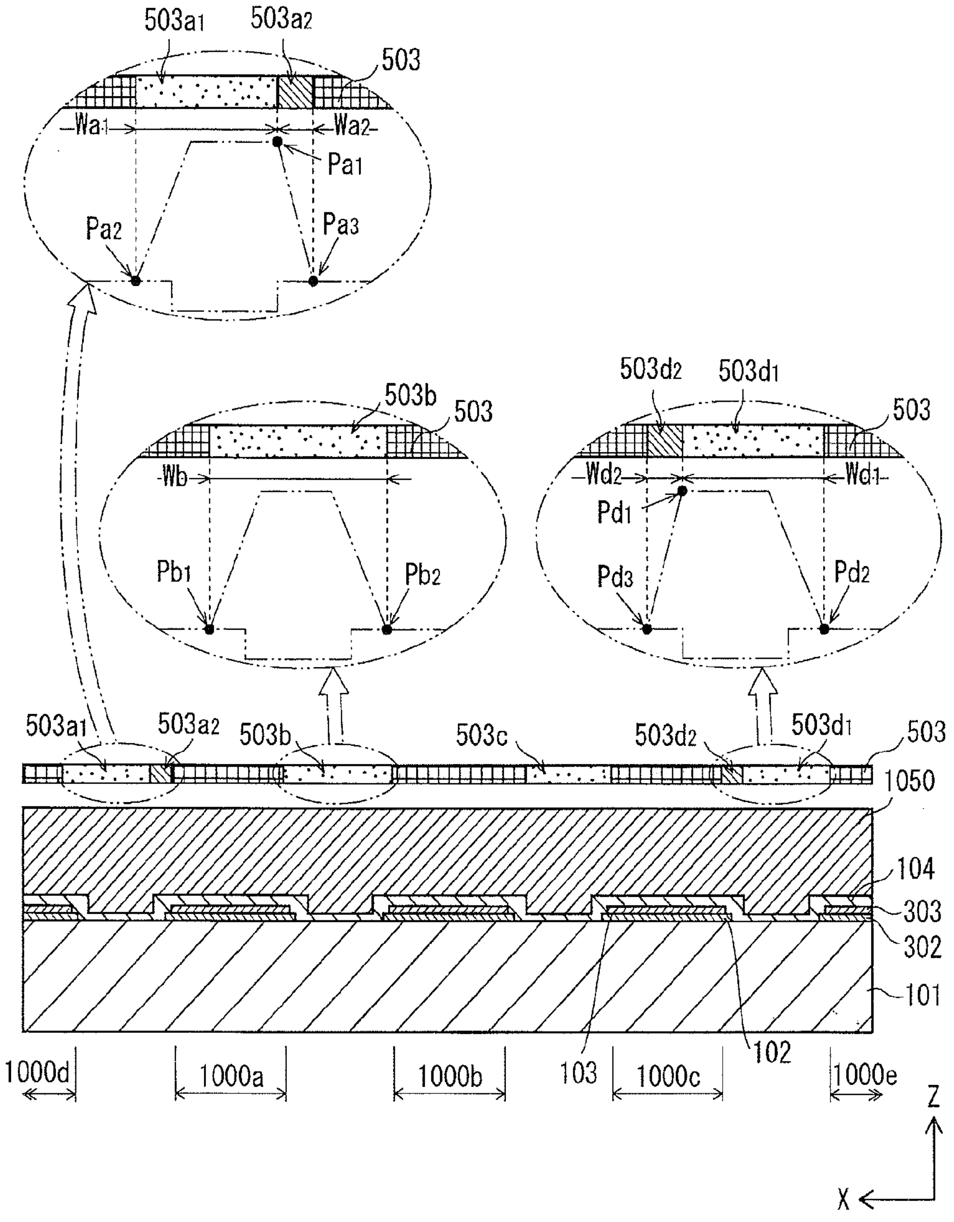
105a
1000d
105e

FIG. 12


503a1
503a2
503
Wa1
Wa2
Pa1
Pa2
Pa3
503b
503
Wb
Pb1
Pb2
503d2
503d1
503
Wd2
Wd1
Pd1
Pd3
Pd2
503a1
503a2
503b
503c
503d2
503d1
503
1050
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303
302
101
1000d
1000a
1000b
103
1000c
102
1000e
Z
X

FIG. 13A

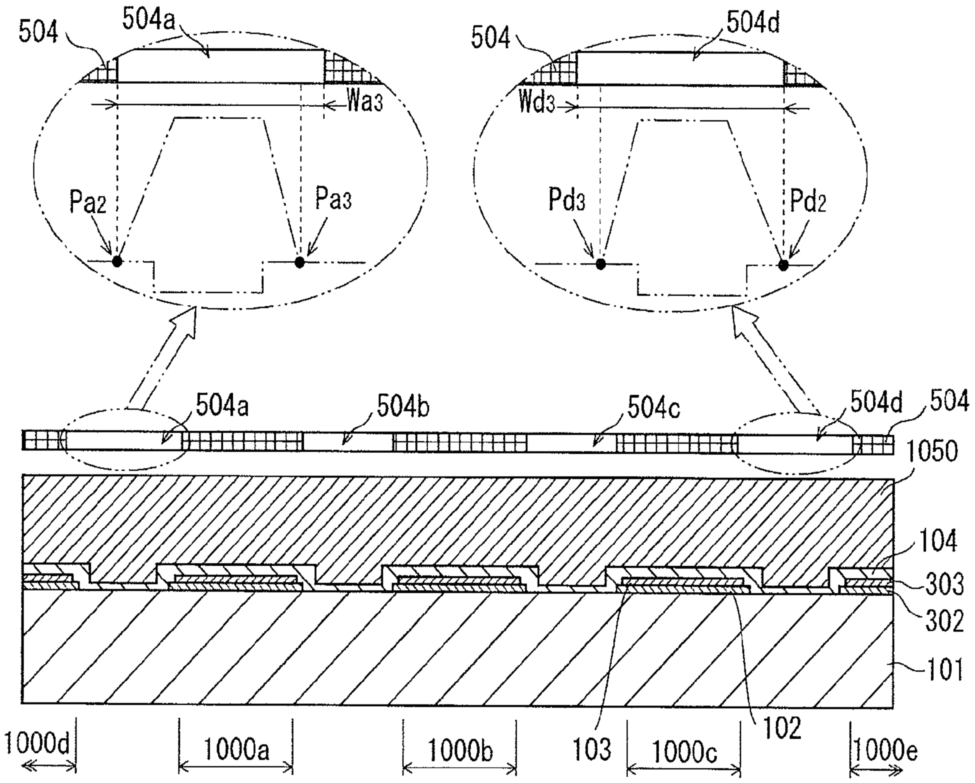
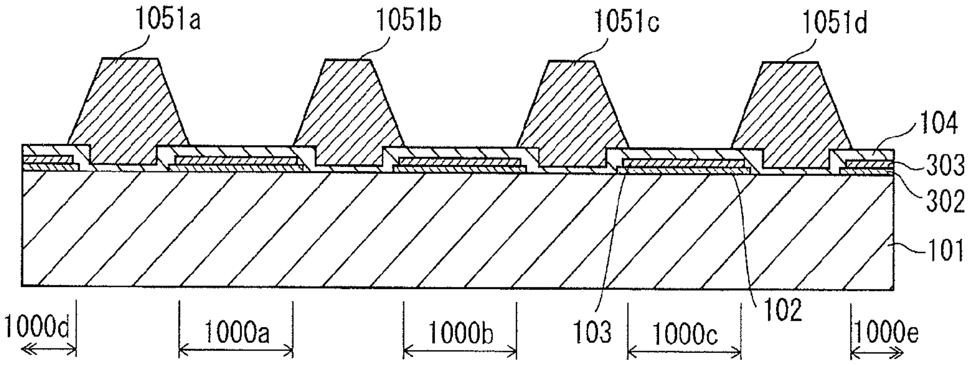


FIG. 13B



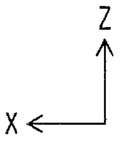


FIG. 14A

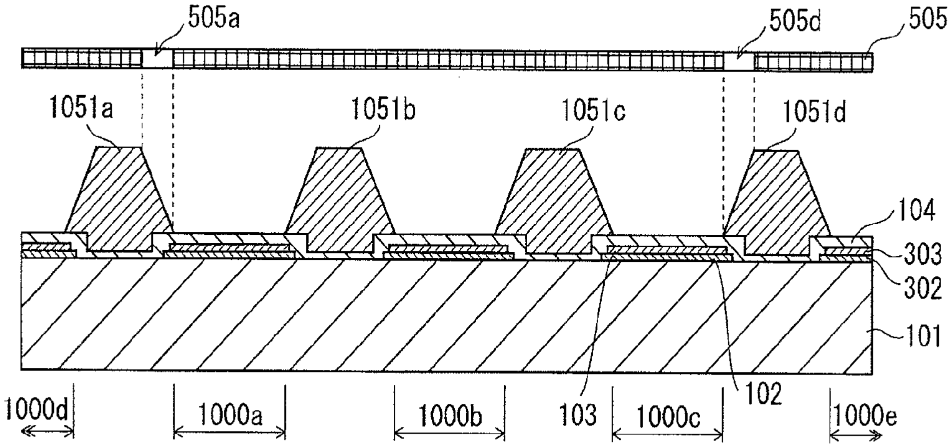
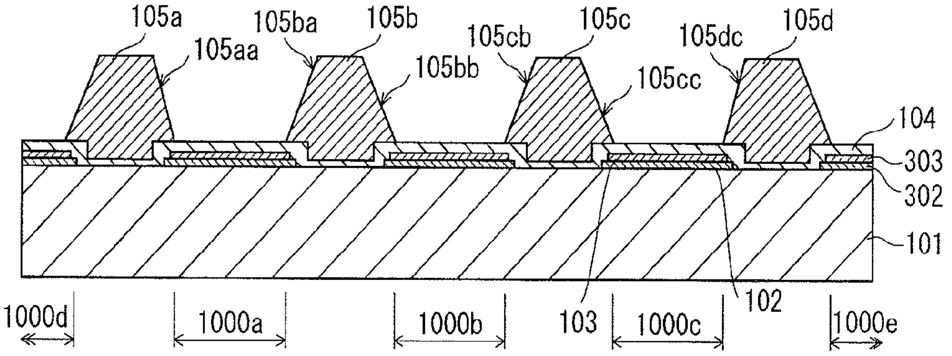


