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(12) **United States Patent**
Matsushima

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(45) **Date of Patent:** ***Dec. 9, 2014**

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 86 days.

This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

- (63) Continuation of application No. PCT/JP2010/006143, filed on Oct. 15, 2010.

(51) **Int. Cl.**

H01L 29/18 (2006.01)
H01L 29/20 (2006.01)
H01L 33/00 (2010.01)
H01L 29/08 (2006.01)
H01L 21/00 (2006.01)
H01L 51/50 (2006.01)
H01L 27/32 (2006.01)
H01L 33/08 (2010.01)
H01L 51/56 (2006.01)
H01L 51/00 (2006.01)
H01L 51/52 (2006.01)

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

CPC **H01L 51/50** (2013.01); **H01L 27/3246** (2013.01); **H01L 33/08** (2013.01); **H01L 51/56** (2013.01); **H01L 51/0005** (2013.01); **H01L 27/3211** (2013.01); **H01L 51/5228** (2013.01); **H01L 51/5234** (2013.01)
USPC **257/89**; 257/88; 257/40; 257/E51.018; 257/E51.022; 438/34; 438/35

(58) **Field of Classification Search**

CPC H01L 27/3246; H01L 27/3211; H01L

27/3276; H01L 27/3283; H01L 27/3295; H01L 51/0005; H01L 51/50; H01L 51/56; H01L 51/5228; H01L 51/5234; H01L 33/08
USPC 257/40, 88, 89, E27.119, E51.018, 257/E51.022; 438/28, 34, 35; 315/504
See application file for complete search history.

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Primary Examiner — Fernando L Toledo

Assistant Examiner — Aaron Gray

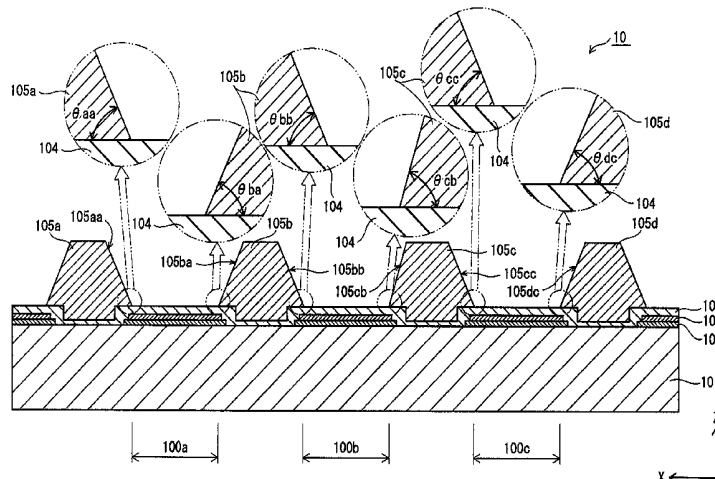
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(57)

ABSTRACT

A pixel in the panel includes sub-pixels **100a**, **100b**, and **100c**. Bank **105a** separates organic light-emitting layer of sub-pixel **100a** and organic light-emitting layer of a sub-pixel of a pixel that is adjacent to sub-pixel **100a**. Bank **105d** separates organic light-emitting layer of sub-pixel **100c** and organic light-emitting layer of a sub-pixel of a pixel that is adjacent to sub-pixel **100c**. Bank **105b** separates organic light-emitting layer of sub-pixel **100a** and organic light-emitting layer of sub-pixel **100b**. Bank **105c** separates organic light-emitting layer of sub-pixel **100b** and organic light-emitting layer of sub-pixel **100c**. Inclination angle θ_{cb} of sidewall **105cb** of bank **105c** located on the side of sub-pixel **100c** is set to be larger than other inclination angles θ_{aa} , θ_{ba} , θ_{bb} , θ_{cc} and θ_{dc} .

37 Claims, 26 Drawing Sheets



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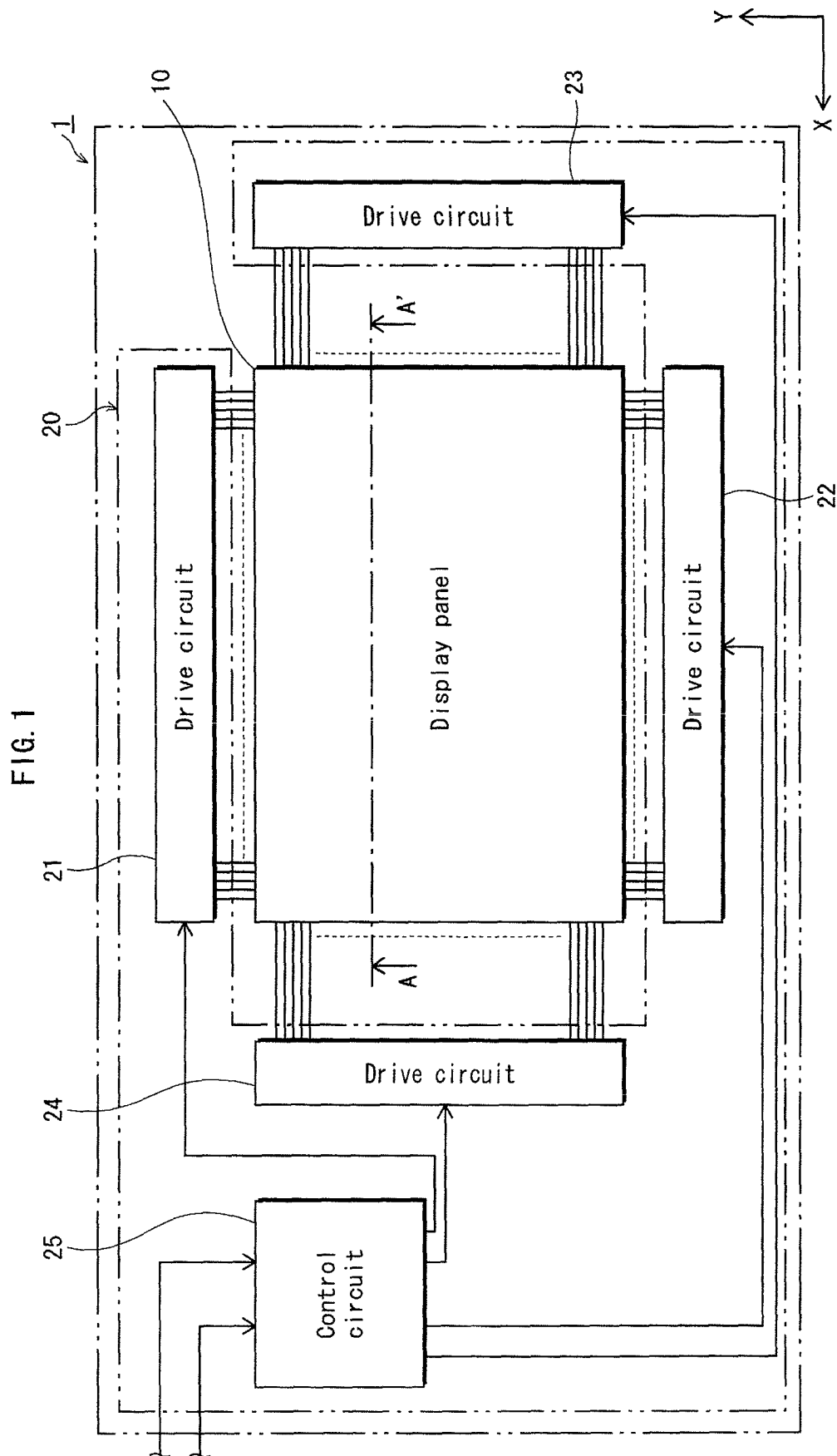