FIG. 14B



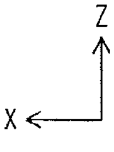


FIG. 15A

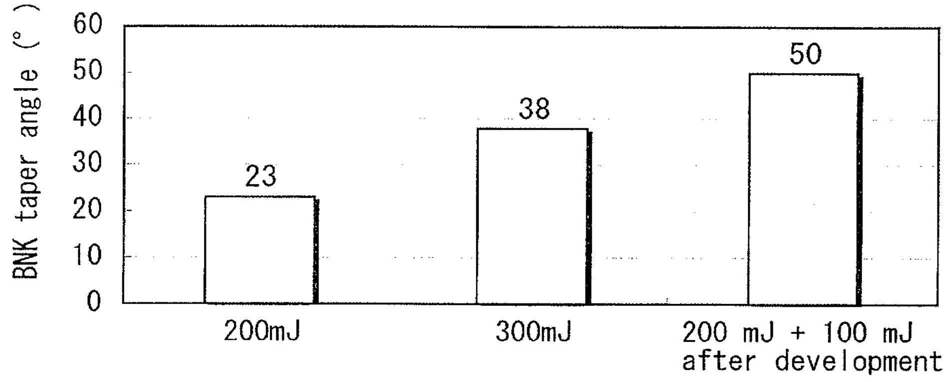


FIG. 15B

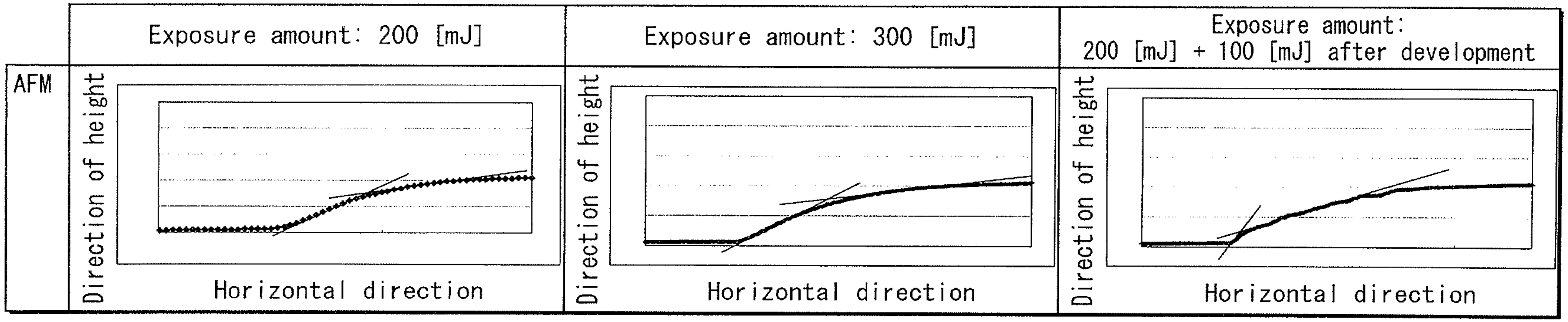


FIG. 16A

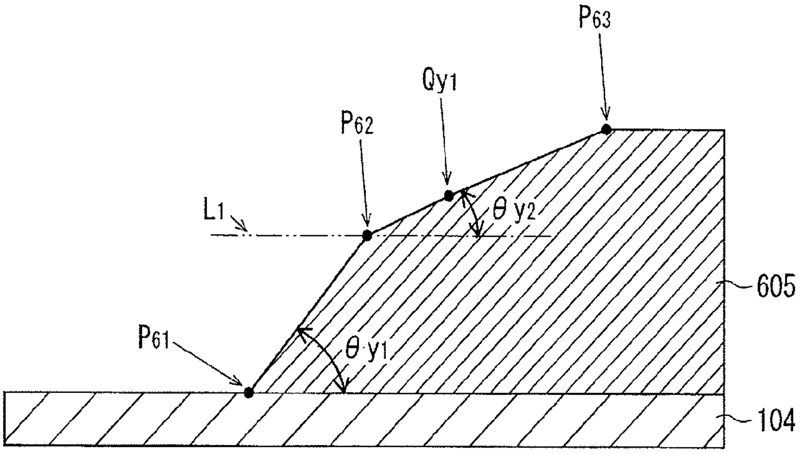


FIG. 16B

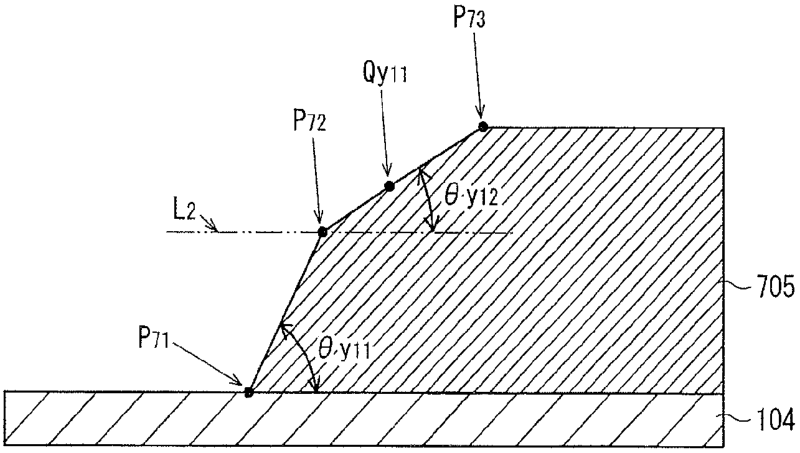


FIG. 17

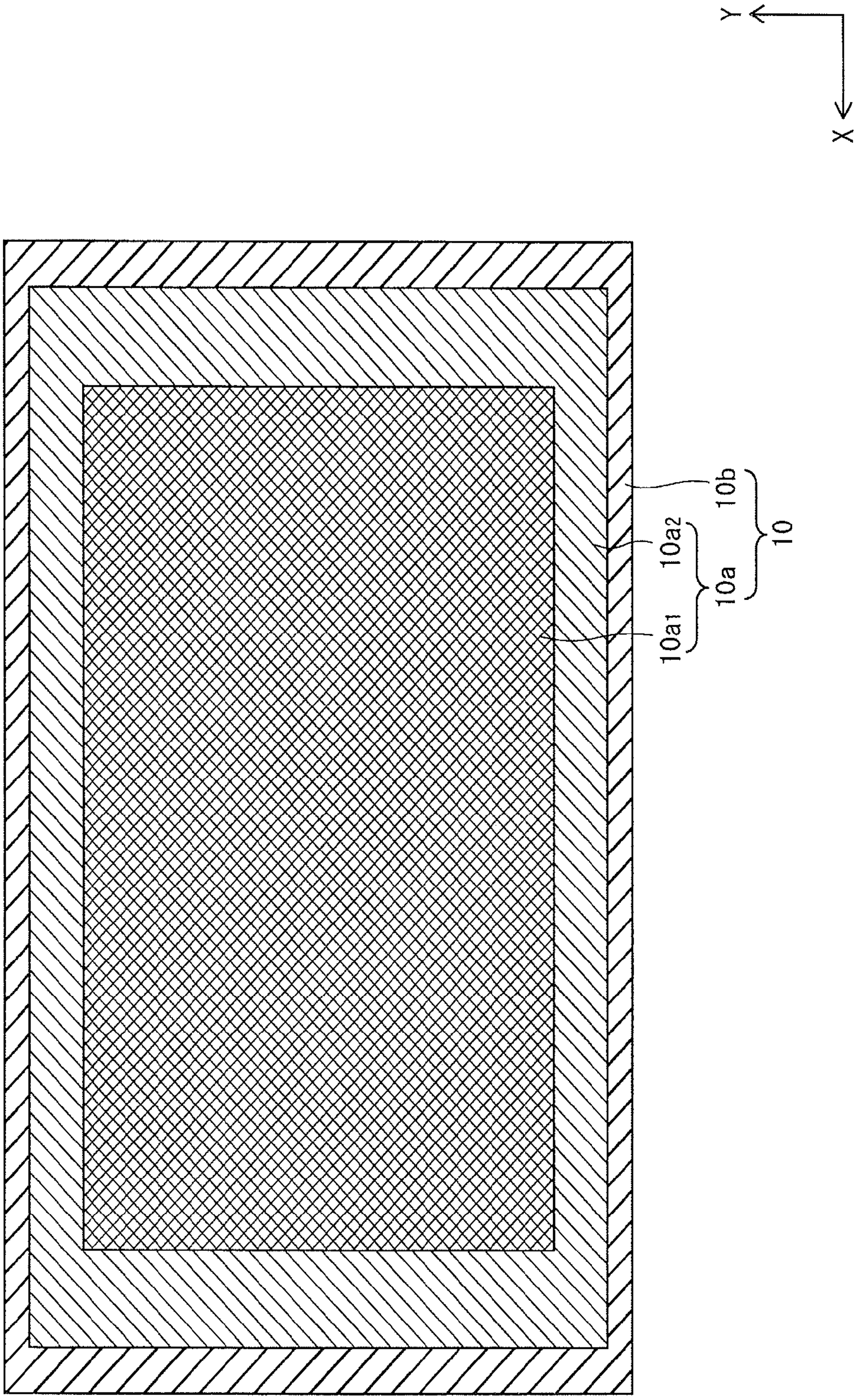


FIG. 18

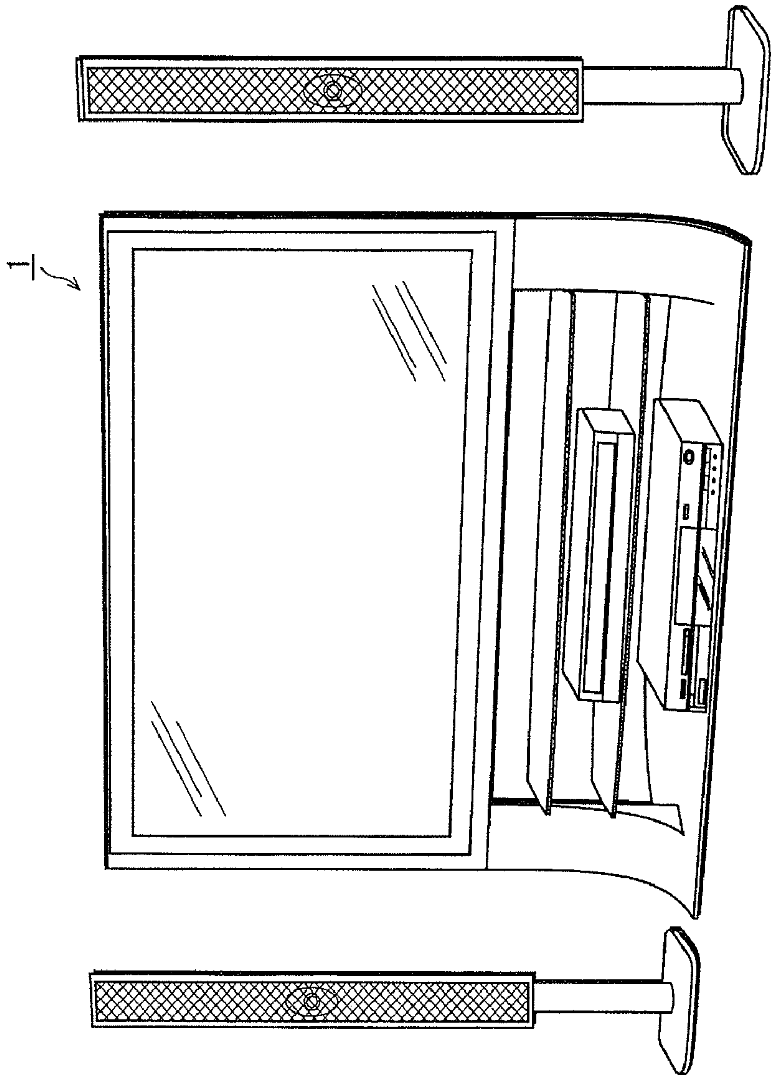


FIG. 19

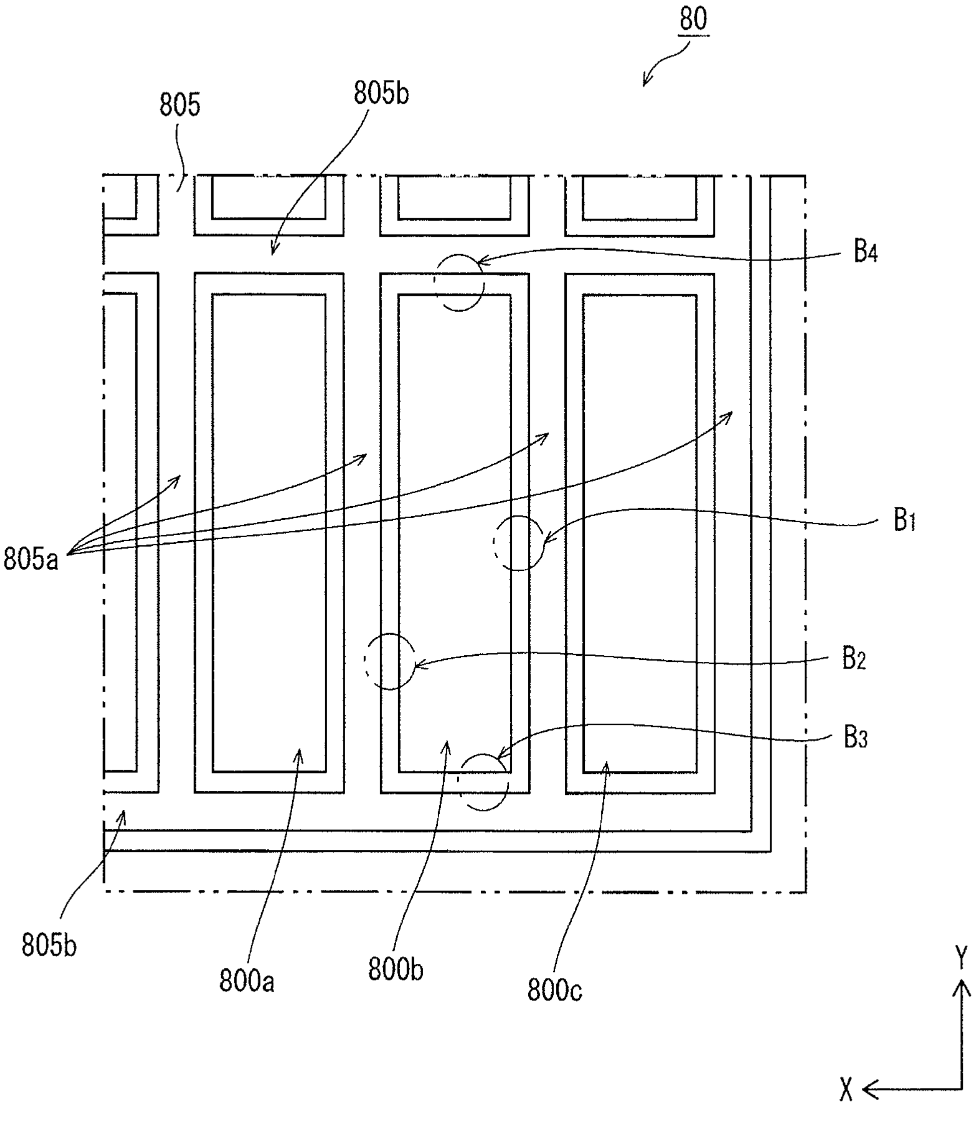


FIG. 20

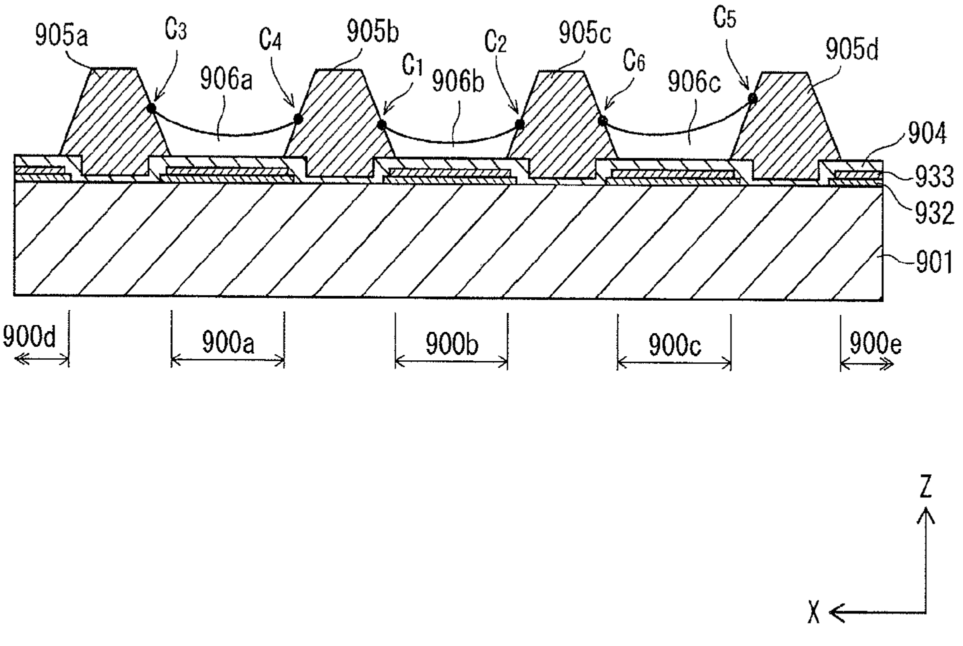

905a
C3
C4
905b
C1
906a
906b
C2
905c
C6
906c
C5
905d
904
933
932
901
900d
900a
900b
900c
900e
Z
X

FIG. 21A

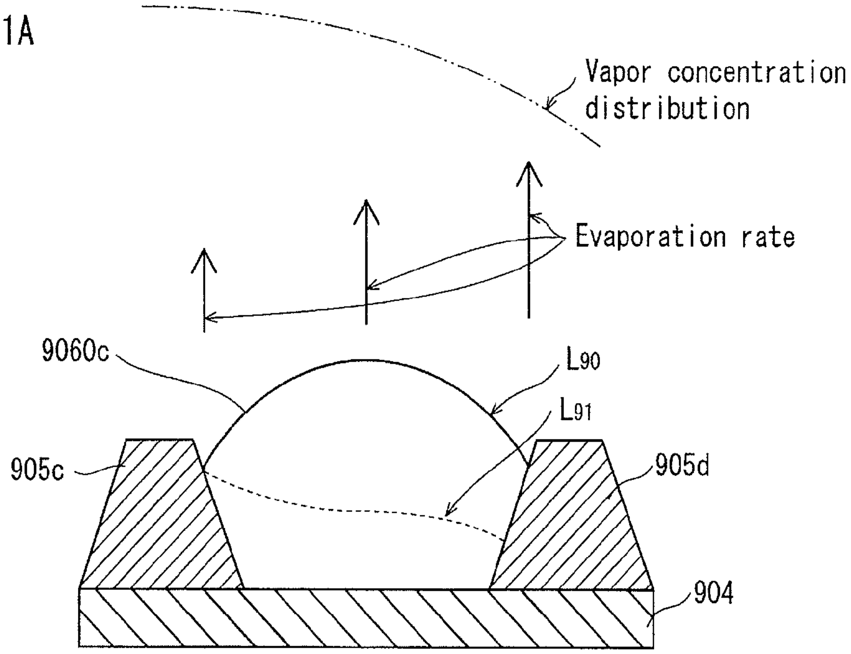


FIG. 21B

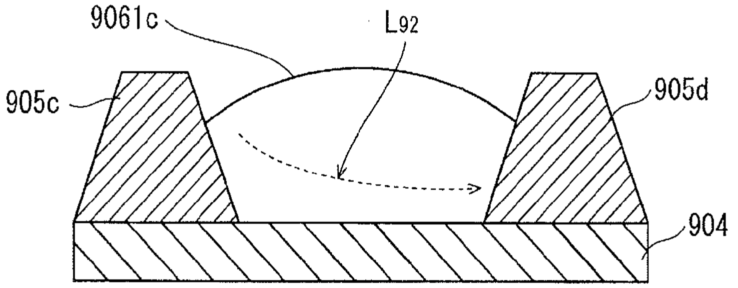
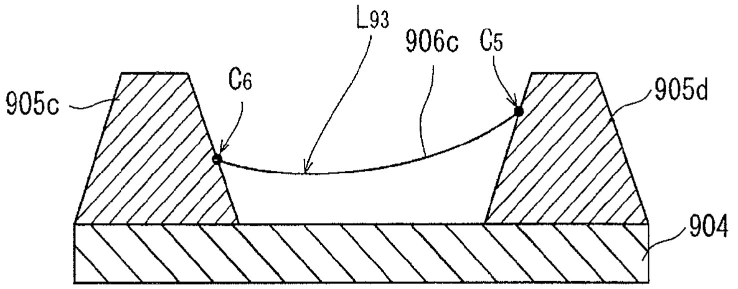


FIG. 21C



ORGANIC LIGHT-EMITTING PANEL, MANUFACTURING METHOD THEREOF, AND ORGANIC DISPLAY DEVICE

[0001] This is a continuation application of PCT Application No. PCT/JP2010/006149 filed on Oct. 15, 2010, designating the United States of America, the disclosure of which, including the specification, drawings and claims, is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates an organic light-emitting panel, a manufacturing method thereof, and an organic display device.

BACKGROUND ART

[0003] In recent years, progress has been made in the research and development of display devices that use the phenomenon of electroluminescence occurring in organic material. Each light-emitting cell of such a display device is composed of an anode and a cathode with an organic light-emitting layer therebetween. When the display device is driven, holes are injected through the anode, electrons are injected through the cathode, and the holes and electrons recombine within the organic light-emitting layer, thereby emitting the light.

[0004] Banks composed of insulating material partition the organic light-emitting layer into light-emitting cells. The organic light-emitting layer is formed by dripping ink, which includes an organic light-emitting material, into each region separated by the banks and drying the ink.

[0005] Meanwhile, a problem with the organic light-emitting layer formed in this way is that it is difficult for the layer to have a uniform film thickness.

[0006] As one example of technologies for evening out the film thickness of the organic light-emitting layer, Patent Literature 1 discloses providing a convexity on the inner sidewall of the bank in order to control the pinning location of the ink. In other words, according to the technology of Patent Literature 1, the pinning location of the ink dripped in one light-emitting cell can be set to the convexity. With this technology, it is possible to secure a uniform film thickness to a certain degree.

CITATION LIST

Patent Literature

[0007] Patent Literature 1: Japanese Patent Application Publication No. 2007-311235

SUMMARY OF INVENTION

Technical Problem

[0008] It is considered difficult, however, to use the technology of Patent Literature 1 to detect in advance how the organic light-emitting layer of a display device is uneven in film thickness and, based on the detection results, form a minute convexity for each region or each inner sidewall of the bank to a high degree of precision. Therefore, it is not easy to maintain the organic light-emitting layer at a uniform film thickness over the entire region of the organic light-emitting panel.

[0009] It is an object of the present invention to solve the above problems by providing a display device, and a manufacturing method thereof, that has a uniform film thickness in the organic light-emitting layer across the entire panel and has an even luminance within the panel.

Solution to Problem

[0010] In order to solve the above problems, an organic light-emitting panel according to an aspect of the present invention has the following structure.

[0011] The organic light-emitting panel according to an aspect of the present invention comprises: an array of a plurality of pixels; one or more non-light-emitting cells each being provided between a different pair of adjacent pixels; a plurality of light-emitting cells provided in such a manner that each pixel includes at least three light-emitting cells that are arranged in an alignment and emit light of different colors, the at least three light-emitting cells including a first light-emitting cell located at an end of the alignment, a second light-emitting cell located at a central portion of the alignment, and a third light-emitting cell located at another end of the alignment; an underlying layer formed below the array of the plurality of pixels; a plurality of first electrodes each included in the underlying layer and placed below a different one of the plurality of light-emitting cells; a plurality of organic light-emitting layers each formed in a different one of the plurality of light-emitting cells by applying, for each pixel, at least three types of ink, that contain different organic light-emitting materials corresponding one-to-one to the different colors of light, respectively to the at least three light-emitting cells substantially at a same time; and a second electrode formed to be away from the underlying layer with each organic light-emitting layer therebetween.

[0012] The above organic light-emitting panel further comprises a plurality of banks formed above the underlying layer, separating the light-emitting cells, and defining each light-emitting cell, each of the plurality of pixels being structured such that among inner sidewalls facing each other in respective adjacent banks defining the first light-emitting cell and the third light-emitting cell, sidewalls adjacent to non-light-emitting cells have larger inclination angles than sidewalls adjacent to the second light-emitting cell, and inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell have substantially equal inclination angles.

Advantageous Effects of Invention

[0013] In the above organic light-emitting panel according to an aspect of the present invention, for each pixel, three types of ink respectively corresponding to the first, second and third light-emitting cells are applied substantially at the same time, and thereby the organic light-emitting cells are formed. In this case, with regard to the second light-emitting cell whose two ends have the same ink vapor concentration, since the ink is applied at the same time to the first and third light-emitting cells that are adjacent to the second light-emitting cell, the organic light-emitting layer in the second light-emitting cell is not likely to become uneven in film thickness. Accordingly, with the above structure where inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell have substantially equal inclination angles, it is possible to prevent the organic light-emitting layer from becoming uneven in film thickness.

[0014] On the other hand, with regard to the first light-emitting cell, ink is applied to the second light-emitting cell adjacent to the first light-emitting cell, but not to a non-light-emitting cell adjacent to the first light-emitting cell. Thus an end of the first light-emitting cell on the second light-emitting cell side has a higher ink vapor concentration than the opposite end thereof. Thus the film thickness of the light-emitting layer tends to be larger at an end on the non-light-emitting cell side than at the end on the second light-emitting cell side. Accordingly, the light-emitting layer therein is likely to become uneven in film thickness.

[0015] However, in the above organic light-emitting panel according to an aspect of the present invention, among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell, a sidewall adjacent to a non-light-emitting cell has a larger inclination angle than a sidewall adjacent to the second light-emitting cell. With this structure, the pinning location of the ink in the sidewall on the non-light-emitting cell side is relatively higher than the pinning location of the ink in the sidewall on the second light-emitting cell side. This enables the film thickness of the organic light-emitting layer in the first light-emitting cell on the non-light-emitting cell side to be decreased. As a result, it is possible to prevent the organic light-emitting layer in the first light-emitting cell from becoming uneven in film thickness between two ends thereof (an end on the non-light-emitting cell side and an end on the second light-emitting cell side).

[0016] Furthermore, similarly to the above relationship between opposite sidewalls of two adjacent banks defining the first light-emitting cell, among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell, a sidewall adjacent to a non-light-emitting cell has a larger inclination angle than a sidewall adjacent to the second light-emitting cell. With this structure, the pinning location of the ink in the sidewall on the non-light-emitting cell side is relatively higher than the pinning location of the ink in the sidewall on the second light-emitting cell side. This enables the film thickness of the organic light-emitting layer in the first light-emitting cell on the non-light-emitting cell side to be decreased. As a result, it is possible to prevent the organic light-emitting layer in the third light-emitting cell from becoming uneven in film thickness between two ends thereof (an end on the non-light-emitting cell side and an end on the second light-emitting cell side).

[0017] As described above, in the above organic light-emitting panel according to an aspect of the present invention, it is possible to prevent the organic light-emitting layer in each light-emitting cell from becoming uneven in film thickness between two opposite ends thereof, providing excellent light-emitting characteristics in the same pixel.

BRIEF DESCRIPTION OF DRAWINGS

[0018] FIG. **1** is a block diagram showing the configuration of an organic display device **1** according to the Embodiment of the present invention.

[0019] FIG. **2** is a schematic cross-sectional view showing a sub-pixel **100** included in a display panel **10**.

[0020] FIG. **3** is a schematic plan view showing a bank **105** in the display panel **10**.

[0021] FIG. **4** is a schematic cross-sectional view showing the structure of sub-pixels **100***a* to **100***c* included in the display panel **10** and banks **105***a* to **105***d* defining the sub-pixels **100***a* to **100***c*.

[0022] FIG. **5**A is a schematic cross-sectional view showing pinning locations when the taper angle of the bank sidewall is small; FIG. **5**B is a schematic cross-sectional view showing pinning locations when the taper angle of the bank sidewall is large; FIG. **5**C is a schematic cross-sectional view showing the condition of the organic light-emitting layer after drying when the taper angle of the bank sidewall is small; and FIG. **5**D is a schematic cross-sectional view showing the condition of the organic light-emitting layer after drying when the taper angle of the bank sidewall is large.

[0023] FIG. **6** summarizes the relationship between the inclination angle of the bank sidewall (taper angle) θ, the pinning height H, and the film thickness T of the organic light-emitting layer.

[0024] FIG. **7** shows a distribution of film thickness of the organic light-emitting layer in samples **1**-**3**.

[0025] FIG. **8** shows a distribution of film thickness of the organic light-emitting layer in samples **4** and **5**.

[0026] FIGS. **9**A, **9**B, and **9**C are schematic cross-sectional views showing, in order, the main processes in the manufacturing method of the display panel **10**.

[0027] FIGS. **10**A and **10**B are schematic cross-sectional views showing, in order, the main processes in the manufacturing method of the display panel **10**.

[0028] FIG. **11** is a schematic cross-sectional view showing an ink application process in the manufacturing method of the display panel **10**.

[0029] FIG. **12** is a schematic cross-sectional view showing the main processes in the manufacturing method of Modification 1.

[0030] FIGS. **13**A and **13**B are schematic cross-sectional views showing the main processes in the manufacturing method of Modification 2.

[0031] FIGS. **14**A and **14**B are schematic cross-sectional views showing the main processes in the manufacturing method of Modification 2.