FIG. 2

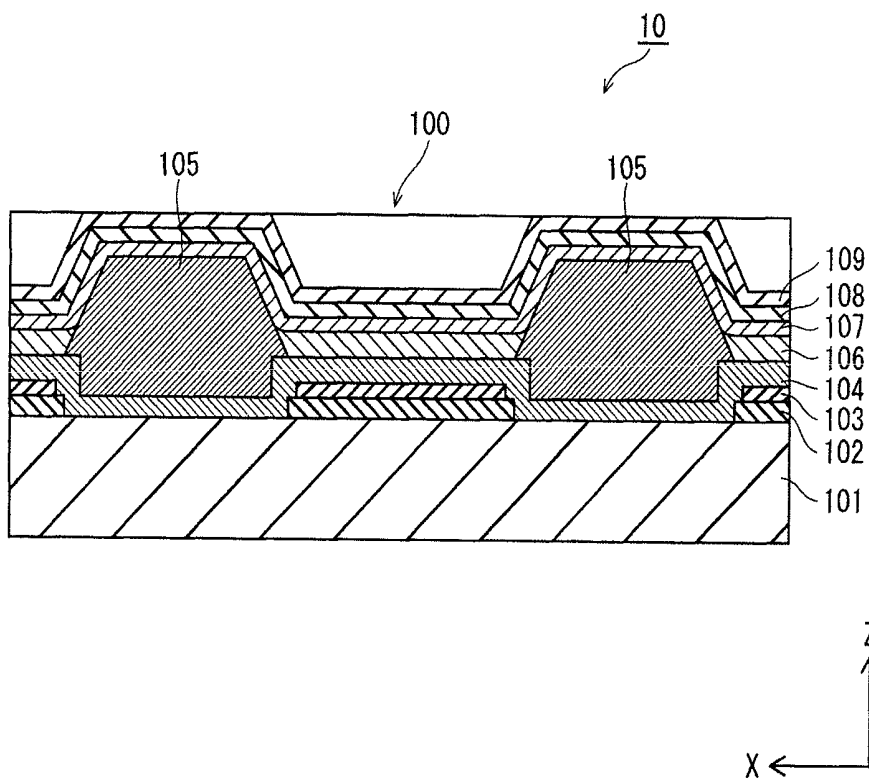


FIG. 3

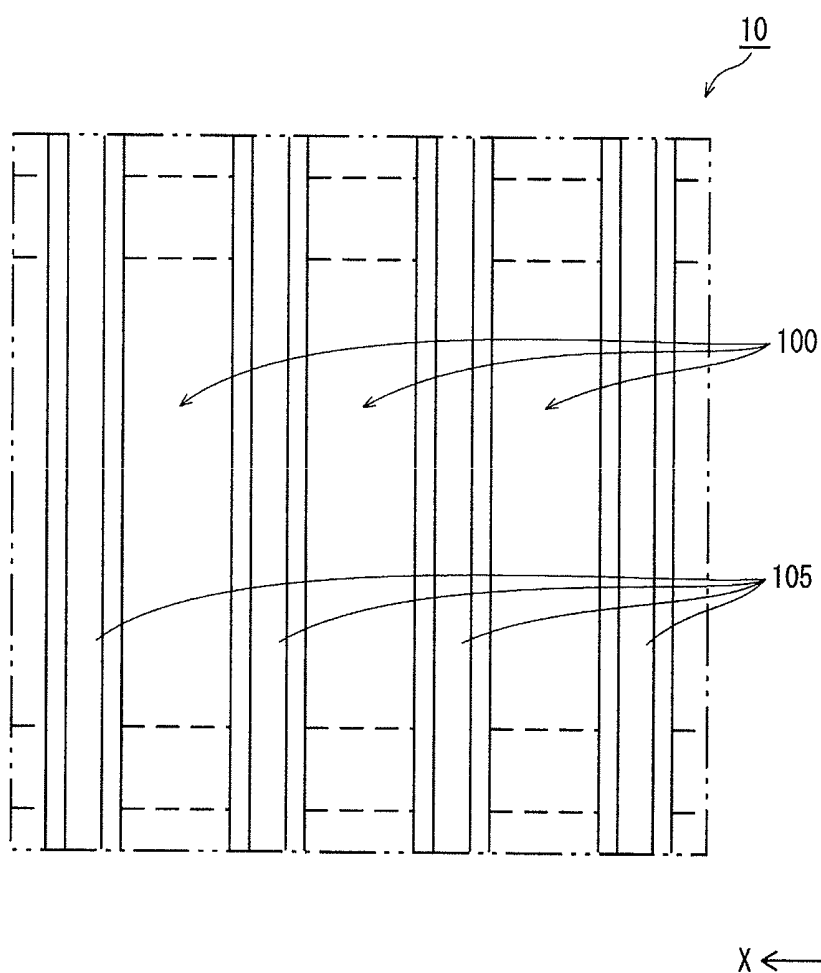


FIG. 4

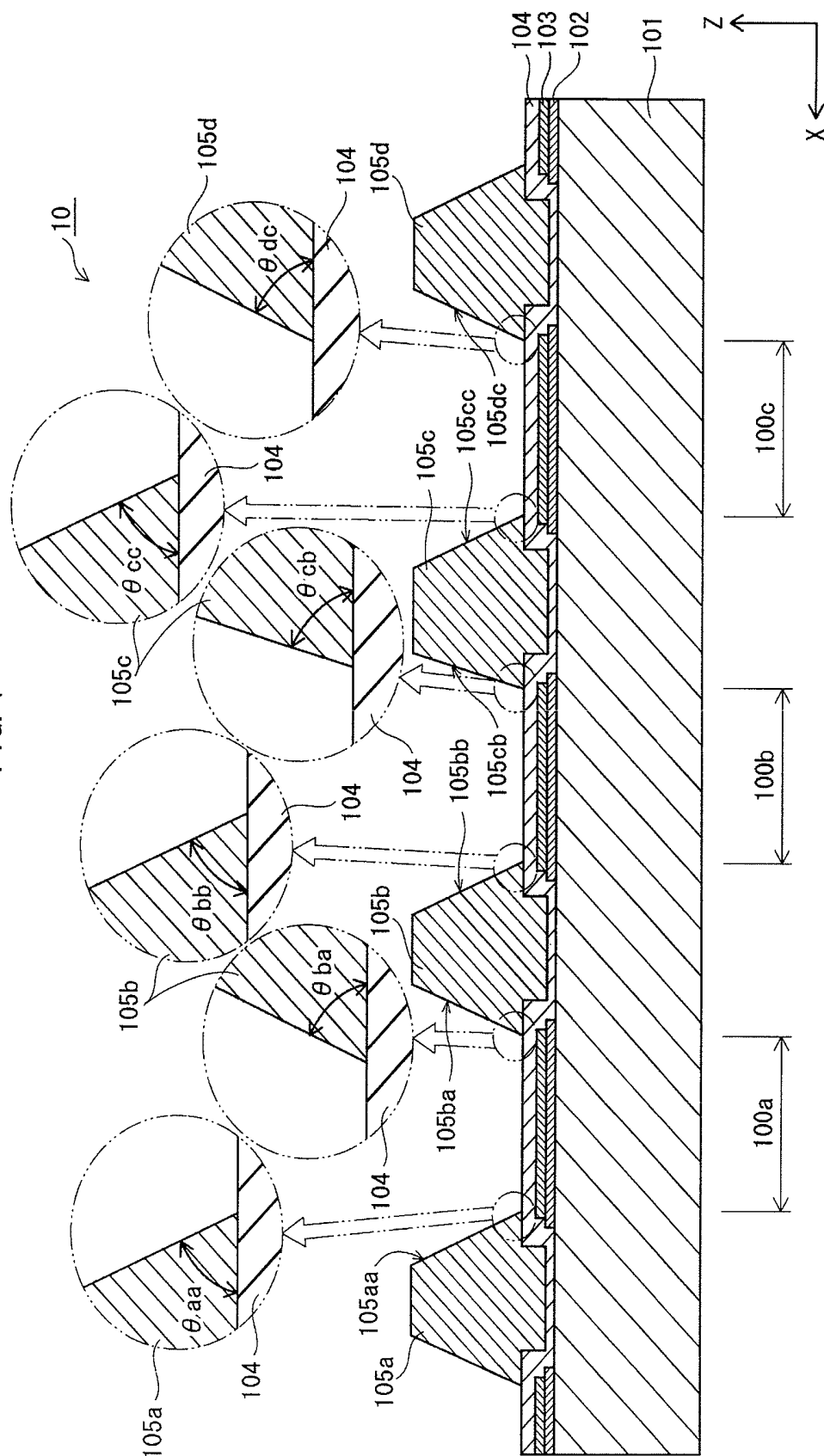


FIG. 5A

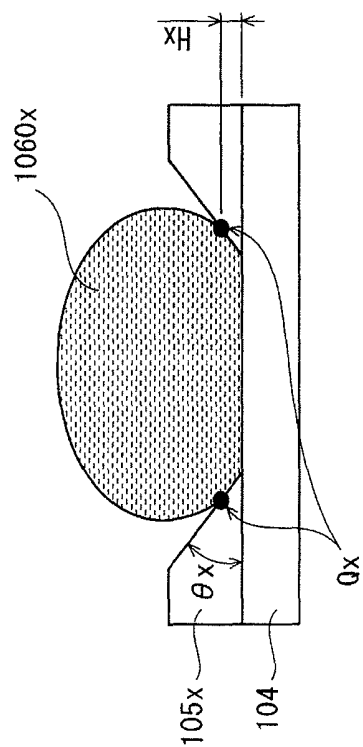


FIG. 5C

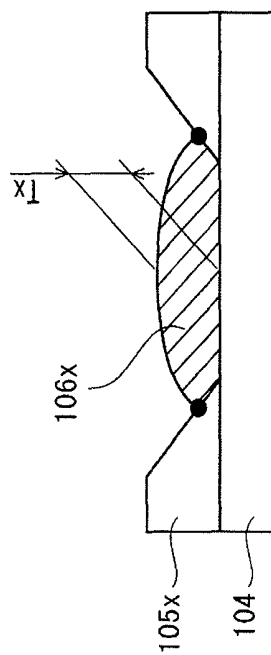


FIG. 5B

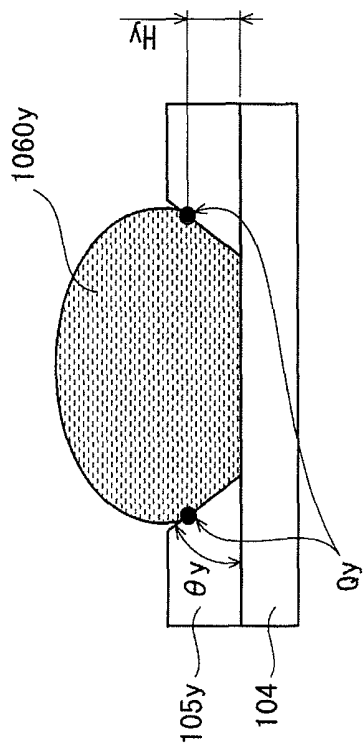


FIG. 5D

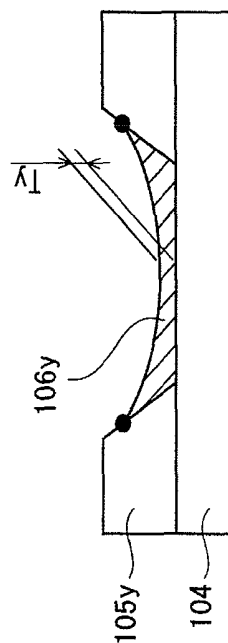


FIG. 6

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

FIG. 7

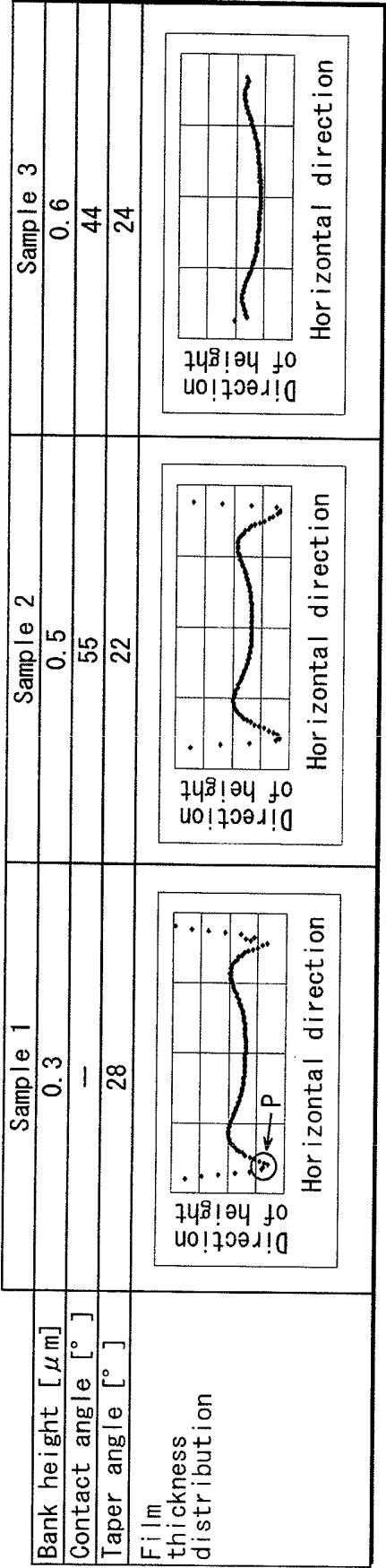


FIG. 8

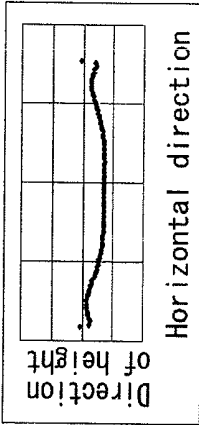
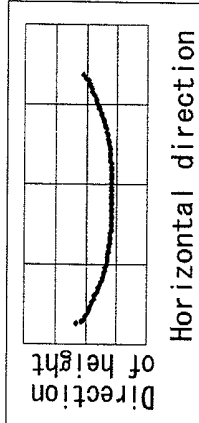
	Sample 4	Sample 5
Bank height [μm]	0.7	1.0
Contact angle [$^{\circ}$]	43	47
Taper angle [$^{\circ}$]	28	50
Film thickness distribution		