[0032] FIG. **15**A shows the relationship between the taper angle of a bank and exposure/developing; and FIG. **15**B shows AFM graphs that indicate the shapes of formed banks.

[0033] FIGS. **16**A and **16**B are schematic cross-sectional views provided for explanation of definition of the taper angle.

[0034] FIG. **17** is a schematic plan view showing regions **10***a***1**, **10***a***2** and **10***b* in the display panel **10**.

[0035] FIG. **18** is an external perspective view showing an example of the appearance of a set that includes the organic display device **1**.

[0036] FIG. **19** is a schematic plan view showing a bank **805** in a display panel **80** of Modification 3.

[0037] FIG. **20** is a schematic cross-sectional view showing how the film thickness distribution of the organic light-emitting layer is uneven in a series of sub-pixels of the display panel.

[0038] FIGS. **21**A, **21**B, and **21**C are schematic cross-sectional views showing the vapor concentration distribution during formation of the organic light-emitting layer, and unevenness of film shape in the ink drying process.

DESCRIPTION OF EMBODIMENTS

[Outline of Aspects of Present Invention]

[0039] The organic light-emitting panel according to an aspect of the present invention comprises: an array of a plurality of pixels; one or more non-light-emitting cells each being provided between a different pair of adjacent pixels; a plurality of light-emitting cells provided in such a manner that each pixel includes at least three light-emitting cells that are arranged in an alignment and emit light of different colors, the at least three light-emitting cells including a first light-emitting cell located at an end of the alignment, a second light-emitting cell located at a central portion of the alignment, and a third light-emitting cell located at another end of the alignment; an underlying layer formed below the array of the plurality of pixels; a plurality of first electrodes each included in the underlying layer and placed below a different one of the plurality of light-emitting cells; a plurality of organic light-emitting layers each formed in a different one of the plurality of light-emitting cells by applying, for each pixel, at least three types of ink, that contain different organic light-emitting materials corresponding one-to-one to the different colors of light, respectively to the at least three light-emitting cells substantially at a same time; and a second electrode formed to be away from the underlying layer with each organic light-emitting layer therebetween.

[0040] The above organic light-emitting panel further comprises a plurality of banks formed above the underlying layer, separating the light-emitting cells, and defining each light-emitting cell, each of the plurality of pixels being structured such that among inner sidewalls facing each other in respective adjacent banks defining the first light-emitting cell and the third light-emitting cell, sidewalls adjacent to non-light-emitting cells have larger inclination angles than sidewalls adjacent to the second light-emitting cell, and inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell have substantially equal inclination angles.

[0041] In the above organic light-emitting panel according to an aspect of the present invention, for each pixel, three types of ink respectively corresponding to the first, second and third light-emitting cells are applied substantially at the same time, and thereby the organic light-emitting cells are formed. In this case, with regard to the second light-emitting cell whose two ends have the same ink vapor concentration, since the ink is applied at the same time to the first and third light-emitting cells that are adjacent to the second light-emitting cell, the organic light-emitting layer in the second light-emitting cell is not likely to become uneven in film thickness. Accordingly, with the above structure where inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell have substantially equal inclination angles, it is possible to prevent the organic light-emitting layer from becoming uneven in film thickness.

[0042] On the other hand, with regard to the first light-emitting cell, ink is applied to the second light-emitting cell adjacent to the first light-emitting cell, but not to a non-light-emitting cell adjacent to the first light-emitting cell. Thus an end of the first light-emitting cell on the second light-emitting cell side has a higher ink vapor concentration than the opposite end thereof. Thus the film thickness of the light-emitting layer tends to be larger at an end on the non-light-emitting cell side than at the end on the second light-emitting cell side. Accordingly, the light-emitting layer therein is likely to become uneven in film thickness.

[0043] However, in the above organic light-emitting panel according to an aspect of the present invention, among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell, a sidewall adjacent to a non-light-emitting cell has a larger inclination angle than a sidewall adjacent to the second light-emitting cell. With this structure, the pinning location of the ink in the sidewall on the non-light-emitting cell side is relatively higher than the pinning location of the ink in the sidewall on the second light-emitting cell side. This enables the film thickness of the organic light-emitting layer in the first light-emitting cell on the non-light-emitting cell side to be decreased. As a result, it is possible to prevent the organic light-emitting layer in the first light-emitting cell from becoming uneven in film thickness between two ends thereof (an end on the non-light-emitting cell side and an end on the second light-emitting cell side).

[0044] Furthermore, similarly to the above relationship between opposite sidewalls of two adjacent banks defining the first light-emitting cell, among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell, a sidewall adjacent to a non-light-emitting cell has a larger inclination angle than a sidewall adjacent to the second light-emitting cell. With this structure, the pinning location of the ink in the sidewall on the non-light-emitting cell side is relatively higher than the pinning location of the ink in the sidewall on the second light-emitting cell side. This enables the film thickness of the organic light-emitting layer in the first light-emitting cell on the non-light-emitting cell side to be decreased. As a result, it is possible to prevent the organic light-emitting layer in the third light-emitting cell from becoming uneven in film thickness between two ends thereof (an end on the non-light-emitting cell side and an end on the second light-emitting cell side).

[0045] As described above, in the above organic light-emitting panel according to an aspect of the present invention, it is possible to prevent the organic light-emitting layer in each light-emitting cell from becoming uneven in film thickness between two opposite ends thereof, providing excellent light-emitting characteristics in the same pixel.

[0046] In the above organic light-emitting panel according to an aspect of the present invention, each of the one or more non-light-emitting cells may include none of the organic light-emitting layers, may include a third electrode made of a same material as a material of the first electrodes, may be placed below the second electrode, and may electrically connect the third electrode with the second electrode.

[0047] In the organic light-emitting panel, it is general that the second electrode, which is located at an upper position (on the light extraction side) than the organic light-emitting layer, is made of a light-transmissive material (for example, ITO or IZO). However, these materials exhibit a high electrical resistance. In view of this, each non-light-emitting cell electrically connects the third electrode with the second electrode to decrease the electrical resistance, thereby securing excellent light-emitting characteristics and preventing a voltage drop even when the panel has a large size. The third electrode is, for example, a bus bar.

[0048] In the above organic light-emitting panel according to an aspect of the present invention, the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell and the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell may have substantially equal inclination angles.

[0049] In the above organic light-emitting panel according to an aspect of the present invention, each non-light-emitting cell is provided between adjacent pixels, and ink for forming the organic light-emitting cells is applied to the first, second and third light-emitting cells substantially at a same time, for each pixel. In this case, an end of the first light-emitting cell on the non-light-emitting cell side and an end of the third light-emitting cell on the non-light-emitting cell side have substantially the same ink vapor concentration. In this case, when the panel is structured as described above, namely, the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell and the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell have substantially equal inclination angles, the pinning locations of the ink in these sidewalls can be set to the same level.

[0050] Therefore, with the above structure, it is possible to prevent the organic light-emitting layers in the first, second and third light-emitting cells in each pixel from becoming uneven in film thickness, providing excellent light-emitting characteristics.

[0051] In the above organic light-emitting panel according to an aspect of the present invention, the sidewall adjacent to the second light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell and the inner sidewalls facing each other in the adjacent banks defining the second light-emitting cell may have substantially equal inclination angles.

[0052] In the above organic light-emitting panel according to an aspect of the present invention, each non-light-emitting cell is provided between adjacent pixels, and ink for forming the organic light-emitting cells is applied to the first, second and third light-emitting cells substantially at a same time, for each pixel. In this case, an end of the first light-emitting cell on the second light-emitting cell side and ends of the second light-emitting cell on the first and third light-emitting cell sides have substantially the same ink vapor concentration.

[0053] In this case, when the panel is structured as described above, namely, the sidewall adjacent to the second light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell and the inner sidewalls facing each other in the adjacent banks defining the second light-emitting cell have substantially equal inclination angles, the pinning locations of the ink in these sidewalls can be set to the same level. Accordingly, with the above structure, it is possible to prevent the organic light-emitting layers in the first, second and third light-emitting cells in each pixel from becoming uneven in film thickness, providing excellent light-emitting characteristics.

[0054] In the above organic light-emitting panel according to an aspect of the present invention, the sidewall adjacent to the second light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell and the inner sidewalls facing each other in the adjacent banks defining the second light-emitting cell may have substantially equal inclination angles.

[0055] In the above organic light-emitting panel according to an aspect of the present invention, each non-light-emitting cell is provided between adjacent pixels, and ink for forming the organic light-emitting cells is applied to the first, second and third light-emitting cells substantially at a same time, for each pixel. In this case, an end of the third light-emitting cell on the second light-emitting cell side and ends of the second light-emitting cell on the first and third light-emitting cell sides have substantially the same ink vapor concentration.

[0056] In this case, when the panel is structured as described above, namely, the sidewall adjacent to the second light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell and the inner sidewalls facing each other in the adjacent banks defining the second light-emitting cell have substantially equal inclination angles, the pinning locations of the ink in these sidewalls can be set to the same level. Accordingly, with the above structure, it is possible to prevent the organic light-emitting layers in the first, second and third light-emitting cells in each pixel from becoming uneven in film thickness, providing excellent light-emitting characteristics.

[0057] In the above organic light-emitting panel according to an aspect of the present invention, the inclination angles of the sidewalls of the banks can be set to the following ranges.

[0058] (a1) an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell is in a range from 35 degrees to 45 degrees inclusive,

[0059] (a2) an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell is in a range from 35 degrees to 45 degrees inclusive,

[0060] (a3) an inclination angle of the sidewall adjacent to the second light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell is in a range from 25 degrees to 35 degrees inclusive,

[0061] (a4) an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell is in a range from 25 degrees to 35 degrees inclusive, and

[0062] (a5) inclination angles of the inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell are in a range from 25 degrees to 35 degrees inclusive.

[0063] In the above organic light-emitting panel according to an aspect of the present invention, each inclination angle may be formed between each of inner sidewalls facing each other in adjacent banks and an upper surface of the underlying layer (which corresponds to the first electrode, hole injection layer, or hole injection transporting layer).

[0064] An organic display device according to another aspect of the present invention includes any one of the above organic light-emitting panels according to an aspect of the present invention. Therefore, the organic display device according to another aspect of the present invention produces the advantageous effect that is provided by the organic light-emitting panel according to an aspect of the present invention, that is to say, the advantageous effect of preventing the organic light-emitting layer from becoming uneven in film thickness and providing excellent light-emitting characteristics.

[0065] A manufacturing method of an organic light-emitting panel according to a further aspect of the present invention is a manufacturing method of an organic light-emitting panel including an array of a plurality of pixels and one or more non-light-emitting cells that are each provided between a different pair of adjacent pixels, and the manufacturing method comprises the following steps.

[0066] (first step) forming, on a substrate, an underlying layer including a plurality of first electrodes;

[0067] (second step) layering a photoresist material on the underlying layer;

[0068] (third step) forming, for each pixel, a plurality of openings corresponding to a plurality of light-emitting cells and one or more openings corresponding to the non-light-emitting cells by performing an exposure with a mask laid on the layered photoresist material to form a pattern, and forming a plurality of banks to separate the light-emitting cells and the non-light-emitting cells and define each light-emitting cell and each non-light-emitting cell;

[0069] (fourth step) forming a plurality of organic light-emitting layers by dripping ink that includes organic light-emitting materials into the plurality of openings corresponding to the plurality of light-emitting cells, and drying the ink; and

[0070] (fifth step) forming a second electrode above each organic light-emitting layer,

[0071] In the above manufacturing method of an organic light-emitting panel according to a further aspect of the present invention, in the third step, for each of at least part of the plurality of pixels to be formed, a first opening corresponding to a first light-emitting cell located at an end of an alignment in which the light-emitting cells are to be formed, a second opening corresponding to a second light-emitting cell located at a central portion of the alignment, and a third opening corresponding to a third light-emitting cell located at another end of the alignment, are formed, further each of the plurality of pixels is formed such that among inner sidewalls facing each other in respective adjacent banks defining the first light-emitting cell and the third light-emitting cell, sidewalls adjacent to non-light-emitting cells have larger inclination angles than sidewalls adjacent to the second light-emitting cell, and inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell have substantially equal inclination angles, and in the fourth step, the organic light-emitting layers are formed by dripping, for each pixel, three types of ink corresponding one-to-one to three colors of light into the first opening, the second opening and the third opening substantially at a same time.

[0072] With adoption of the above manufacturing method, it is possible to set the pinning locations of the ink applied in the fourth step to be higher in the sidewalls adjacent to non-light-emitting cells than the other sidewalls, among inner sidewalls facing each other in respective adjacent banks defining the first light-emitting cell and the third light-emitting cell.

[0073] The above manufacturing method of an organic light-emitting panel according to a further aspect of the present invention can prevent the organic light-emitting layers from becoming uneven in film thickness based on the mechanism that, after the ink is dried, the larger the inclination angle of a sidewall of a bank is, the smaller the film thickness of the organic light-emitting layer near the sidewall is. Thus the manufacturing method makes it possible to manufacture an organic light-emitting panel having excellent light-emitting characteristics.

[0074] In the above manufacturing method according to an aspect of the present invention, in the third step, when the exposure of the photoresist material is performed, an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell may be made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, by causing a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell to be exposed to a larger amount of light than a part of the photoresist material corresponding to the sidewall adjacent to the second light-emitting cell, and an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell may be made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, by causing a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell to be exposed to a larger amount of light than a part of the photoresist material corresponding to the sidewall adjacent to the second light-emitting cell.

[0075] With the above manufacturing method, the relative relationship among the pinning locations is adjusted, which makes it possible to prevent the organic light-emitting layers from becoming uneven in film thickness in all the light-emitting cells, and manufacture an organic light-emitting panel having excellent light-emitting characteristics.

[0076] In the above manufacturing method according to a further aspect of the present invention, in the third step, when the exposure of the photoresist material is performed, an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell may be made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, by using different masks for respective parts of the photoresist material corresponding to the two sidewalls so that a light transmissivity at a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell is lower than a light transmissivity at a part of the photoresist material corresponding to the sidewall adjacent to the second light-emitting cell, and an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell may be made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, by using different masks for respective parts of the photoresist material corresponding to the two sidewalls so that a light transmissivity at a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell is lower than a light transmissivity at a part of the photoresist material corresponding to the sidewall adjacent to the second light-emitting cell.

[0077] With the above manufacturing method, the relative relationship among the pinning locations is adjusted, which makes it possible to prevent the organic light-emitting layers from becoming uneven in film thickness in all the light-emitting cells, and manufacture an organic light-emitting panel having excellent light-emitting characteristics.

[0078] In the above manufacturing method according to a further aspect of the present invention, in the third step, after the photoresist material is exposed and developed, an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell may be made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, by additionally performing an exposure process onto a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell, and an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell may be made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, by additionally performing an exposure process onto a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell.

[0079] With the above manufacturing method, the relative relationship among the pinning locations is adjusted, which makes it possible to prevent the organic light-emitting layers from becoming uneven in film thickness in all the light-emitting cells, and manufacture an organic light-emitting panel having excellent light-emitting characteristics.

[0080] An organic display device according to a further aspect of the present invention includes an organic light-emitting panel manufactured by any one of the above manufacturing methods according to another aspect of the present invention.

[0081] With the above manufacturing method, the relative relationship among the pinning locations is adjusted, which makes it possible to prevent the organic light-emitting layers from becoming uneven in film thickness in all the light-emitting cells, and manufacture an organic light-emitting panel having excellent light-emitting characteristics.

[0082] (Process by Which the Embodiment According to the Present Invention was Achieved)

[0083] As a result of intense study, the inventor of the present invention discovered the following with regard to the organic light-emitting panel recited in the Background Art and the organic display device provided with the organic light-emitting panel.

[0084] Typically, as shown in FIG. **20**, an anode **902** and an electrode coating layer **903** covering the anode **902** are formed on a substrate **901**, for each of sub-pixels **900***a*, **900***b*, and **900***c*. A hole injection layer **904** is then formed to cover the entire surface of the electrode coating layer **903** and the substrate **901**, and on the hole injection layer **904**, organic light-emitting layers **906***a*, **906***b*, and **906***c* of different colors are formed one-to-one in sub-pixels **900***a*, **900***b*, and **900***c*. The organic light-emitting layers **906***a*, **906***b*, and **906***c* are separated from each other by the banks formed to stand on the hole injection layer **904**.

[0085] Also, in the organic light-emitting panel, for example, a pixel is composed of three sub-pixels **900***a*, **900***b*, and **900***c*, and non-light-emitting cells **900***d* and **900***e* are present between the pixel and adjacent pixels on both sides thereof. Each of the non-light-emitting cells **900***d* and **900***e* has a bus bar **932** and an electrode coating layer **933** covering the bus bar **932**, but does not have an organic light-emitting layer.

[0086] As shown in FIG. **20**, in an organic light-emitting panel of a conventional technology, an uneven film thickness is observed in the organic light-emitting layers **906***a* and **906***c* of the sub-pixels **900***a* and **900***c* that are adjacent to the non-light-emitting cells **900***d* and **900***e*, respectively. More specifically, the organic light-emitting layer **906***a* in the sub-pixel **900***a* becomes higher at a point C_3 near the bank **905***a* than at a point C_4 near the bank **905***b* and also higher than the organic light-emitting layer **906***b* in the sub-pixel **900***b* at points C_1 and C_2 near the banks **905***b* and **905***c*. Similarly, the organic light-emitting layer **906***c* in the sub-pixel **900***c* becomes higher at a point C_5 near the bank **905***d* than at a point C_6 near the bank **905***c* and also higher than the organic light-emitting layer **906***b* in the sub-pixel **900***b* at points C_1 and C_2 near the banks **905***b* and **905***c*.

[0087] After repeated examination of the above phenomenon, the inventor assumed that reduction in uniformity of film thickness in the organic light-emitting layer is caused by a non-uniform vapor concentration distribution during ink drying, as described in the following. That is to say, as shown in FIG. **21**A, suppose a state in which ink **9060***c* for forming the organic light-emitting layer has been applied in an area between the bank **905***c* and the bank **905***d*, and the right-hand side of FIG. **21**A is lower than the left-hand side in vapor concentration distribution as indicated by the two dot chain line. In this case, the film thickness in the organic light-emitting layer becomes uneven for the following reasons.

[0088] As shown in FIG. **21**A, a surface profile L_{90} of ink **9060***c* has been swollen up at the center of the sub-pixel immediately after the ink is dripped. When drying the ink, due to the non-uniform vapor concentration distribution as mentioned above, the evaporation rate varies in reverse proportion to the vapor concentration, and therefore it can be theoretically considered that the ink changes to have a surface profile L_{91}.

[0089] However, as shown in FIG. **21**B, solvent in the ink **9061***c* flows during drying as shown by the dotted arrow L_{92}. This is because solvent flows to compensate for solvent that has evaporated (i.e. flows to minimize surface free energy), and along with the flow of the solvent, the solute (organic light-emitting material) also flows. Therefore, as shown in FIG. **21**C, if the vapor concentration distribution is not uniform, the organic light-emitting layer **906***c* is formed to have a surface profile L_{93} in which the closer to the bank **905***d* the layer is, the higher the layer is (i.e. the layer is higher at the point C_5 than at the point C_6).

[0090] The inventor therefore deduced that, in an organic light-emitting panel, the film thickness of the organic light-emitting layer decreases in uniformity due to non-uniformity of vapor concentration distribution during ink drying.

[0091] This led the inventor to reach a technical feature in which the bank sidewalls are made to have different inclination angles so that the bank sidewalls have different pinning locations, resulting in a uniform film thickness of the organic light-emitting layer.

Embodiment

[0092] The following describes an example of an embodiment of the present invention with reference to the drawings.

[0093] Note that the following Embodiment is simply an example to clearly illustrate a structure of the present invention and the acts and effects thereof. The present invention is in no way limited to the following Embodiment except in its essential characteristic elements.

[0094] 1. Configuration of Display Device **1**

[0095] The overall structure of the display device **1** according to the present Embodiment is described with reference to FIG. **1**.

[0096] As shown in FIG. **1**, the display device (organic display device) **1** includes a display panel unit **10** and a drive control unit **20** connected to the display panel unit **10**. The display panel unit **10** is an organic light-emitting panel that uses the phenomenon of electroluminescence occurring in organic material and is composed of a plurality of pixels arrayed two-dimensionally in the X-Y plane direction.

[0097] The drive control unit **20** is composed of four drive circuits **21**-**24** and a control circuit **25**.

[0098] Note that in an actual display device **1**, the placement of the drive control unit **20** with respect to the display panel unit **10** is not limited in this way.

[0099] 2. Structure of Display Panel **10**

[0100] The structure of the display panel **10** is described with reference to FIG. **2**. Note that, as an example, the display panel **10** in the present Embodiment is a top emission type organic light-emitting panel including a plurality of pixels arranged in a matrix, each pixel including sub-pixels that are each provided with an organic light-emitting layer having a luminescent color of either red (R), green (G), or blue (B). FIG. **2** depicts one sub-pixel **100** in a pixel.

[0101] As shown in FIG. **2**, in the display panel **10**, an anode **102** is formed above a TFT substrate (hereinafter simply referred to as a "substrate") **101**, and an electrode coating layer **103** and hole injection transporting layer **104** are layered above the anode **102** in this order. Note that the anode **102** and electrode coating layer **103** are formed separately for each sub-pixel **100**.

[0102] Above the hole injection transporting layer **104**, banks **105**, made of insulating material, are provided to stand to separate the sub-pixels **100** from each other. An organic light-emitting layer **106** is formed in the region in each sub-pixel **100** separated by the banks **105**, and an electron injection layer **107**, cathode **108**, and passivation layer **109** are layered above the organic light-emitting layer **106** in this order.

[0103] a) Substrate **101**

[0104] The substrate **101** is made of a base of an insulating material such as alkali-free glass, soda glass, non-fluorescent glass, phosphate glass, borate glass, quartz, acrylic resin, styrenic resin, polycarbonate resin, epoxy resin, polyethylene, polyester, silicone resin, alumina, etc. Although not illustrated, in the substrate **101**, a TFT layer, a passivation film, an interlayer insulation film, etc. are laminated.

[0105] b) Anode **102**

[0106] The anode **102** is composed of a single layer or of a laminate of a plurality of layers, either being made of a conductive material, such as aluminum (Al), alloy including Al, silver (Ag), alloy of silver, palladium, and copper (APC), alloy of silver, rubidium, and gold (ARA), alloy of molybdenum and chromium (MoCr), alloy of nickel and chromium (NiCr), etc. Note that in the case of a top emission type panel such as the panel in the Embodiment, it is preferable that the anode **102** be made of a highly reflective material.

[0107] c) Electrode Coating Layer **103**

[0108] The electrode coating layer **103** is made of, for example, indium tin oxide (ITO) and covers at least a part of the top surface the anode **102** in the Z axis direction.

[0109] d) Hole Injection Transporting Layer **104**

[0110] The hole injection transporting layer **104** is a layer of an oxide such as silver (Ag), molybdenum (Mo), chromium (Cr), vanadium (V), tungsten (W), nickel (Ni), or iridium (Ir), or a conductive polymer material such as PEDOT (Poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate)). A hole injection transporting layer **104** made of a metal oxide among the above materials has the function of assisting with hole generation and of injecting and transporting holes stably into the organic light-emitting layer **106**. The hole injection transporting layer **104** has a high work function.

[0111] When the hole injection transporting layer **104** is made of an oxide of a transition metal, a plurality of levels can be occupied since there are a plurality of oxidation numbers. This makes hole injection easy and allows for reduction of driving voltage.

[0112] e) Banks **105**

[0113] The banks **105** are made of an organic material such as resin and have insulating properties. Examples of the organic material used to form the banks **105** include acrylic resin, polyimide resin, novolac-type phenolic resin, etc. It is also preferable that the banks **105** have organic solvent resistance.

[0114] Furthermore, since the banks **105** are etched and baked when formed, it is preferable that the banks be made of a highly resistant material that will not change in shape or quality during the etching and baking processes. To provide the banks with liquid repellency, the sidewalls can be fluoridated.

[0115] Note that as the insulating material used in forming the banks **105**, any liquid repellent material with a resistivity of 10^5 Ω·cm can be used, starting with the above materials. Using a material with a resistivity of less than 10^5 Ω·cm leads to production of leak current between the anode **102** and the cathode **108**, or between adjacent sub-pixels **100**, which causes a variety of problems such as increased power consumption.

[0116] Furthermore, if a hydrophilic material is used to form the banks **105**, the difference in affinity/liquid repellency between the sidewall of the banks **105** and the surface of the hole injection transporting layer **104** becomes small, and it thus becomes difficult to selectively maintain the ink, which includes an organic substance for forming the organic light-emitting layer **106**, at the opening of the banks **105**.

[0117] The structure of the banks **105** need not be a single layer as shown in FIG. **2**, but may adopt a multi-layered structure composed of two or more layers. In such a case, the above materials may be combined for each layer, or layers may alternate between non-organic and organic material.

[0118] f) Organic Light-Emitting Layer **106**

[0119] The organic light-emitting layer **106** has a function to emit light when an excitation state is produced by the recombination of holes injected through the anode **102** with electrons injected through the cathode **108**. The material used to form the organic light-emitting layer **106** needs to be a light-emitting organic material, a film of which can be formed by wet printing.

[0120] More specifically, it is preferable that the organic light-emitting layer **106** be made of a fluorescent material such as an oxinoid compound, perylene compound, coumarin compound, azacoumarin compound, oxazole compound, oxadiazole compound, perinone compound, pyrrolo-pyrrole compound, naphthalene compound, anthracene compound, fluorene compound, fluoranthene compound, tetracene compound, pyrene compound, coronene compound, quinolone compound and azaquinolone compound, pyrazoline derivative and pyrazolone derivative, rhodamine compound, chrysene compound, phenanthrene compound, cyclopentadiene compound, stilbene compound, diphenylquinone compound, styryl compound, butadiene compound, dicyanomethylene pyran compound, dicyanomethylene thiopyran compound, fluorescein compound, pyrylium compound, thiapyrylium compound, selenapyrylium compound, telluropyrylium compound, aromatic aldadiene compound, oligophenylene compound, thioxanthene compound, anthracene compound, cyanine compound, acridine compound, metal complex of an 8-hydroxyquinoline compound, metal complex of a 2-bipyridine compound, complex of a Schiff base and a group three metal, metal complex of oxine, rare earth metal complex, etc., as recited in Japanese Patent Application Publication No. H5-163488.

[0121] g) Electron Injection Layer **107**

[0122] The electron injection layer **107** has a function to transport electrons injected through the cathode **108** to the organic light-emitting layer **106** and is preferably made of, for example, barium, phthalocyanine, lithium fluoride, or a combination thereof.