FIG. 10A

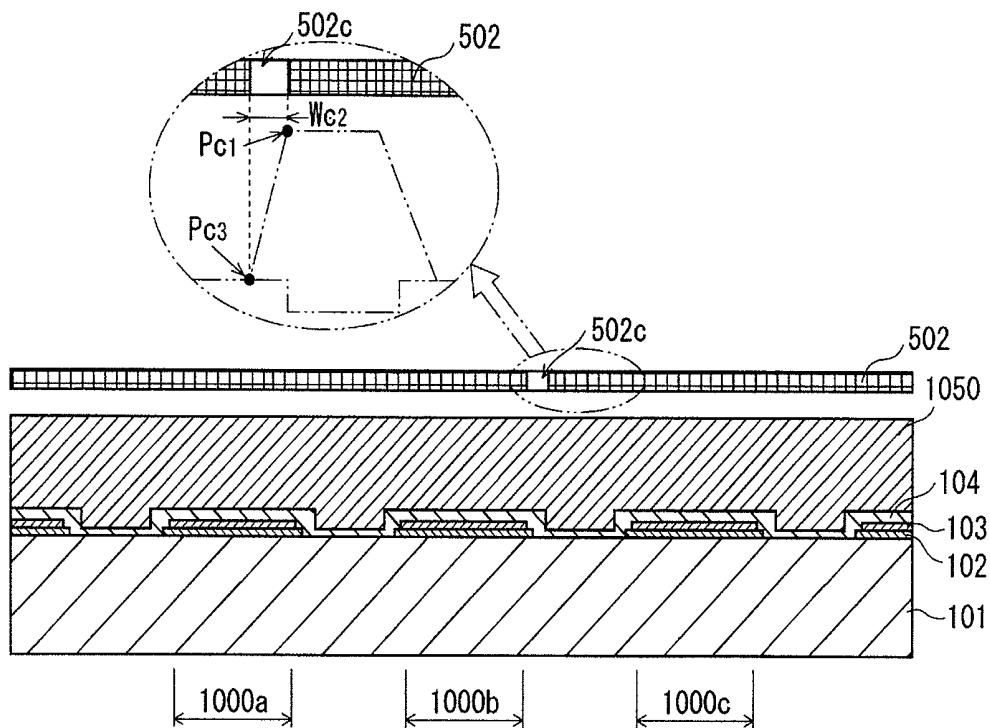


FIG. 10B

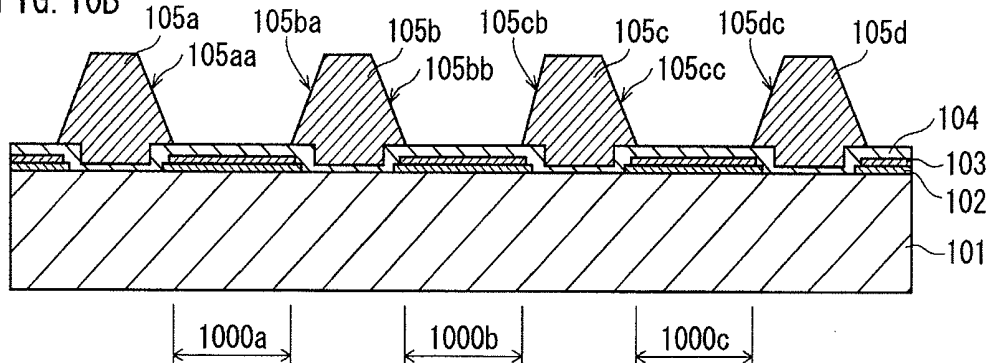


FIG. 10C

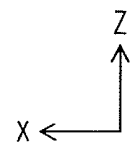
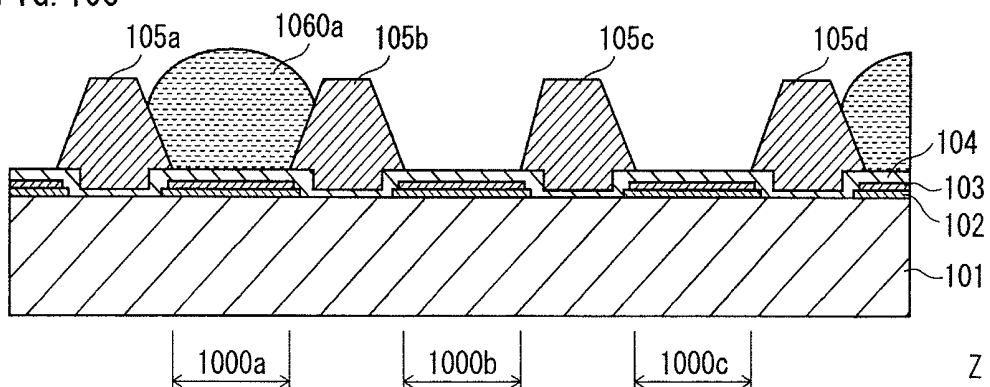


FIG. 11A

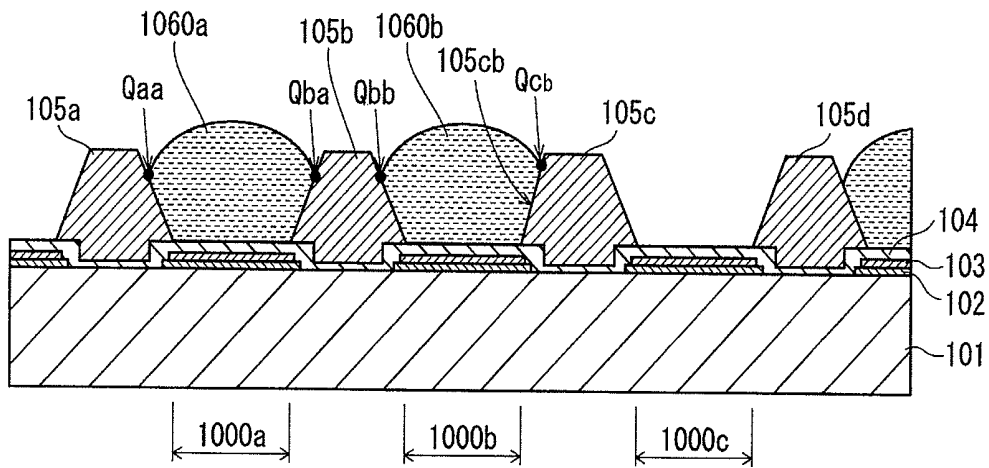


FIG. 11B

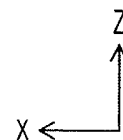
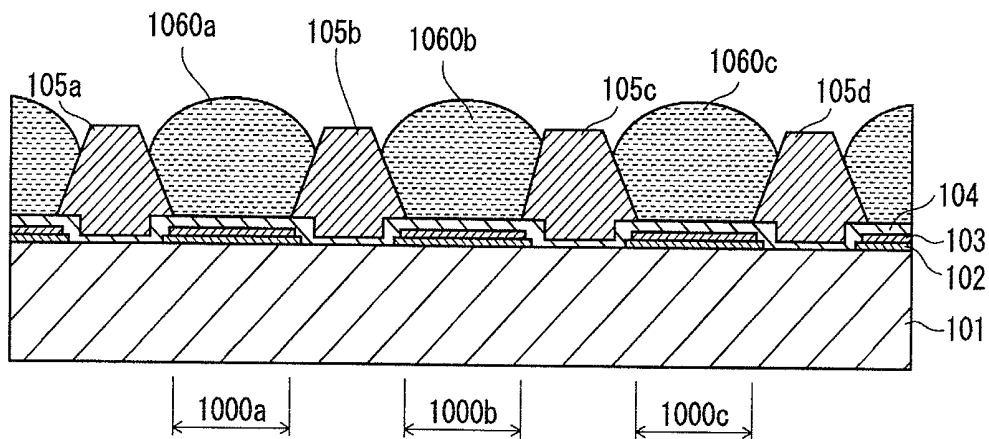