[0123] h) Cathode **108**

[0124] The cathode **108** is made of, for example, ITO, indium zinc oxide (IZO), etc. When the display panel **10** is a top-emission type, it is preferable that the cathode **108** be made of a light-transmissive material. It is preferable that the light transmissivity be 80% or greater.

[0125] The material used to form the cathode **108** may be, in addition to the above materials, for example, an alkali metal, alkali earth metal, or a laminate structure having, in the following order, a layer that includes a halide of an alkali metal or alkali earth metal and a layer that includes silver. The layer that includes silver may be made of silver alone, or from a silver alloy. Also, in order to increase light extraction efficiency, a highly-transparent refraction index adjustment layer may be provided above the layer that includes silver.

[0126] i) Passivation Layer **109**

[0127] The passivation layer **109** has a function to control the organic light-emitting layer **106** or other layers from being exposed to water or air and is made of, for example, silicon nitride (SiN), silicon oxynitride (SiON) etc. When the display panel **10** is a top-emission type, it is preferable that the passivation layer **109** be made of a light-transmissive material.

[0128] 3. Structure of Banks **105**

[0129] As shown in FIG. **3**, in the display panel **10** of the present Embodiment, the banks **105** are arranged in lines, as one example. More specifically, the banks **105** each extend along the Y axis and separate the adjacent sub-pixels **100** in the X axis direction. The sub-pixels **100** are formed so that each of the regions separated by the banks **105** in each pixel emits a different color. For example, one pixel is composed of three sub-pixels that emit light of red (R), green (G), and blue (B), respectively.

[0130] 4. Structure of Banks **105** in Each Region

[0131] The structure of the banks **105** in each region is described with reference to FIG. **4**. Note that FIG. **4** is a schematic cross-sectional view taken along line A-A' passing through the display panel **10** in FIG. **1**, and schematically illustrating some parts thereof.

[0132] As shown in FIG. **4**, in the display panel **10**, an anode **102** is formed on a TFT substrate (hereinafter simply referred to as a "substrate") **101** for each of sub-pixels **100***a*, **100***b*, and **100***c*, and an electrode coating layer **103** and hole injection transporting layer **104** are layered on the anode **102** in this order.

[0133] Above the hole injection transporting layer **104**, banks **105***a*, **105***b*, **105***c*, and **105***d* made of an insulating material are provided to stand to separate the sub-pixels **100***a*, **100***b*, and **100***c*. Note that, in each region of the sub-pixels **100***a*, **100***b*, and **100***c* separated by the banks **105***a*, **105***b*, **105***c*, and **105***d*, an organic light-emitting layer, electron injection layer, cathode, and passivation layer are layered in this order (not illustrated in FIG. **4**).

[0134] In the display panel **10** of the present Embodiment, one pixel is composed of a set of sub-pixels **100***a*, **100***b*, and **100***c*, and non-light-emitting cells **100***d* and **100***e* are provided between the pixel and adjacent pixels on both sides thereof, respectively. The sub-pixel **100***a* and the non-light-emitting cell **100***d* are separated from each other by a bank **105***a*, and the non-light-emitting cell **100***d* and an adjacent sub-pixel of a pixel that is on the left-hand side in the X axis direction are separated from each other by a bank **105***e*. The sub-pixel **100***c* and the non-light-emitting cell **100***e* are separated from each other by a bank **105***d*, and the non-light-emitting cell **100***e* and an adjacent sub-pixel of a pixel that is on the right-hand side in the X axis direction are separated from each other by a bank **105***f*.

[0135] As shown in FIG. **4**, in each of the non-light-emitting cells **100***d* and **100***e*, an electrode (bus bar) **302** which is made of the same material as the anode **102** is formed, and the electrode coating layer **303** is formed to cover the electrode **302**. The hole injection transporting layer **104** is provided to extend over and cover the electrode coating layers **303**. Although not illustrated, the cathode is formed above the hole injection transporting layer **104**, and the electrode **302** is electrically connected with the cathode **108**.

[0136] Note that, in the non-light-emitting cells **100***d* and **100***e*, no organic light-emitting layer is formed. The above structures help reduce electrical resistance in the cathode **108** made of ITO or the like, thus preventing a voltage drop.

[0137] As shown in FIG. **4**, in the display panel **10** of the present Embodiment, sidewalls **105***aa*, **105***ba*, **105***bb*, **105***cb*, **105***cc*, and **105***dc* of banks **105***a*, **105***b*, **105***c* and **105***d* respectively form angles θaa, θba, θbb, θcb, θcc, and θdc with surfaces of the hole injection transporting layers **104**, which are referred to as underlying layers here.

[0138] In the present Embodiment, the angles θaa, θba, θbb, θcb, θcc, and θdc satisfy the relationships in the following expressions.

$$\theta aa > \theta ba = \theta bb = \theta cb = \theta cc \quad \text{[Expression 1]}$$

$$\theta dc > \theta ba = \theta bb = \theta cb = \theta cc \quad \text{[Expression 2]}$$

[0139] Note that in the present Embodiment, the angles θaa, θba, θbb, θcb, θcc, and θdc are preferably be set within the following ranges.

$$25° < \theta ba = \theta bb = \theta cb = \theta cc < 35° \quad \text{[Expression 3]}$$

$$35° < \theta aa < 45° \quad \text{[Expression 4]}$$

$$35° < \theta dc < 45° \quad \text{[Expression 5]}$$

[0140] The reason why the inclination angles θaa, θba, θbb, θcb, θcc, and θdc of the sidewalls **105***aa*, **105***ba*, **105***bb*, **105***cb*, **105***cc*, and **105***dc* are set to satisfy the above Expressions 1 to 5 is that the arrangement of the non-light-emitting cells **100***d* and **100***e* between adjacent pixels and the ink application form of ink **1060***a*, **1060***b*, and **1060***c*, which will be described later, need to be taken into account.

[0141] 5. Relationship Between Inclination Angle θ of Sidewall of Banks **105** and Film Thickness of Organic Light-Emitting Layer **106**

[0142] The relationship between the inclination angles θ of the sidewalls of the banks **105** and the film thickness of the organic light-emitting layer **106** is described with reference to FIGS. **5** and **6**. Note that FIG. **5** is a schematic rendering of the structure of a sub-pixel.

[0143] As shown in FIG. **5**A, the inclination angle of the sidewall of bank **105***x* (the angle between the sidewall and the surface of the hole injection transporting layer **104**) is represented by angle θx, and as shown in FIG. **5**B, the inclination angle of the sidewall of bank **105***y* (the angle between the sidewall and the surface of the hole injection transporting layer **104**) is represented by angle θy. Here, the angles θx and θy satisfy the following relationship.

$\theta y>\theta x$ [Expression 6]

[0144] When ink **1060***x* and ink **1060***y*, which include an organic light-emitting material, are each dripped into the openings bounded by the banks **105***x* and **105***y*, respectively, the pinning locations Px and Py respectively have heights Hx and Hy that satisfy the following relationship.

$Hy>Hx$ [Expression 7]

[0145] As shown in FIG. **5**C, after drying the ink **1060***x*, the height Hx of the pinning location Px is relatively low, which causes the organic light-emitting layer **106***x* to swell at the central portion of the sub-pixel to a film thickness of Tx.

[0146] On the other hand, as shown in FIG. **5**D, after drying the ink **1060***y*, the height Hy of the pinning location Py is relatively high, which causes the organic light-emitting layer **106***y* to sag at the central portion of the sub-pixel to a film thickness of Ty.

[0147] The thicknesses Tx and Ty satisfy the following relationship.

$Tx>Ty$ [Expression 8]

[0148] FIG. **6** summarizes the above relationships. As shown in FIG. **6**, as the inclination angle (taper angle) θ of the bank **105** grows smaller, the pinning height H lowers, and as a result, the film thickness T of the organic light-emitting layer **106** becomes thicker. Conversely, as the inclination angle (taper angle) θ of the bank **105** grows larger, the pinning height H becomes higher, and as a result, the film thickness T of the organic light-emitting layer **106** becomes thinner.

[0149] Based on the above factors, five samples were created and evaluated. FIGS. **7** and **8** show the results.

[0150] As shown in FIGS. **7** and **8**, as compared to the distribution of film thickness of sample **2**, the pinning location is higher in samples **3** and **4**, which have a larger taper angle. Note that in FIGS. **7** and **8**, the horizontal axis represents the horizontal direction, and the vertical axis represents the direction of height.

[0151] In sample **5**, however, in which the bank has a taper angle (inclination angle) of 50°, the film thickness is less uniform than in sample **2**.

[0152] 6. Manufacturing Method of Display Panel **40**

[0153] The following describes the characteristic processes of the manufacturing method of the display panel **10** according to the present Embodiment with reference to FIGS. **9** and **10**. Note that with regard to the manufacturing processes that are omitted in the following description, any of the variety of processes suggested by conventional technologies may be used.

[0154] First, as shown in FIG. **9**A, above the substrate **101** in the direction of the Z axis, anodes **102** and electrode coating layers **103** are layered in this order in regions in which sub-pixels **1000***a*, **1000***b*, and **1000***c* are to be formed. Furthermore, a bus bar **302** and an electrode coating layer **303** are layered in this order in regions **1000***d* and **1000***e* in which non-light-emitting cells are to be formed. A hole injection transporting layer **104** is then layered on top of the electrode coating layers **103** and **303** so as to cover the entire surface. The anodes **102** and the bus bar **302** are formed, for example, by first forming a thin film made of Al or Al alloy or a thin Ag film by the sputtering method or vacuum deposition method and then patterning the thin Ag film by the photolithography method.

[0155] The electrode coating layers **103** and **303** are formed, for example, by forming a thin ITO film on the surface of the anodes **102** using a method such as the sputtering method and then patterning the thin ITO film by a method such as photolithography. To form the hole injection transporting layer **104**, first a metal film is formed on the surface of the substrate **101**, including the surfaces of the electrode coating layers **103** and **303**, by a method such as the sputtering method. Subsequently, the metal film becomes oxidized, forming the hole injection transporting layer **104**.

[0156] Next, as shown in FIG. **9**B, the spin coat method, for example, is used to form a bank material layer **1050** so as to cover the top of the hole injection transporting layer **104**. A photoresist material is used to form the bank material layer **1050**. Specifically, as described above, an organic material having insulating properties such as acrylic resin, polyimide resin, novolac-type phenolic resin, etc. can be used.

[0157] Next, as shown in FIG. **9**C, a mask **501** is placed above the bank material layer **1050**, the mask **501** having openings **501***a*, **501***b*, **501***c*, and **501***d* at the locations for forming the banks. In this state, exposure is performed via the openings **501***a*, **501***b*, **501***c*, and **501***d* of the mask **501**.

[0158] Note that, as shown in FIG. **9**C, in the mask **501**, a width Wb of the opening **501***b* located on the left-hand side of a region **1000***b* in which a sub-pixel is to be formed (hereinafter, such a region is referred to as "planned sub-pixel formation region"), is defined by points Pb**1** and Pb**2** positioned at the foots of the sidewalls **105***ba* and **105***bb* of the bank **105***b* that is to be formed (see FIG. **4**). The opening **501***c* in the mask **501**, which is located on the right-hand side of the planned sub-pixel formation region **1000***b*, is defined by a similar relationship.

[0159] On the other hand, a width Wa**1** of the opening **501***a* located between the planned sub-pixel formation region **1000***a* and the planned non-light-emitting cell formation region **1000***d* is defined by a point Pa**1** being at the upper edge of the sidewall **105***aa* of the bank **105***a* that is to be formed (see FIG. **4**) and a point Pa**2** being at the foot of the bank on the planned non-light-emitting cell formation region **1000***d* side (see FIG. **4**); and a width Wd**1** of the opening **501***d* located between the planned sub-pixel formation region **1000***c* and the planned non-light-emitting cell formation region **1000***e* is defined by a point Pd**1** being at the upper edge of the sidewall **105***dc* of the bank **105***d* that is to be formed (see FIG. **4**) and a point Pd**2** being at the foot of the bank on the planned non-light-emitting cell formation region **1000***e* side (see FIG. **4**).

[0160] Next, as shown in FIG. **10**A, a mask **502** is placed above the bank material layer **1050**, the mask **502** having openings **502***a* and **502***d* at the locations corresponding to respective sidewalls **105***aa* and **105***dc* of the banks **105***a* and **105***d* (see FIG. **4**). In this state, the second exposure is performed via the openings **502***a* and **502***d* of the mask **502**.

[0161] Note that, as shown in FIG. **10**A, in the mask **502**, a width Wa**2** of the opening **502***a* is defined by a point Pa**3** being at the foot of the sidewall **105***aa* of the bank **105***a* that is to be formed and a point Pa**1** being at the upper edge of the sidewall **105***aa*; and a width Wd**2** of the opening **502***d* is defined by a point Pd**3** being at the foot of the sidewall **105***dc* of the bank **105***d* that is to be formed and a point Pd**1** being at the upper edge of the sidewall **105***dc*.

[0162] Next, the development and baking are performed to form the banks **105***a*, **105***b*, **105***e*, and **105***d* as shown in FIG. **10**B. As described above, the sidewall **105***aa* of the bank **105***a* on the planned sub-pixel formation region **1000***a* side and the sidewall **105***dc* of the bank **105***d* on the planned sub-pixel formation region **1000***c* side are larger than the sidewalls **105***ba*, **105***bb*, **105***cb*, and **105***cc* of the banks **105***b* and **105***c* in inclination angle.