FIG. 12A

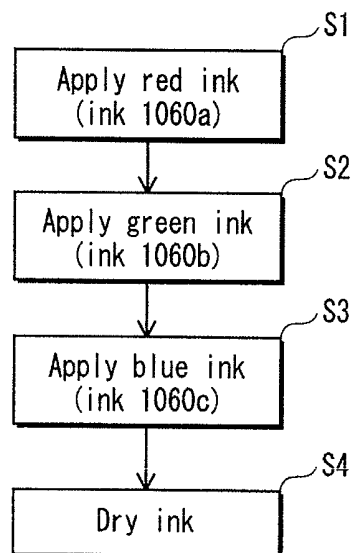


FIG. 12B

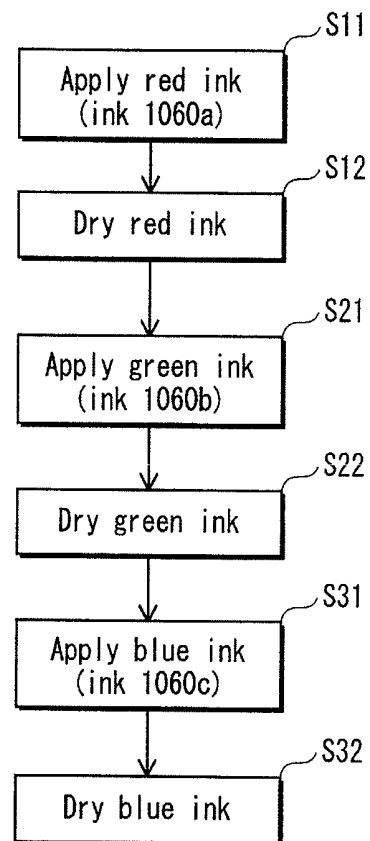


FIG. 13

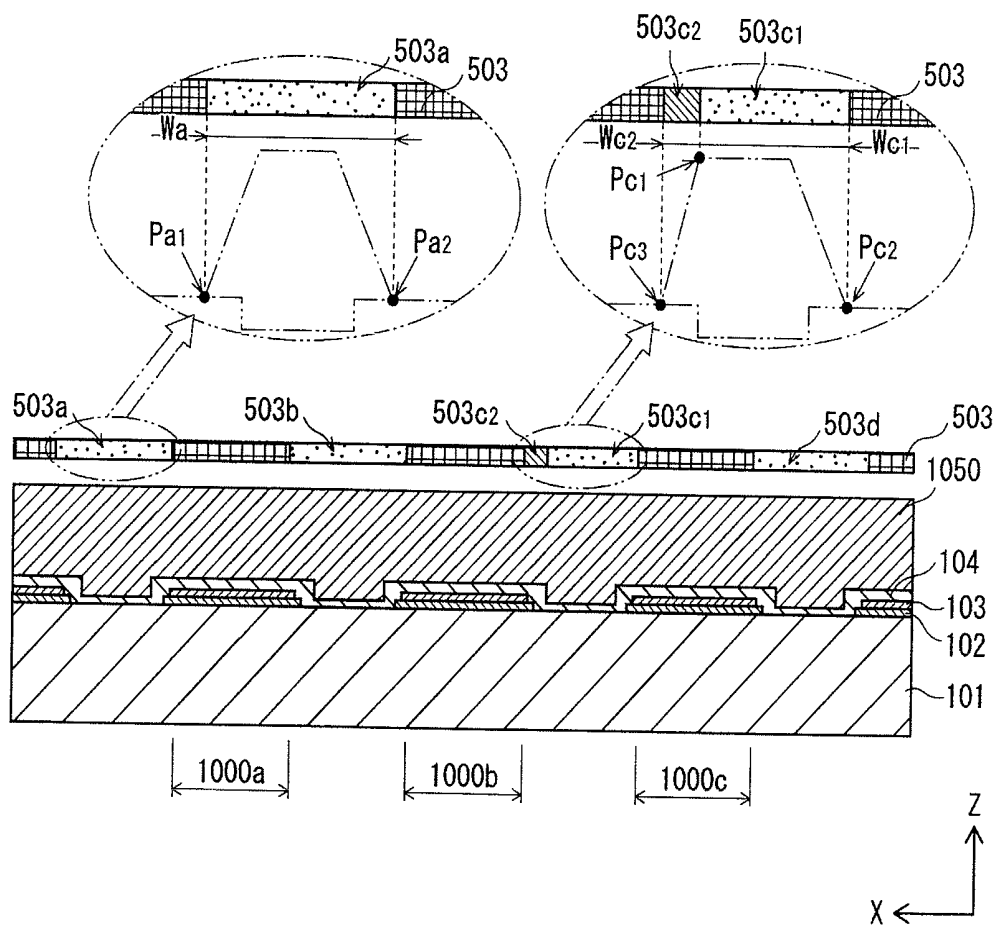


FIG. 14A

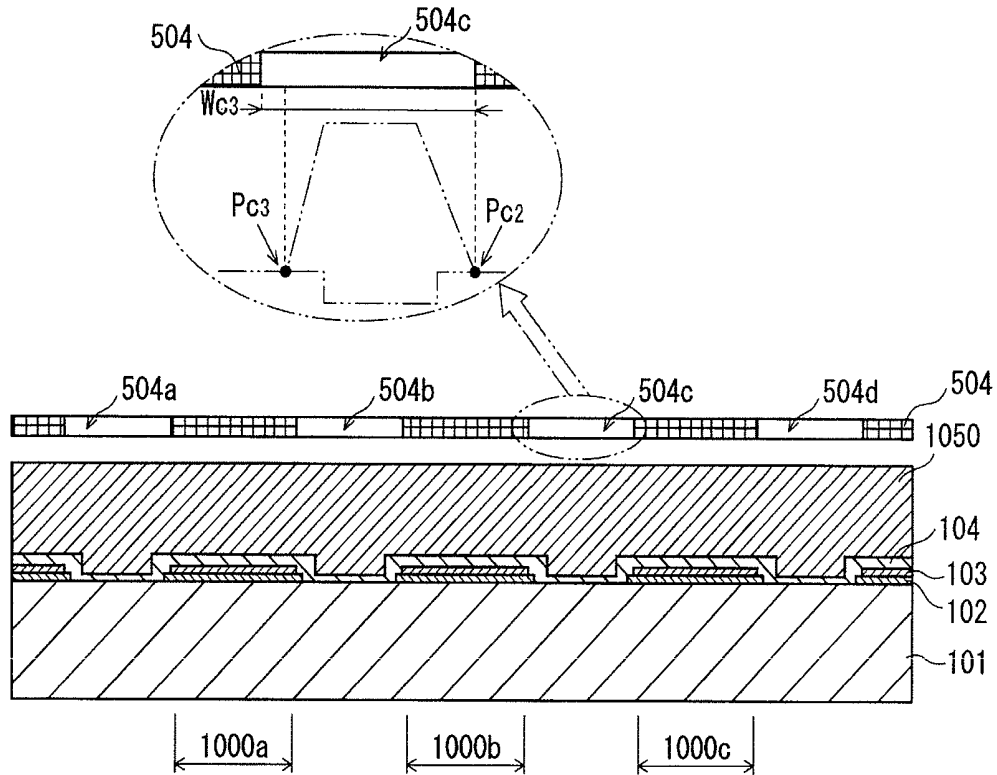


FIG. 14B

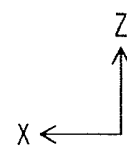
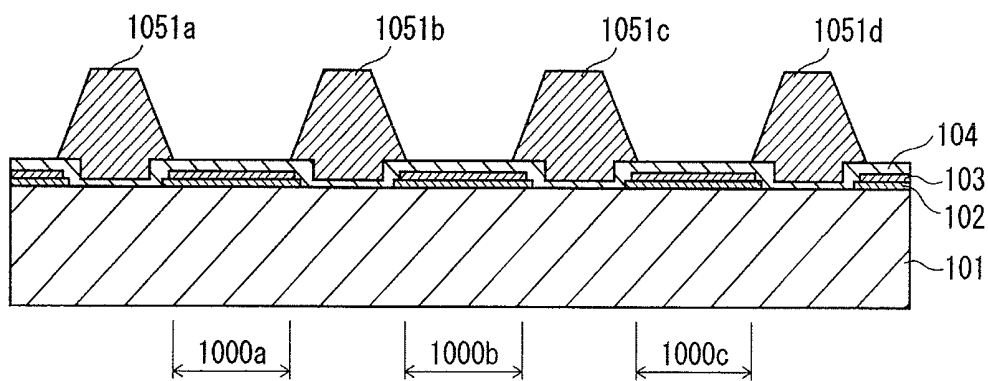


FIG. 15A

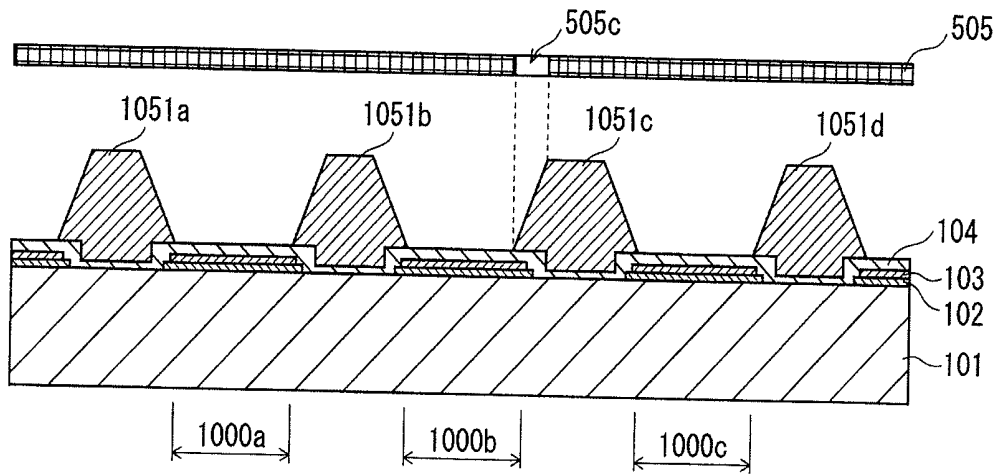


FIG. 15B

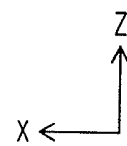
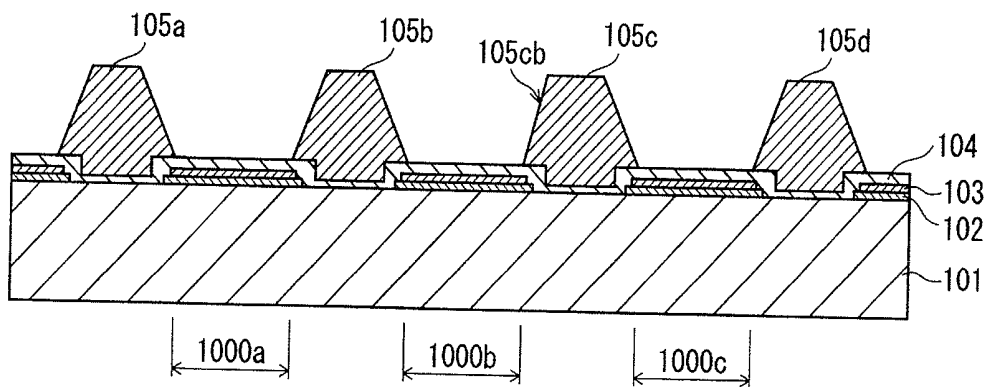


FIG. 16A

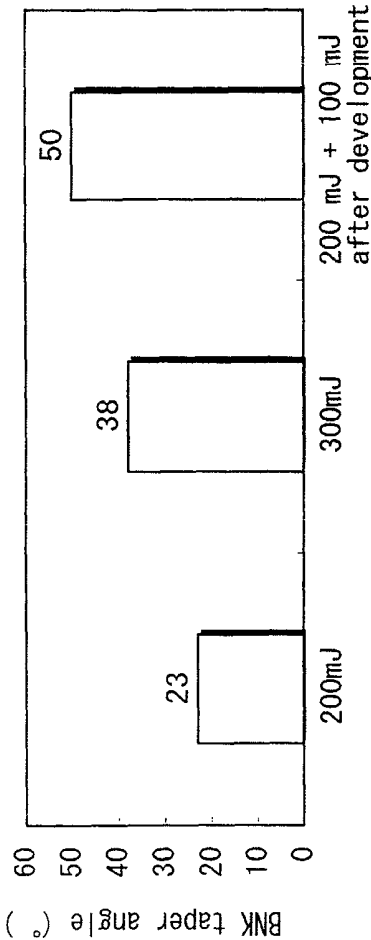
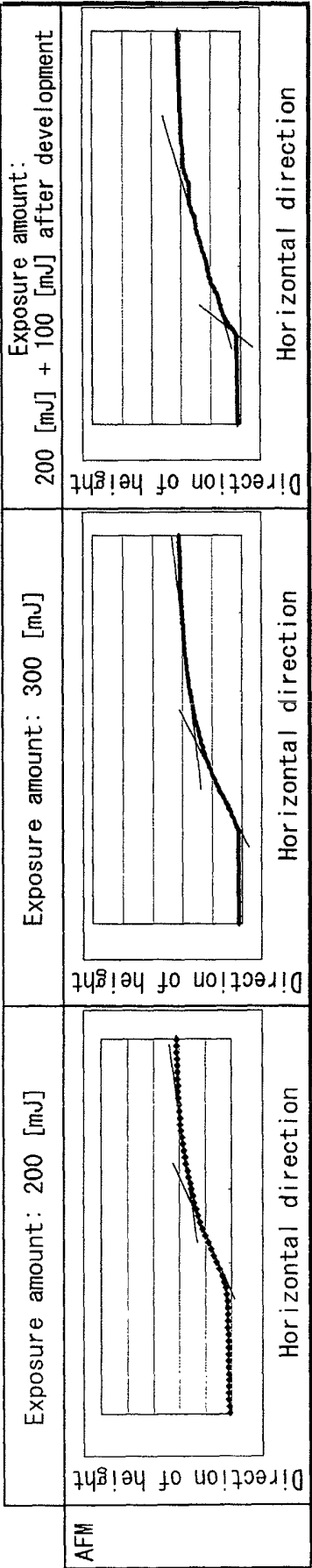


FIG. 16B



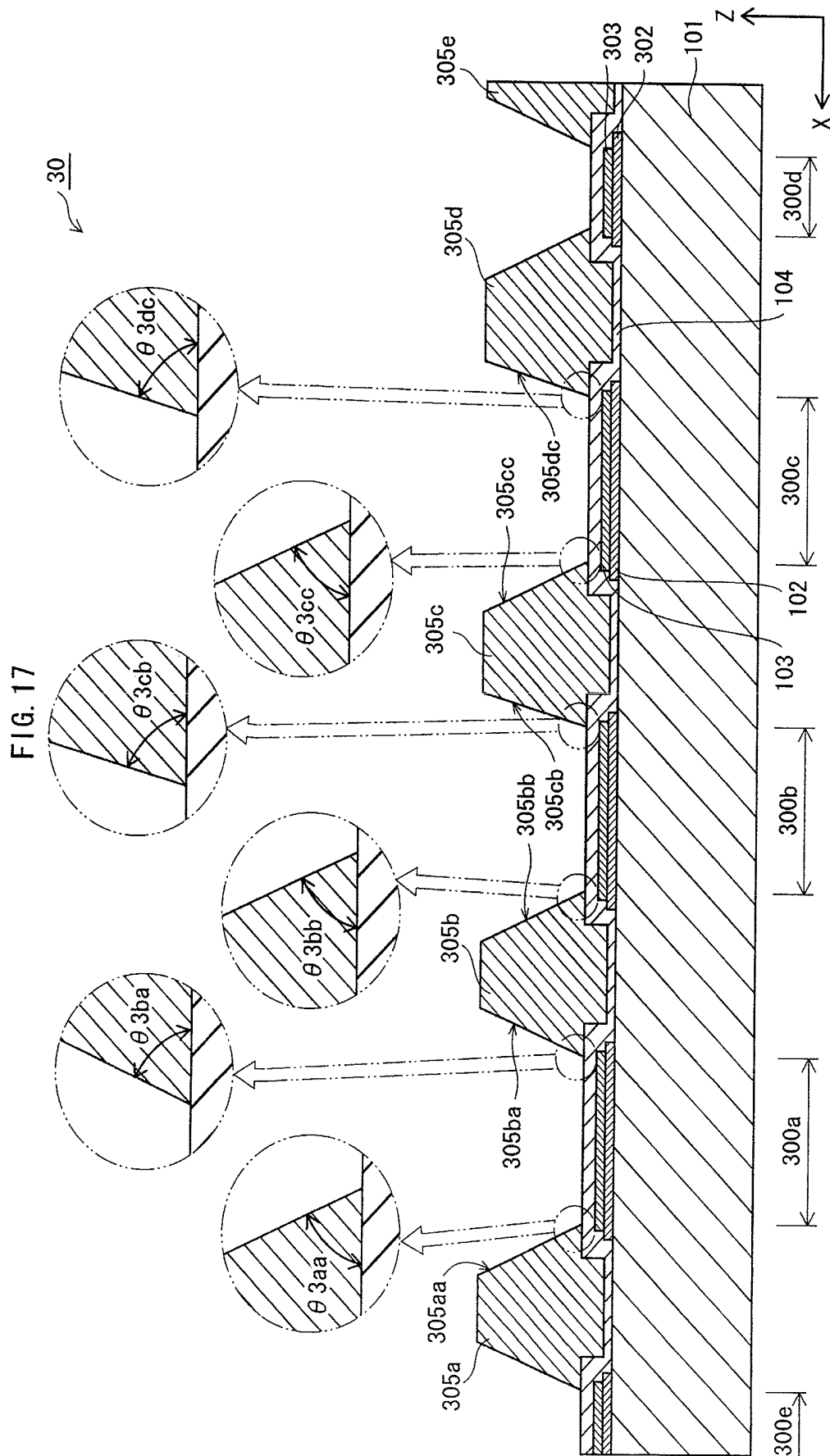


FIG. 18A

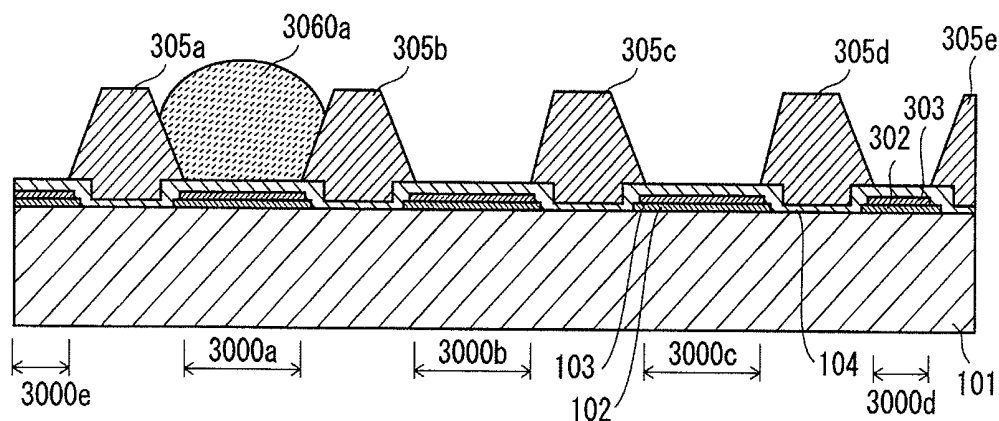


FIG. 18B

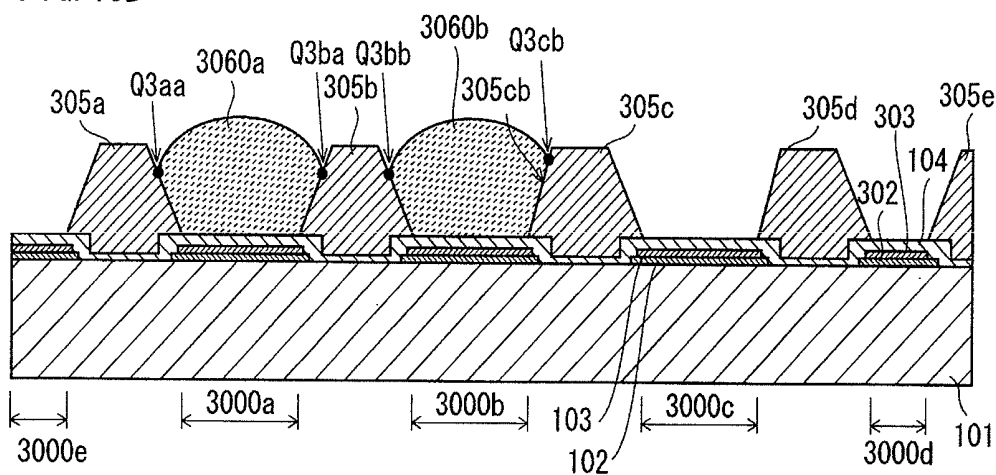
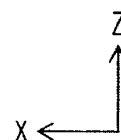
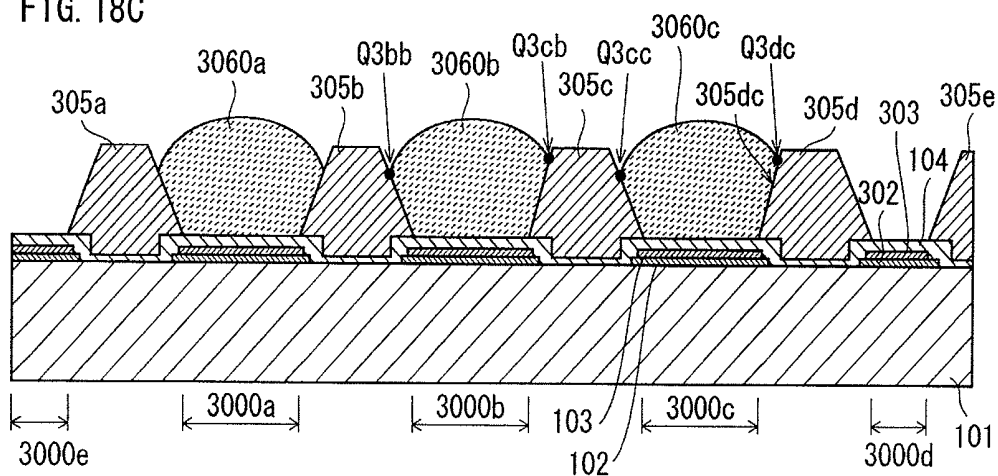