[0163] Subsequently, as shown in FIG. **11**, the following inks are applied to the following openings substantially at the same time by the inkjet method or the like, the inks all including an organic light-emitting material: ink **1060***a* to an opening (the planned sub-pixel formation region **1000***a*) bounded by the banks **105***a* and **105***b*; ink **1060***b* to an opening (the planned sub-pixel formation region **1000***b*) bounded by the banks **105***b* and **105***c*; and ink **1060***c* to an opening (the planned sub-pixel formation region **1000***c*) bounded by the banks **105***c* and **105***d*.

[0164] Here, since, as described above, the inclination angle θaa of the sidewall **105***aa* of the bank **105***a* and the inclination angle θdc of the sidewall **105***dc* of the bank **105***d* are set to be larger than the inclination angles θba, θbb, θcb, and θcc of the other sidewalls, the pinning locations Qaa and Qdc of the inks **1060***a* and **1060***c* in the sidewalls **105***aa* and **105***dc* of the banks **105***a* and **105***d* become higher in position than the pinning locations Qba, Qbb, Qcb, and Qcc.

[0165] By setting the pinning locations Qaa and Qdc to be higher than the other pinning locations Qba, Qbb, Qcb, and Qcc, it is possible to prevent the formed organic light-emitting layer from having a non-uniform film thickness. More specifically, when an ink application method of applying the inks **1060***a*, **1060***b*, and **1060***c* substantially at the same time is adopted, due to the presence of the planned non-light-emitting cell formation regions **1000***d* and **1000***e* on the left-hand side of the planned sub-pixel formation region **1000***a* and on the right-hand side of the planned sub-pixel formation region **1000***c* respectively, non-uniformity of vapor concentration distribution in the horizontal direction arises in each of the planned sub-pixel formation regions **1000***a* and **1000***c*. In such a case, by setting the respective inclination angles θaa and θdc of the sidewalls **105***aa* and **105***dc* of the banks **105***a* and **105***d* to be larger than those of the other sidewalls, the formed organic light-emitting layer **106** can be prevented from having a non-uniform film thickness.

[0166] Note that, although not illustrated, subsequently the ink is dried, and the electron injection layer **107**, cathode **108**, passivation layer **109**, etc, are layered in this order to form the display panel **10**.

[0167] 7. Advantageous Effects

[0168] As shown in FIG. **4**, in the display panel **10** of the display device **1** according to the present Embodiment, inclination angle θaa of the sidewall **105***aa* of the bank **105***a* positioned on the sub-pixel **100***a* side, and inclination angle θdc of the sidewall **105***dc* of the bank **105***d* positioned on the sub-pixel **100***c* side, are set larger than the inclination angles θba, θbb, θcb, and θcc of other sidewalls **105***ba*, **105***bb*, **105***cb*, and **105** cc. As a result, as shown in FIG. **11**, when the inks **1060***a*, **1060***b*, and **1060***c* are applied, the pinning locations Qaa and Qdc are higher in position than the other pinning locations Qba, Qbb, Qcb, and Qcc.

[0169] θn the other hand, inclination angles θba, θbb, θcb, and θcc of sidewalls **105***ba*, **105***bb*, **105***cb*, and **105***cc* are equal.

[0170] This enables sub-pixels **100***a*, **100***b*, and **100***c* to have a uniform film thickness in the organic light-emitting layer **106** of the display panel **10** after drying, which produces an advantageous effect of having little luminance unevenness.

[0171] Note that, by using the manufacturing method of the display device **1** in the present Embodiment, which has been described with reference to FIGS. **9**, **10**, and **11**, the display device **1** having the above advantageous effect can be manufactured.

[0172] Also, the term “equal” does not necessarily mean that the targets are completely equal with each other in numerical value, but includes, for example, a measurement error in manufacturing of the display device **1**. More specifically, it is suggested that, in the display panel **10**, the inclination angles are recognized as being equal as far as the difference in luminous efficiency (luminance unevenness) between sub-pixels **100***a*, **100***b*, and **100***c*, which correspond to the inclination angles, falls in an acceptable range.

[Modification 1]

[0173] Next, with reference to FIG. **12**, Modification 1 of the manufacturing method of the display device **1** is described. FIG. **12** illustrates processes corresponding to processes illustrated in FIGS. **9**C to **10**A.

[0174] As shown in FIG. **12**, first a bank material layer **1050** is formed to cover the hole injection transporting layer **104**, and then a mask **503** is placed above the bank material layer **1050**. The mask **503** is provided with light transmissive portions **503***a***1**, **503***a***2**, **503***b*, **503***c*, **503***d***1**, and **503***d***2**. The light transmissive portions **503***a***1** and **503***a***2** are provided at locations corresponding to a portion in which the bank **105***a* is to be formed; the light transmissive portion **503***b* is provided at a location corresponding to a portion in which the bank **105***b* is to be formed; the light transmissive portion **503***c* is provided at a location corresponding to a portion in which the bank **105***c* is to be formed; and the light transmissive portions **503***d***1** and **503***d***2** are provided at locations corresponding to a portion in which the bank **105***d* is to be formed.

[0175] In the manufacturing method of the display device **1** in Modification 1, width Wb of the light transmissive portion **503***b*, which corresponds to the left-hand side of the planned sub-pixel formation region **1000***b*, is defined by points Pb1 and Pb2 at the feet of the sidewalls **105***ba* and **105***bb* of the bank **105***b* (see FIG. **4**) that is to be formed.

[0176] On the other hand, width Wa1 of the light transmissive portion **503***a***1**, which corresponds to a region between the planned sub-pixel formation region **1000***a* and the planned non-light-emitting cell formation region **1000***d*, is defined by a point Pa2 being at the foot of the bank **105***a* that is to be formed (see FIG. **4**); and width Wa2 of the light transmissive portion **503***a***2** is defined by points Pa1 and Pa3 that are positioned at the upper edge and the foot of the sidewall **105***aa* of the bank **105***a* that is to be formed, respectively (see FIG. **4**). Similarly, width Wd1 of the light transmissive portion **503***d***1**, which corresponds to a region between the planned sub-pixel formation region **1000***c* and the planned non-light-emitting cell formation region **1000***e*, is defined by a point Pd2 being at the foot of a sidewall of the bank **105***d* to be formed, on the planned non-light-emitting cell formation region **1000***e* side (see FIG. **4**); and width Wd2 of the light transmissive portion **503***d***2** is defined by points

Pd**1** and Pd**3** that are positioned at the upper edge and the foot of the sidewall **105***dc* of the bank **105***d*, respectively (see FIG. **4**).

[0177] The mask **503** is made from a half-tone or the like, and the light transmissive portions **503***a***1**, **503***b*, **503***c*, and **503***d***1** differ from the light transmissive portions **503***a***2** and **503***d***2** in light transmissivity. More specifically, the light transmissive portions **503***a***2** and **503***d***2** are larger than the light transmissive portions **503***a***1**, **503***b*, **503***c*, and **503***d***1** in light transmissivity.

[0178] In the state where the mask **503** having the above structure is set in place, the exposure and development, and then baking are performed to form the banks **105***a*, **105***b*, **105***c*, and **105***d* as shown in FIG. **10**B. That is to say, sidewalls having larger inclination angles are formed at locations which are exposed to light via the light transmissive portions **503***a***2** and **503***d***2** having a larger light transmissivity than the light transmissive portions **503***a***1**, **503***b*, **503***c*, and **503***d***1**, in accordance with the relationships indicated by the Expressions 1 and 2.

[0179] Note that subsequent processes are the same as those in the above Embodiment.

[0180] The display device **1** can be manufactured by the above manufacturing method as well.

[Modification 2]

[0181] Next, with reference to FIGS. **13** and **14**, Modification 2 of the manufacturing method of the display device **1** is described. FIGS. **13**A to **14**B illustrate processes corresponding to the processes illustrated in FIGS. **9**C to **10**B.

[0182] As shown in FIG. **13**A, first a bank material layer **1050** is formed to cover the hole injection transporting layer **104**, and then a mask **504** is placed above the bank material layer **1050**. The mask **504** has openings **504***a*, **504***b*, **504***c*, and **504***d* corresponding to the portions at which banks **105** are to be formed.

[0183] The openings **504***b* and **504***c* are formed to have the same width as the openings **501***b* and **501***c* in the mask **501** used in the manufacturing method of the above Embodiment.

[0184] On the other hand, a width Wa**3** of the opening **504***a* located between the planned sub-pixel formation region **1000***a* and the planned non-light-emitting cell formation region **1000***d* in correspondence with the bank **105***a* that is to be formed (see FIG. **4**) is set to be larger than a width that is defined by points Pa**1** and Pa**3** being at the feet of the bank **105***a* that is to be formed (see FIG. **4**), as indicated by the two dot chain line in FIG. **13**A; and a width Wd**3** of the opening **504***d* located between the planned sub-pixel formation region **1000***c* and the planned non-light-emitting cell formation region **1000***e* in correspondence with the bank **105***d* that is to be formed (see FIG. **4**) is set to be larger than a width that is defined by points Pd**2** and Pd**3** being at the feet of the bank **105***d* that is to be formed (see FIG. **4**), as indicated by the two dot chain line in FIG. **13**A. More specifically, the width is made larger at the portions where the inclination angles are to be larger.

[0185] In the state where the mask **504** is set in place as shown in FIG. **13**A, the exposure and development in the first round are performed. After this process is performed, as shown in FIG. **13**B, bank material layers **1051***a*, **1051***b*, **1051***c*, and **1051***d* remain in the locations corresponding to the openings **504***a*, **504***b*, **504***c*, and **504***d.*

[0186] Note that, as shown in FIG. **13**B, the inclination angles of the sidewalls in the bank material layers **1051***a*, **1051***b*, **1051***c*, and **1051***d* are uniform after the first exposure and development are performed. It should be noted however that the widths of the bank material layers **1051***a* and **1051***d* in the X axis direction are larger than the widths of the bank material layers **1051***b* and **1051***c* in the X axis direction.

[0187] In Modification 2, the baking is not performed at this point in time.

[0188] As shown in FIG. **14**A, a mask **505** is placed above the bank material layers **1051***a*, **1051***b*, **1051***c*, and **1051***d* after they are formed. In the mask **505**, openings (**505***a* and **505***d*) are provided only at the locations where the inclination angles are to be larger (sidewall **105***aa* of the bank **105***a*, and sidewall **105***dc* of the bank **105***d*) among the locations in the mask **505** corresponding to the sidewalls of the banks **105***a*, **105***b*, **105***c*, and **105***d* that are to be formed.

[0189] In the state where the mask **505** is set in place, the exposure and development in the second round are performed, and then the baking is performed to form the banks **105***a*, **105***b*, **105***c*, and **105***d* as shown in FIG. **14**B.

[0190] Subsequently, the display device **1** can be manufactured by performing the same processes as in the above Embodiment or the like.

[Verification of Manufacturing Method]

[0191] Using a concrete example, the shape of the banks after formation was verified for the manufacturing methods of the above Embodiment and Modifications 1 and 2. The results are described with reference to FIG. **16**.

[0192] As shown in FIG. **15**A, the larger the amount of exposure is, the larger the inclination angle of a sidewall of a formed bank is. More specifically, when the exposure and development are performed with 200 mJ of exposure amount, the inclination angle of a sidewall of the formed bank is 23°, whereas when the exposure and development are performed with 300 mJ of exposure amount, the inclination angle of a sidewall of the formed bank is 38°. The results are also shown by the Atomic Force Microscope (AFM) in FIG. **15**B.

[0193] Furthermore, as shown in FIGS. **15**A and **15**B, when the exposure and development in the first round is performed with 200 mJ of exposure amount and then the exposure and development in the second round is performed with 100 mJ of exposure amount, the inclination angle of a sidewall of the formed bank is 50°. This corresponds to the manufacturing method of Modification 2 and is considered to be effective in creating a large inclination angle of the bank sidewall.

[0194] Note that in FIG. **15**B, the horizontal axis represents the horizontal direction, and the vertical axis represents the direction of height.

[Other Considerations]

[0195] Firstly, in the above Embodiment and Modifications 1 and 2, it is schematically illustrated that the surface of each sidewall of the banks **105**, **105***a*-**105***d*, **105***x*, and **105***y* is planar. However, the surface of each sidewall of the banks may not necessarily be planar. For example, FIG. **16**A illustrates a bank **605** whose sidewall has two surfaces: a surface extending from a point P_{61} to a point P_{62}; and a surface extending from the point P_{62} to a point P_{63}. In this case, a pinning location Qy**1** during ink application is present on the surface between the points P_{62} and P_{63}. Here, an inclination angle θy**2** formed between this the surface and a virtual straight line L_1 passing through the point P_{62} is important in the relationship with the pinning location.

[0196] However, the angle θy**2** can be controlled by controlling an angle θy**1**, which is formed between the surface of the underlying layer, namely the hole injection transporting layer **104**, and the surface between points P_{61} and P_{62} of the sidewall of the bank **605**, when the bank **605** is formed. Thus, in the actuality, the above effects can be obtained by controlling the inclination angle θy**1**. For example, if a bank **705** is formed such that an angle θy**11** formed between the surface of the hole injection transporting layer **104** and a surface between points P_{71} and P_{72} is larger than the angle θy**1** shown in FIG. **16**A (see FIG. **16**B), then an angle θy**12** formed between a surface between points P_{72} and P_{73} and a virtual straight line L_2 also becomes larger than the angle θy**2** shown in FIG. **16**A.