FIG. 18C



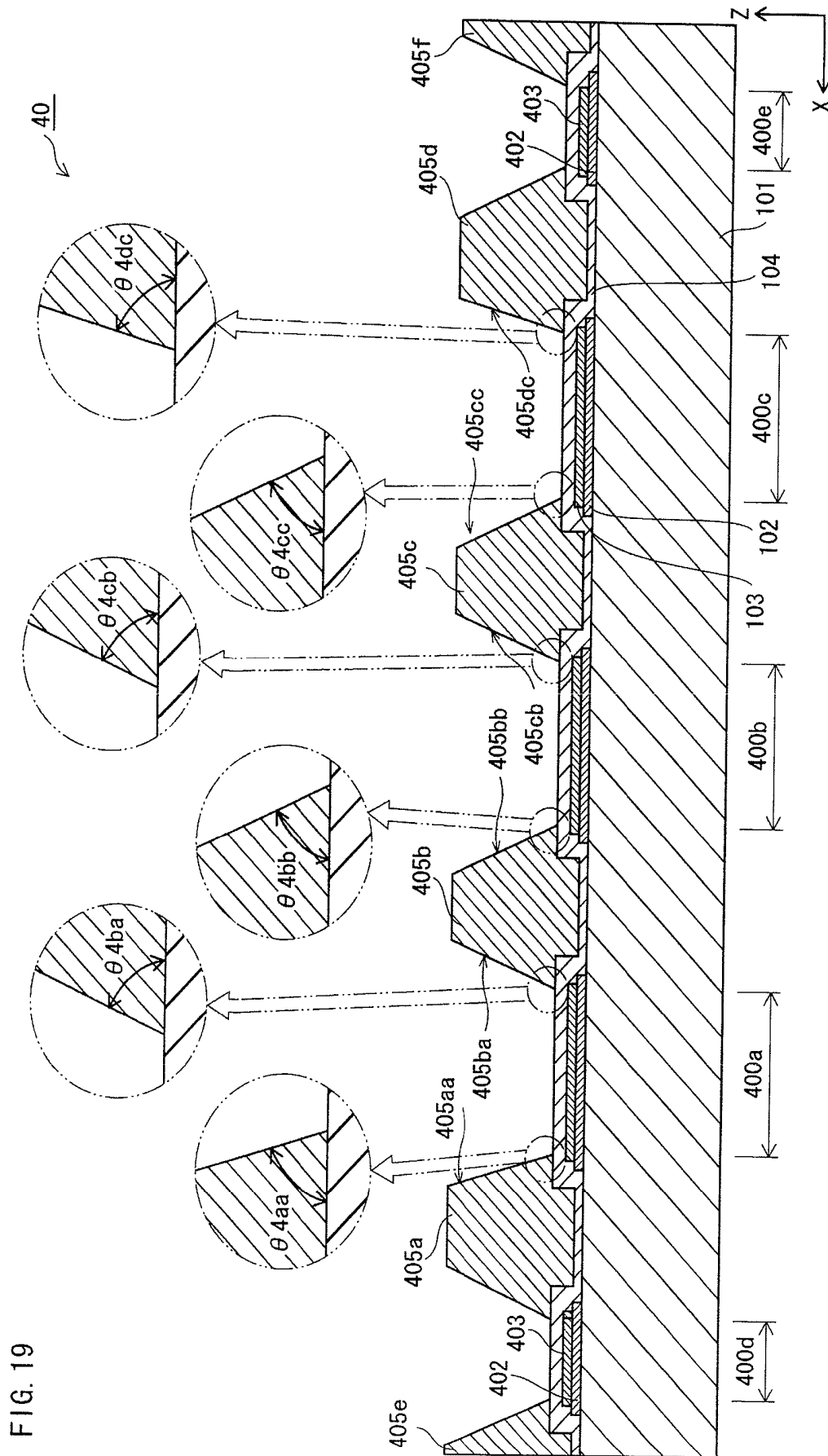


FIG. 20

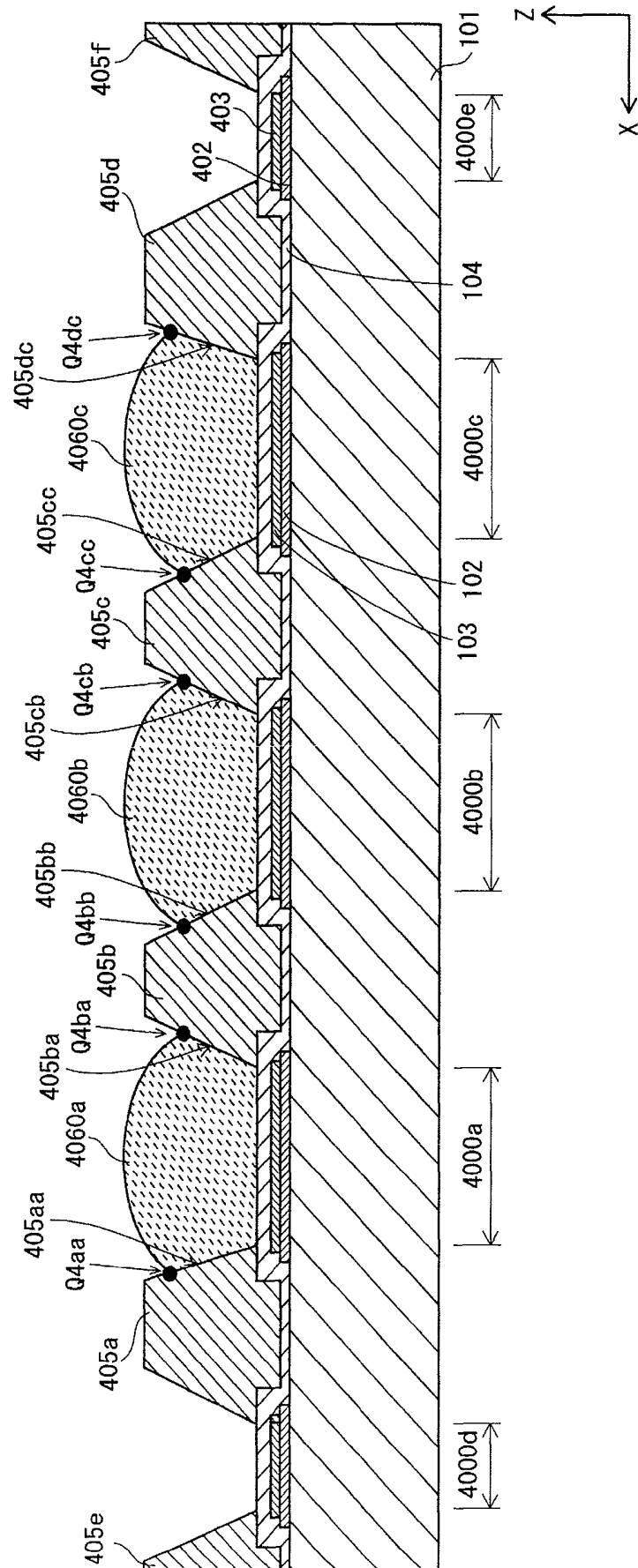


FIG. 21A

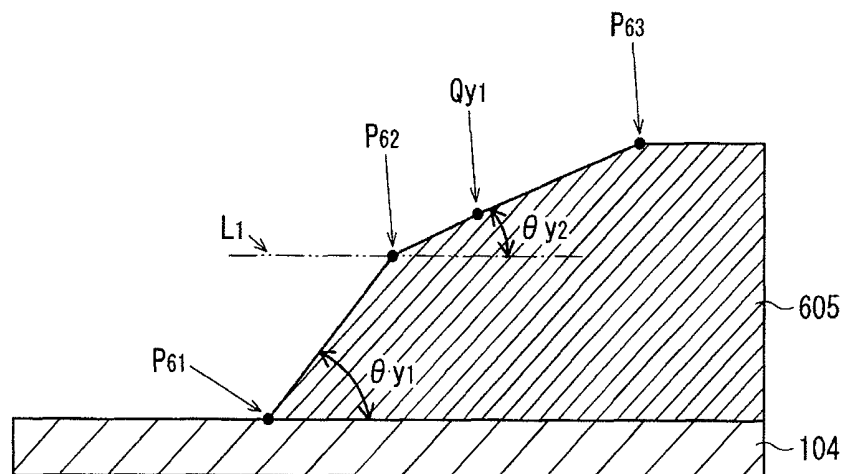


FIG. 21B

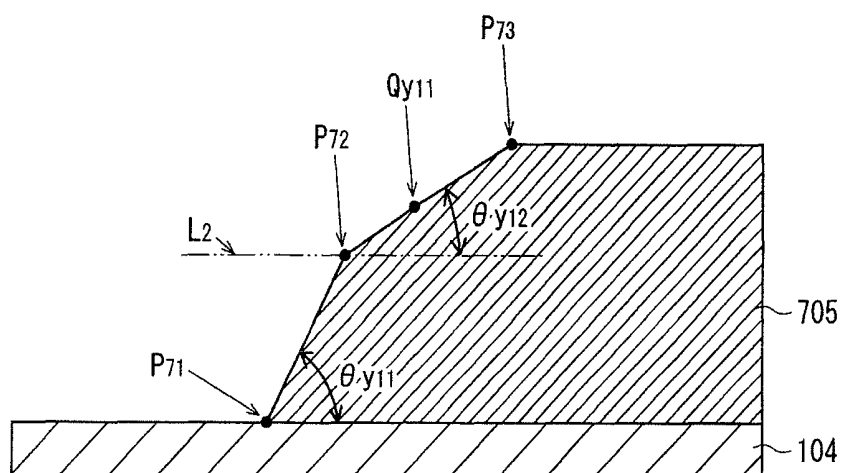


FIG. 22

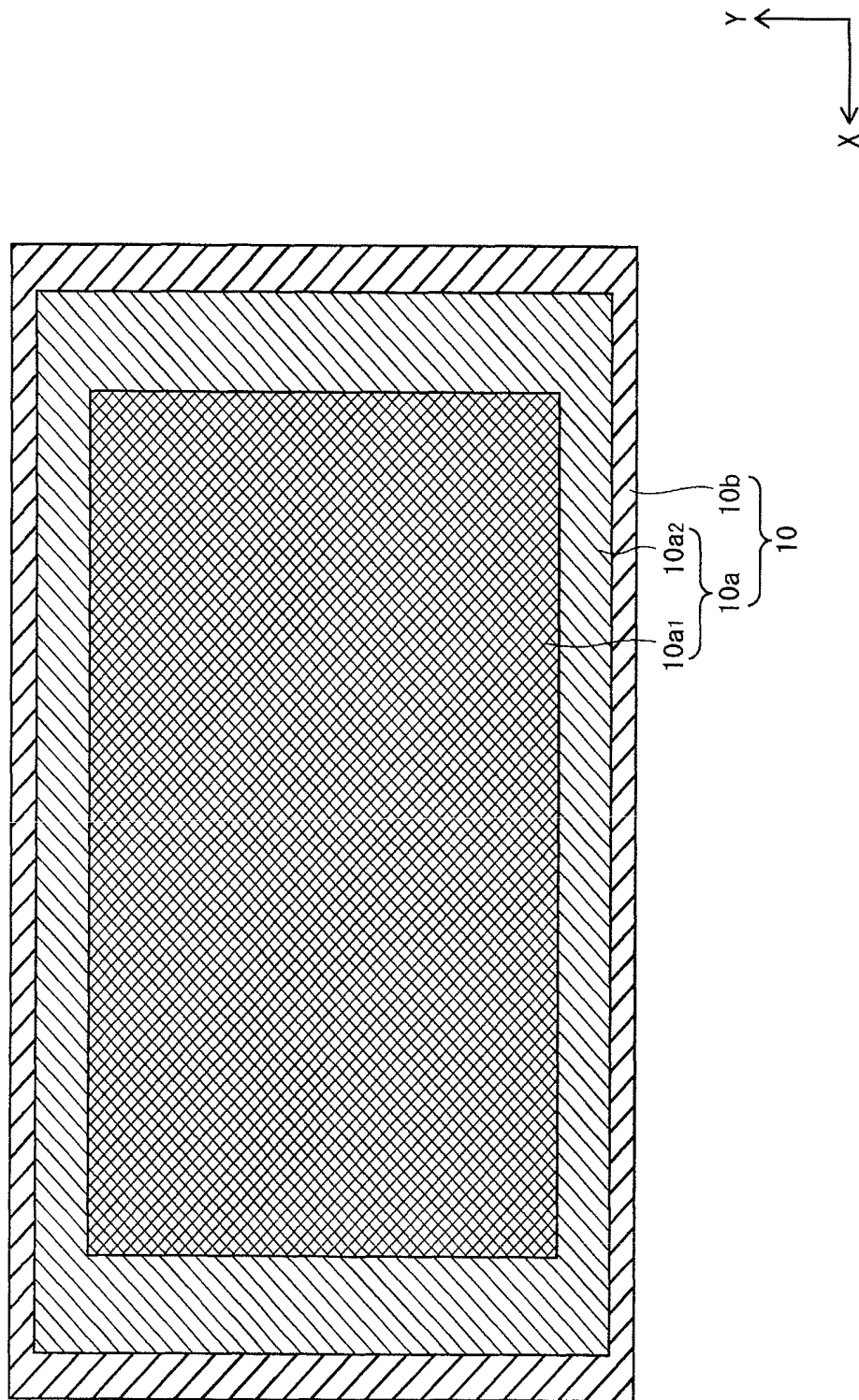


FIG. 23

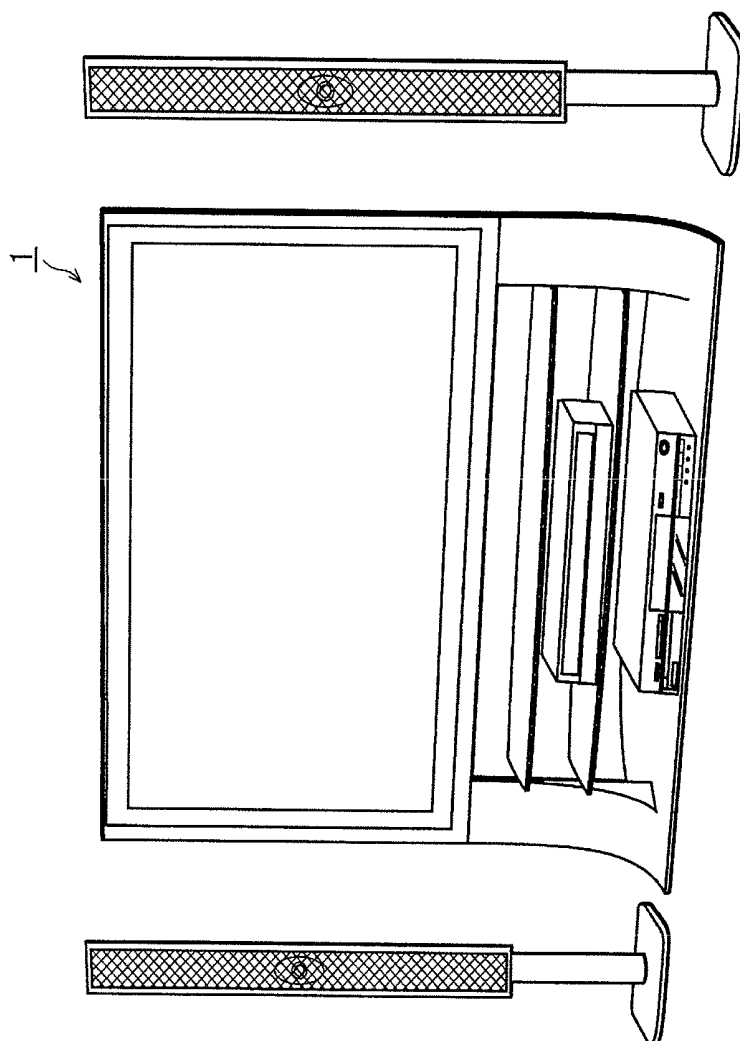


FIG. 24

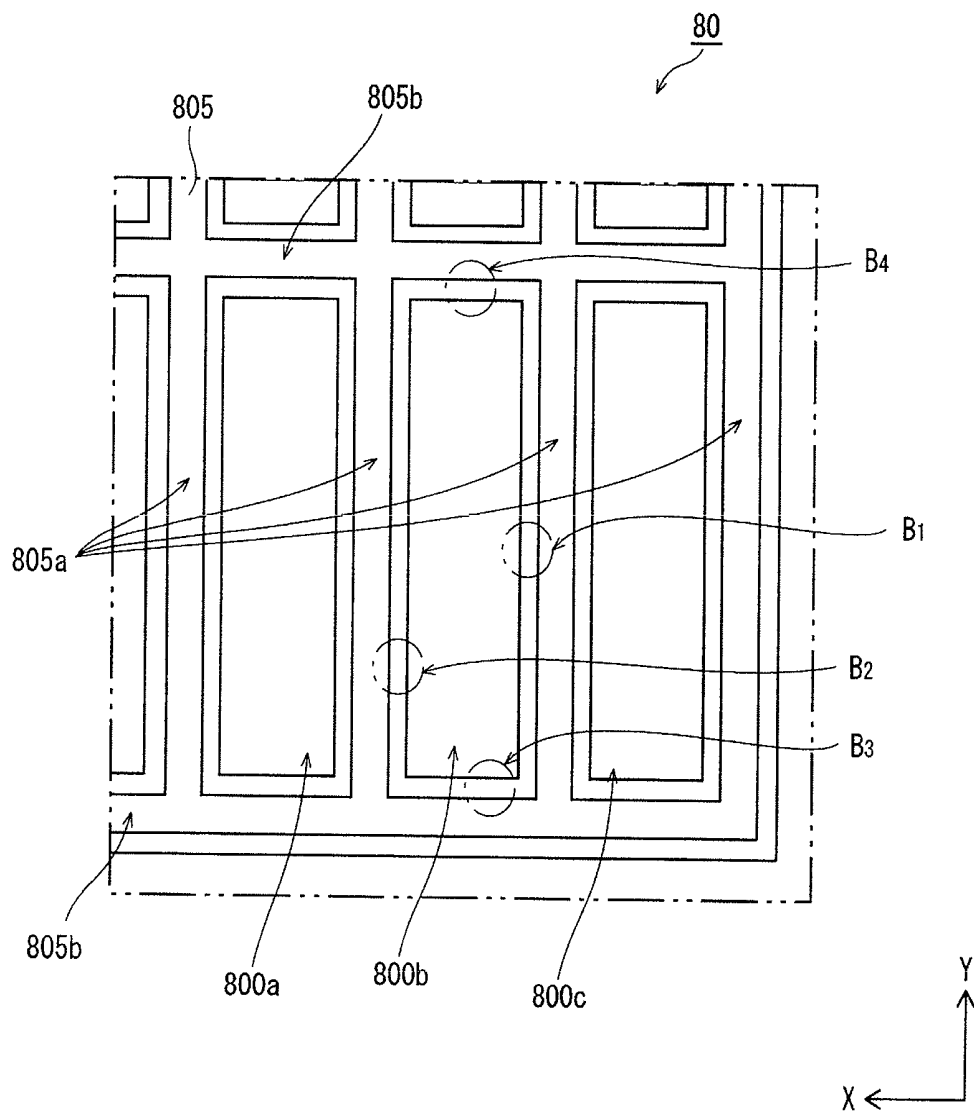


FIG. 25A

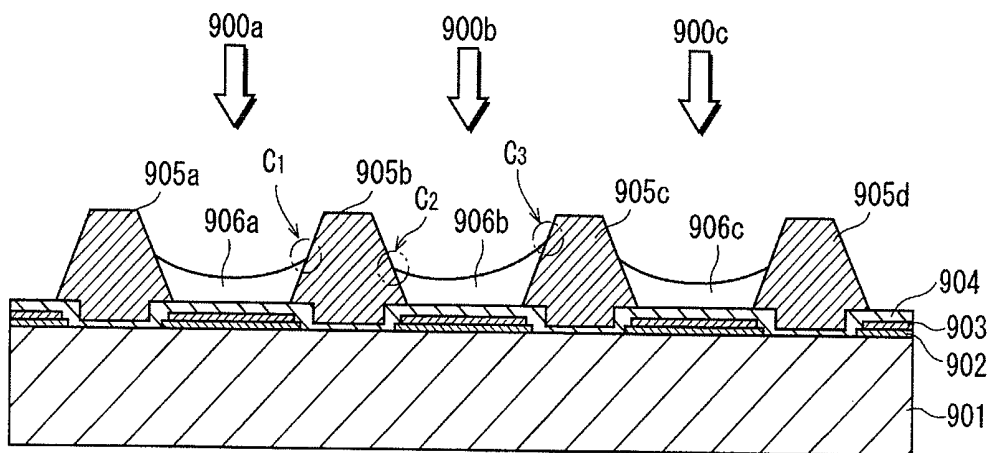


FIG. 25B

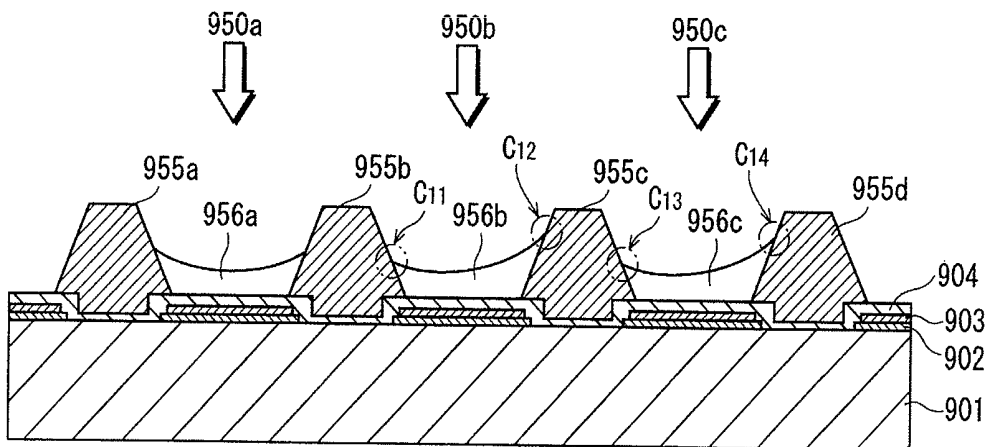


FIG. 26A

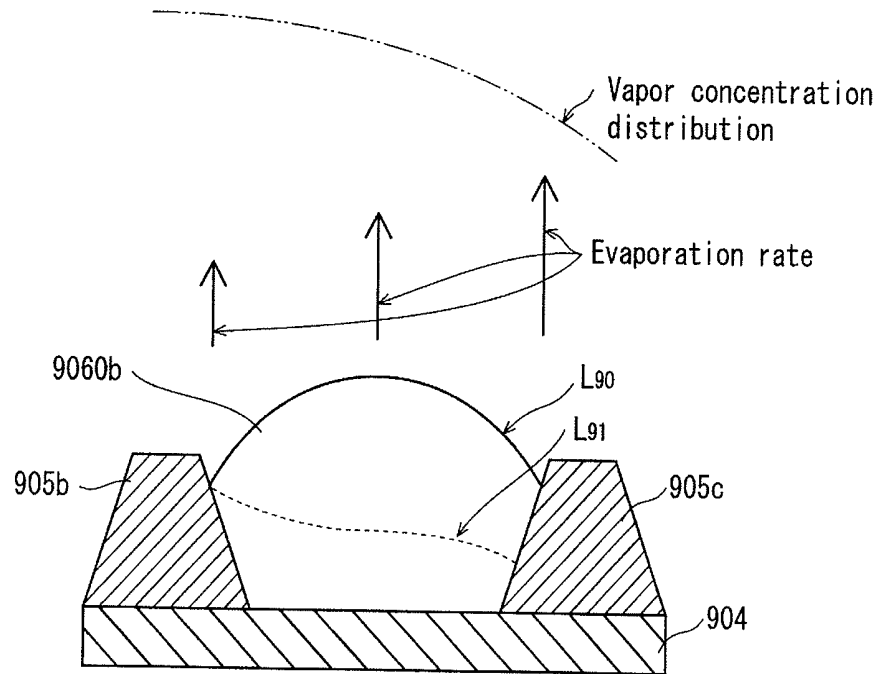


FIG. 26B

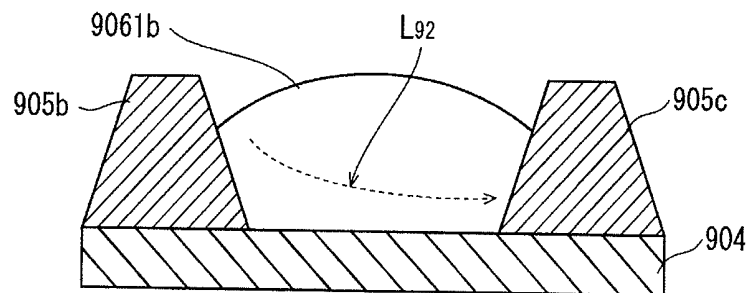
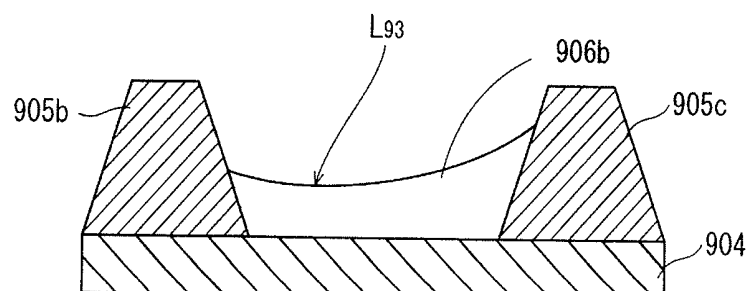


FIG. 26C



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

This is a continuation application of PCT Application No. PCT/JP2010/006143 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

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

BACKGROUND ART

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.

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.

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.

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

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

SUMMARY OF INVENTION

Technical Problem

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.

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

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

The organic light-emitting panel according to an aspect of the present invention comprises: an array of a plurality of pixels; a plurality of light-emitting cells which, provided in each pixel and arranged in an alignment, emit light of different colors, each light-emitting cell including an underlying layer, a first electrode provided in the underlying layer, an organic light-emitting layer, and a second electrode formed on an opposite side of the organic light-emitting layer from the underlying layer; and a plurality of banks which, formed above the underlying layer, define each light-emitting cell by separating the light-emitting cells one from another, the plurality of pixels including a pixel that is structured such that two inner sidewalls, which face each other in two adjacent banks defining a predetermined light-emitting cell among the plurality of light-emitting cells, have different inclination angles.

Advantageous Effects of Invention

The above organic light-emitting panel according to an aspect of the present invention is structured such that two inner sidewalls, which face each other in two adjacent banks defining the predetermined light-emitting cell, have different inclination angles. This structure makes it possible to adjust the pinning location when ink is dripped during the manufacturing. To be more specific, the larger the inclination angle of a sidewall of a bank is, the higher the pinning location is; and the smaller the inclination angle of a sidewall of a bank is, the lower the pinning location is.