[0197] Secondly, in the above Embodiment and Modifications 1 and 2, it is not specified to what part of the region of the display panel **10** the above-described structure can be applied. However, the above-described structure may be applied to the entire region of the display panel, or may be applied to a part of the region. As shown in FIG. **17**, the display panel **10** can be divided formally into areas **10***a* and **10***b* in a direction along the surface of the display panel **10**, wherein the area **10***a* is located at the center, and the area **10***b* surrounds the area **10***a*. The area **10***a* is connected to a source electrode or a drain electrode of the TFT layer below which the anodes are formed, and contributes to the emission of light. On the other hand, the area **10***b* is not connected to any of the source electrode and drain electrode of the TFT layer below which the anodes are formed, and does not contribute to the emission of light. It is considered that, if the area **10***a* is further divided formally into a central area **10***a***1** and a surrounding area **10***a***2**, the uneven film thickness in the organic light-emitting layers of the sub-pixels in the surrounding area **10***a***2** would be more prominent due to the state of vapor concentration distribution during the application of ink.

[0198] Note that the combined area of the surrounding area **10***a***2** and the area **10***b* may occupy approximately 0.5% to several percent (for example, 1%) of the total area of the panel. This range is determined by taking account of the variation in film thickness of the organic light-emitting layers when the inclination angles of the bank sidewalls are not adjusted.

[0199] In the above Embodiment and Modifications 1 and 2, the structures are adopted by way of example to clearly explain the structure, acts and effects of the present invention. Accordingly, the present invention is not limited to the above structures, except for such portions that are essential to the present invention. For example, the above Embodiment has adopted, as one example, a structure in which the anodes **102** are located below the organic light-emitting layers **106** in the Z axis direction, as shown in FIG. **2**. However, not limited to this structure, the present invention may adopt a structure in which the cathodes **108** are located below the organic light-emitting layers **106** in the Z axis direction.

[0200] The display panel has the top-emission structure when it adopts the structure in which the cathodes **108** are located below the organic light-emitting layers **106** in the Z axis direction. In that case, the cathodes **108** become the reflecting electrode layers, and the electrode coating layers **103** are formed above the cathodes **108**.

[0201] Furthermore, the above Embodiment and Modifications do not provide a specific example of the appearance of the display device **1**. However, the display device **1** may be formed as a part of a system illustrated in FIG. **18**, for example. Note that an organic EL display device does not require a backlight as a liquid crystal display device does, and thus is suitable for thin display devices and has excellent characteristics from the view point of system design.

[0202] Also, in the above Embodiment and Modifications 1 and 2, a so-called line bank structure is adopted for the banks **105**, **105***a*-**105***f*, **105***x*, **105***y*, **605**, and **705**, as shown in FIG. **3**. However, not limited to this, the structure of pixel bank **805** shown in FIG. **19** may be adopted. In this structure, a display panel **80** includes the pixel bank **805** which is composed of bank elements **805***a* and bank elements **805***b*, wherein the bank elements **805***a* extend in the Y axis direction and the bank elements **805***b* extend in the X axis direction.

[0203] As shown in FIG. **19**, when the structure of pixel bank **805** is adopted, the same advantageous effects as the above ones can be obtained by increasing the inclination angles of the sidewalls of the bank **805** in the X and Y axis directions defining the sub-pixels **800***a*, **800***b*, and **800***c*. More specifically, the above advantageous effects can be obtained by appropriately adjusting the inclination angles of the sidewalls indicated by the arrows B_1, B_2, B_3, and B_4.

[0204] Also, the inclination angles of the sidewalls of the banks adopted in the above Embodiment and Modifications 1 and 2 may be individually adjusted depending on the vapor concentration distribution observed in the ink application process and drying process when the organic light-emitting layers are formed in the manufacturing process. For example, if the drying device used in the ink drying process has a structure where the vapor flows from the outer circumference of the panel toward the center of the panel, bank sidewalls where the organic light-emitting layers are large in film thickness may have increased inclination angles. This enables the film thickness of the organic light-emitting layers to be uniform, thereby reducing the unevenness in luminance over the entire panel.

[0205] In the above Embodiment and in Modifications 1 and 2, the inclination angle (i.e. taper angle) of bank sidewalls is set in the same manner, without distinction between the luminescent colors (red, green, and blue). However, there may be a case where the organic light-emitting materials of the ink for the respective luminescent colors have different characteristics. In that case, the inclination angles of the bank sidewalls may be defined in accordance with the ink characteristics of each luminescent color.

INDUSTRIAL APPLICABILITY

[0206] The present invention is useful for providing an organic light-emitting panel and an organic display device that exhibit substantially even luminance and are capable of displaying high-quality images.

REFERENCE SIGNS LIST

[0207] **1** display device

[0208] **10**, **80** display panel

[0209] **10***a***1** light-emitting central area

[0210] **10***a***2** light-emitting surrounding area

[0211] **10***b* dummy area

[0212] **20** drive control unit

[0213] **21**-**24** drive circuit

[0214] **25** control circuit

[0215] **100**, **100***a*-**100***c* sub-pixel

[0216] **100***d*, **100***e* non-light-emitting cell

[0217] **101** substrate

[0218] **102** anode

[0219] **103**, **303** electrode coating layer

[0220] **104** hole injection layer

[0221] **105**, **105***a*-**105***f*, **105***x*, **105***y*, **605**, **705**, **805** bank

[0222] **106**, **106***x*, **106***y* organic light-emitting layer

[0223] **107** electron injection layer

[0224] **108** cathode

[0225] **109** passivation layer

[0226] **302** bus bar

[0227] **501**-**505** mask

[0228] **1000***a*-**1000***c* region in which sub-pixel is to be formed

[0229] **1000***d*, **1000***e* non-light-emitting cell

[0230] **1050**, **1051***a*, **1051***b*, **1051***c*, **1051***d* bank material layer

[0231] **1060***a*-**1060***c*, **1060***x*, **1060***y* ink

1. An organic light-emitting panel comprising:

an array of a plurality of pixels;

one or more non-light-emitting cells each being provided between a different pair of adjacent pixels;

a plurality of light-emitting cells provided in such a manner that each pixel includes at least three light-emitting cells that are arranged in an alignment and emit light of different colors, the at least three light-emitting cells including a first light-emitting cell located at an end of the alignment, a second light-emitting cell located at a central portion of the alignment, and a third light-emitting cell located at another end of the alignment;

an underlying layer formed below the array of the plurality of pixels;

a plurality of first electrodes each included in the underlying layer and placed below a different one of the plurality of light-emitting cells;

a plurality of organic light-emitting layers each formed in a different one of the plurality of light-emitting cells by applying, for each pixel, at least three types of ink, that contain different organic light-emitting materials corresponding one-to-one to the different colors of light, respectively to the at least three light-emitting cells substantially at a same time;

a second electrode formed to be away from the underlying layer with each organic light-emitting layer therebetween; and

a plurality of banks formed above the underlying layer, separating the light-emitting cells, and defining each light-emitting cell,

each of the plurality of pixels being structured such that

among inner sidewalls facing each other in respective adjacent banks defining the first light-emitting cell and the third light-emitting cell, sidewalls adjacent to non-light-emitting cells have larger inclination angles than sidewalls adjacent to the second light-emitting cell, and

inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell have substantially equal inclination angles.

2. The organic light-emitting panel of claim **1**, wherein

each of the one or more non-light-emitting cells includes none of the organic light-emitting layers, includes a third electrode made of a same material as a material of the first electrodes, is placed below the second electrode, and electrically connects the third electrode with the second electrode.

3. The organic light-emitting panel of claim **1**, wherein

the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell and

the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell have substantially equal inclination angles.

4. The organic light-emitting panel of claim **1**, wherein

the sidewall adjacent to the second light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell and the inner sidewalls facing each other in the adjacent banks defining the second light-emitting cell have substantially equal inclination angles.

5. The organic light-emitting panel of claim **1**, wherein

the sidewall adjacent to the second light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell and the inner sidewalls facing each other in the adjacent banks defining the second light-emitting cell have substantially equal inclination angles.

6. The organic light-emitting panel of claim **1**, wherein

an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell is in a range from 35 degrees to 45 degrees inclusive,

an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell is in a range from 35 degrees to 45 degrees inclusive,

an inclination angle of the sidewall adjacent to the second light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell is in a range from 25 degrees to 35 degrees inclusive,

an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell is in a range from 25 degrees to 35 degrees inclusive, and

inclination angles of the inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell are in a range from 25 degrees to 35 degrees inclusive.

7. The organic light-emitting panel of claim **1**, wherein

each inclination angle is formed between each of inner sidewalls facing each other in adjacent banks and an upper surface of the underlying layer.

8. An organic display device including an organic light-emitting panel defined in claim **1**.

9. A manufacturing method of an organic light-emitting panel including an array of a plurality of pixels and one or more non-light-emitting cells that are each provided between a different pair of adjacent pixels, the manufacturing method comprising:

a first step of forming, on a substrate, an underlying layer including a plurality of first electrodes;

a second step of layering a photoresist material on the underlying layer;

a third step of forming, for each pixel, a plurality of openings corresponding to a plurality of light-emitting cells and one or more openings corresponding to the non-light-emitting cells by performing an exposure with a mask laid on the layered photoresist material to form a pattern, and forming a plurality of banks to separate the light-emitting cells and the non-light-emitting cells and define each light-emitting cell and each non-light-emitting cell;

a fourth step of forming a plurality of organic light-emitting layers by dripping ink that includes organic light-emitting materials into the plurality of openings corresponding to the plurality of light-emitting cells, and drying the ink; and

a fifth step of forming a second electrode above each organic light-emitting layer,

in the third step,

for each of at least part of the plurality of pixels to be formed, a first opening corresponding to a first light-emitting cell located at an end of an alignment in which the light-emitting cells are to be formed, a second opening corresponding to a second light-emitting cell located at a central portion of the alignment, and a third opening corresponding to a third light-emitting cell located at another end of the alignment, are formed,

further each of the plurality of pixels is formed such that

among inner sidewalls facing each other in respective adjacent banks defining the first light-emitting cell and the third light-emitting cell, sidewalls adjacent to non-light-emitting cells have larger inclination angles than sidewalls adjacent to the second light-emitting cell, and

inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell have substantially equal inclination angles, and

in the fourth step, the organic light-emitting layers are formed by dripping, for each pixel, three types of ink corresponding one-to-one to three colors of light into the first opening, the second opening and the third opening substantially at a same time.

10. The manufacturing method of claim **9**, wherein

in the third step,

when the exposure of the photoresist material is performed, an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell is made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, by causing a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell to be exposed to a larger amount of light than a part of the photoresist material corresponding to the sidewall adjacent to the second light-emitting cell, and

an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell is made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, by causing a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell to be exposed to a larger amount of light than a part of the photoresist material corresponding to the sidewall adjacent to the second light-emitting cell.

11. The manufacturing method of claim **9**, wherein

in the third step,

when the exposure of the photoresist material is performed, an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell is made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, by using different masks for respective parts of the photoresist material corresponding to the two sidewalls so that a light transmissivity at a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell is lower than a light transmissivity at a part of the photoresist material corresponding to the sidewall adjacent to the second light-emitting cell, and

an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell is made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, by using different masks for respective parts of the photoresist material corresponding to the two sidewalls so that a light transmissivity at a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell is lower than a light transmissivity at a part of the photoresist material corresponding to the sidewall adjacent to the second light-emitting cell.

12. The manufacturing method of claim **9**, wherein

in the third step,

after the photoresist material is exposed and developed,

an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the first light-emitting cell is made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, by additionally performing an exposure process onto a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell, and

an inclination angle of the sidewall adjacent to a non-light-emitting cell among inner sidewalls facing each other in two adjacent banks defining the third light-emitting cell is made larger than an inclination angle of the sidewall adjacent to the second light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, by additionally performing an exposure process onto a part of the photoresist material corresponding to the sidewall adjacent to the non-light-emitting cell.

13. An organic display device including an organic light-emitting panel manufactured by a manufacturing method defined in claim **9**.

* * * * *

专利名称(译)	有机发光面板，其制造方法以及有机显示装置		
公开(公告)号	US20120193658A1	公开(公告)日	2012-08-02
申请号	US13/434070	申请日	2012-03-29
申请(专利权)人(译)	松下电器产业株式会社		
当前申请(专利权)人(译)	松下电器产业株式会社		
[标]发明人	MATSUSHIMA HIDEAKI		
发明人	MATSUSHIMA, HIDEAKI		
IPC分类号	H01L51/52 H01L51/56		
CPC分类号	H01L27/3218 H01L27/3223 H05B33/10 H01L51/0005 H01L27/3246 H01L27/3248		
其他公开文献	US8624275		
外部链接	Espacenet USPTO		

摘要(译)

面板中的像素包括子像素100a，100b和100c。非发光单元100d和100e分别设置在其两侧的像素和相邻像素之间。子像素100a和非发光单元100d的有机发光层由堤105a分开。类似地，子像素100c和非发光单元100e的有机发光层由堤105d分开;子像素100a和100b的有机发光层由堤105b分开;子像素100b和100c的有机发光层由堤105c分开。与同胞像素100a相邻的堤105a的侧壁105aa的倾斜角θaa和与同胞像素100c相邻的堤105d的侧壁105dc的倾斜角θdc大于其他倾斜角θba，θbb，θcb和θcc。