Also, after the ink is dried, the film thickness of the organic light-emitting layer and the inclination angle of the bank sidewall have a reverse relationship. More specifically, 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, relatively; and the smaller the inclination angle of a sidewall of a bank is, the larger the film thickness of the organic light-emitting layer near the sidewall is, relatively.

Thus, with the structure where two inner sidewalls, which face each other in two adjacent banks defining the predetermined light-emitting cell, have different inclination angles, the organic light-emitting panel according to an aspect of the present invention can prevent the organic light-emitting layer in each light-emitting cell from becoming uneven in film thickness and provide excellent light-emitting characteristics.

BRIEF DESCRIPTION OF DRAWINGS

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

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

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

FIG. 4 is a schematic cross-sectional view showing the structure of sub-pixels 100a to 100c included in the display panel 10 and banks 105a to 105d that separate the sub-pixels 100a to 100c from each other.

FIG. 5A is a schematic cross-sectional view showing pinning locations when the taper angle of the bank sidewall is small; FIG. 5B is a schematic cross-sectional view showing pinning locations when the taper angle of the bank sidewall is large; FIG. 5C 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. 5D 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.

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.

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

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

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

FIGS. 10A-10C are schematic cross-sectional views showing, in order, the main processes in the manufacturing method of the display panel 10.

FIGS. 11A and 11B are schematic cross-sectional views showing, in order, the main processes in the manufacturing method of the display panel 10.

FIG. 12A is a schematic flowchart showing a procedure of applying and drying the inks 1060a-1060c; and FIG. 12B is a schematic flowchart showing another procedure of applying and drying the inks 1060a-1060c.

FIG. 13 is a schematic cross-sectional view showing the main processes in the manufacturing method of Modification 1.

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

FIGS. 15A and 15B are schematic cross-sectional views showing the main processes in the manufacturing method of Modification 2.

FIG. 16A shows the relationship between the taper angle of a bank and exposure/developing; and FIG. 16B shows AFM graphs that indicate the shapes of formed banks.

FIG. 17 is a schematic cross-sectional view showing the structure of sub-pixels 300a-300c, non-light-emitting cells 300d and 300e, and banks 305a-305e included in the display panel provided in the organic light-emitting device of Embodiment 2.

FIGS. 18A-18C are schematic cross-sectional views showing, in order, the processes for applying the inks 3060A-3060C.

FIG. 19 is a schematic cross-sectional view showing the structure of sub-pixels 400a-400c, non-light-emitting cells 400d and 400e, and banks 405a-405f included in the display panel provided in the organic light-emitting device of Embodiment 3.

FIG. 20 is a schematic cross-sectional view showing the state where the inks 4060a-4060c are applied at the same time.

FIGS. 21A and 21B are schematic cross-sectional views provided for explanation of definition of the taper angle.

FIG. 22 is a schematic plan view showing regions 10a1, 10a2 and 10b in the display panel 10.

FIG. 23 is an external perspective view showing an example of the appearance of a set that includes the organic display device 1.

FIG. 24 is a schematic plan view showing a bank 805 in a display panel 80 of Modification 3.

FIGS. 25A and 25B are schematic cross-sectional views showing how the film thickness distribution of the organic light-emitting layer is uneven in a series of sub-pixels of the display panel.

FIGS. 26A-26C 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]

The organic light-emitting panel according to an aspect of the present invention comprises: an array of a plurality of pixels; a plurality of light-emitting cells which, provided in each pixel and arranged in an alignment, emit light of different colors, each light-emitting cell including an underlying layer, a first electrode provided in the underlying layer, an organic light-emitting layer, and a second electrode formed on an opposite side of the organic light-emitting layer from the underlying layer; and a plurality of banks which, formed above the underlying layer, define each light-emitting cell by separating the light-emitting cells one from another, the plurality of pixels including a pixel that is structured such that two inner sidewalls, which face each other in two adjacent banks defining a predetermined light-emitting cell among the plurality of light-emitting cells, have different inclination angles.

The organic light-emitting panel according to an aspect of the present invention is structured such that two inner sidewalls, which face each other in two adjacent banks defining the predetermined light-emitting cell, have different inclination angles. This structure makes it possible to adjust the pinning location when ink is dripped during the manufacturing. To be more specific, the larger the inclination angle of a sidewall of a bank is, the higher the pinning location is; and the smaller the inclination angle of a sidewall of a bank is, the lower the pinning location is.

Also, after the ink is dried, the film thickness of the organic light-emitting layer and the inclination angle of the bank sidewall have a reverse relationship. More specifically, 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, relatively; and the smaller the inclination angle of a sidewall of a bank is, the larger the film thickness of the organic light-emitting layer near the sidewall is, relatively.

Thus, with the structure where two inner sidewalls, which face each other in two adjacent banks defining the predetermined light-emitting cell, have different inclination angles, the organic light-emitting panel according to an aspect of the present invention can prevent the organic light-emitting layer in each light-emitting cell from becoming uneven in film thickness and provide excellent light-emitting characteristics.

Note that, in the above description, the "inclination angle" is an angle formed by a side wall of a bank and an upper surface of an underlying layer on which the bank is provided (the underlying layer corresponds to the first electrode, hole injection layer, hole transporting layer, or hole injection transporting layer).

In the above-described organic light-emitting panel, in each of one or more light-emitting cells other than the predetermined light-emitting cell in the pixel that is structured such that the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell have different inclination angles, two inner sidewalls facing each other may have equal inclination angles.

As described above, with the structure where two inner sidewalls, which face each other in two adjacent banks defining the predetermined light-emitting cell, have different inclination angles, the organic light-emitting panel according to an aspect of the present invention can prevent the organic light-emitting layer in each light-emitting cell from becoming uneven in film thickness and provide excellent light-emitting characteristics. In addition, with the above-described structure where, in each of one or more light-emitting cells other than the predetermined light-emitting cell in the pixel, two inner sidewalls facing each other have equal inclination angles, it is possible to prevent the organic light-emitting layer from becoming uneven in film thickness and provide excellent light-emitting characteristics. This makes it possible to obtain excellent light-emitting characteristics in a plurality of pixels.

Note that the term "equal" above does not mean exact mathematical equivalence, but rather takes factors such as dimensional error during manufacturing of the display device into account. Specifically, the term "equal" refers to making the inclination angles equal within the range permitted in practice by the difference in luminous efficiency (uneven luminance) between the light-emitting cells in the central region and peripheral region of the panel.

In the above-described organic light-emitting panel, the plurality of light-emitting cells in each pixel may include 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, the plurality of pixels are arranged to be continuously adjacent to each other, and the plurality of pixels include a pixel that is structured such that two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have equal inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have different inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have equal inclination angles.

With the above-described structure, when a non-light-emitting cell (for example, a bus bar) is not provided between each pair of adjacent pixels and ink is applied to form organic light-emitting layers in an order of the alignment, if the above-described relationships between the inner sidewalls of the banks and the inclination angles are satisfied, the present invention produces an advantageous effect that it is possible to prevent the organic light-emitting layer in each light-emitting cell from becoming uneven in film thickness and provide excellent light-emitting characteristics.

In the above-described organic light-emitting panel, the plurality of light-emitting cells in each pixel may include 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, a non-light-emitting cell is provided between each pair of adjacent pixels, a bank is provided between each pair of a pixel and a non-light-emitting cell that are adjacent to each other, the bank separating the pixel from the non-light-emitting cell, and the plurality of pixels include a pixel that is structured such that two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have equal inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have different inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles.

With the above-described structure, when a non-light-emitting cell (for example, a bus bar) is provided between each pair of adjacent pixels and ink is applied to form organic light-emitting layers in an order of the alignment, if the above-described relationships between the inner sidewalls of the banks and the inclination angles are satisfied, the present invention produces an advantageous effect that it is possible to prevent the organic light-emitting layer in each light-emitting cell from becoming uneven in film thickness and provide excellent light-emitting characteristics.

In the above-described organic light-emitting panel, the plurality of light-emitting cells in each pixel may include 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, a non-light-emitting cell is provided between each pair of adjacent pixels, a bank is provided between each pair of a pixel and a non-light-emitting cell that are adjacent to each other, the bank separating the pixel from the non-light-emitting cell, and

the plurality of pixels include a pixel that is structured such that two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have different inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have equal inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles.

With the above-described structure, when a non-light-emitting cell (for example, a bus bar) is provided between each pair of adjacent pixels and ink is applied to form organic light-emitting layers at the same time, not in an order of the alignment, if the above-described relationships between the inner sidewalls of the banks and the inclination angles are satisfied, the present invention produces an advantageous effect that it is possible to prevent the organic light-emitting layer in each light-emitting cell from becoming uneven in film thickness and provide excellent light-emitting characteristics.

In the above-described organic light-emitting panel, each non-light-emitting cell may include none of the organic light-emitting layers and may include the second electrode and a third electrode that is made of a same material as the first electrodes, the third electrode and the second electrode being electrically connected with each other.

In an organic light-emitting panel, the second electrode, which is provided at a location upper (closer to the light extraction side) than the organic light-emitting layer, is normally made of a light-transmissive material (such as ITO or IZO). However, these materials have high electric resistance. These matters taken into account, the second electrode and the third electrode are connected in the non-light-emitting cell to reduce the electric resistance so that high light-transmissivity can be maintained to prevent a voltage drop from occurring even in a panel of a large size. The third electrode is, for example, a bus bar.

In the above-described organic light-emitting panel, two regions adjacent to the predetermined light-emitting cell may have different ink vapor concentrations when ink is applied to the predetermined light-emitting cell, and among two inner sidewalls facing each other in two adjacent banks defining the predetermined light-emitting cell, a sidewall of a bank, which is located on a side of a region having a lower ink vapor concentration among the two regions, may have a larger inclination angle than a sidewall of a bank, which is located on a side of a region having a higher ink vapor concentration among the two regions.

In the organic light-emitting panel, when ink is applied to a light-emitting cell that is adjacent to two regions having different ink vapor concentrations, the applied ink forming a light-emitting layer has an inherent tendency to be larger in film thickness at an end located on a side of a region having a lower ink vapor concentration than at an end located on a side of a region having a higher ink vapor concentration. Due to this tendency, the light-emitting layer is likely to have an uneven film thickness.

However, with the above-described structure where, a sidewall of a bank, which is located on a side of a region having a lower ink vapor concentration among the two regions, has a larger inclination angle than a sidewall of a bank, which is located on a side of a region having a higher ink vapor concentration among the two regions, the pinning location of the ink in the sidewall of the bank located on the side of the region having a lower ink vapor concentration becomes relatively higher than the pinning location of the ink in the sidewall of the bank located on the side of the region having a higher ink vapor concentration. As a result, it is possible to restrict the film thickness of the organic light-emitting layer in the sidewall of the bank on the side of the region having a lower ink vapor concentration, thereby preventing the uneven film thickness from occurring between two ends of the predetermined light-emitting cell.

Thus, with the above-described structure, it is possible to prevent the organic light-emitting layer in the predetermined light-emitting cell from becoming uneven in film thickness and provide excellent light-emitting characteristics in each pixel.

In the above-described organic light-emitting panel, a type of ink corresponding to the predetermined light-emitting cell may be applied to the predetermined light-emitting cell in a state where a type of ink corresponding to one light-emitting cell among two light-emitting cells that are adjacent to the predetermined light-emitting cell in a same pixel, has been applied to the one light-emitting cell and before another type of ink corresponding to the other light-emitting cell among the two light-emitting cells starts to be applied to the other light-emitting cell, and a sidewall of a bank located on a side of the other light-emitting cell may have a larger inclination angle than a sidewall of a bank located on a side of the one light-emitting cell.

In the organic light-emitting panel, when ink is applied to a predetermined light-emitting cell in the state where a type of ink corresponding to one light-emitting cell among two light-emitting cells that are adjacent to the predetermined light-emitting cell in a same pixel, has been applied to the one light-emitting cell and before another type of ink corresponding to the other light-emitting cell among the two light-emitting cells starts to be applied to the other light-emitting cell, the ink vapor concentration is higher on the side of the one light-emitting cell than on the side of the other light-emitting cell. Accordingly, the applied ink forming a light-emitting layer tends to be larger in film thickness at an end located on a side of the other light-emitting cell than at an end located on a side of the one light-emitting cell. Due to this tendency, the light-emitting layer is likely to have an uneven film thickness.

However, with the above-described structure where a sidewall of a bank located on a side of the other light-emitting cell has a larger inclination angle than a sidewall of a bank located on a side of the one light-emitting cell, the pinning location of the ink in the sidewall of the bank located on the side of the other light-emitting cell becomes relatively higher than the pinning location of the ink in the sidewall of the bank located on the side of the one light-emitting cell. As a result, it is possible to restrict the film thickness of the organic light-

emitting layer in the sidewall of the bank located on the side of the other light-emitting cell, thereby preventing the uneven film thickness from occurring between two ends of the predetermined light-emitting cell.

Thus, with the above-described structure, it is possible to prevent the organic light-emitting layer in the predetermined light-emitting cell from becoming uneven in film thickness and provide excellent light-emitting characteristics in each pixel.

In the above-described organic light-emitting panel, two regions adjacent to the predetermined light-emitting cell may have different ink vapor concentrations when ink is applied to the predetermined light-emitting cell, and two regions adjacent to a light-emitting cell, which is different from the predetermined light-emitting cell, may have equal ink vapor concentrations when ink is applied to the light-emitting cell.

In the above-described organic light-emitting panel, the plurality of light-emitting cells provided in each pixel may include 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, each organic light-emitting layer being formed by applying, for each pixel, three types of ink, which correspond one-to-one to the different colors of light, respectively to the three light-emitting cells in an order of the first light-emitting cell, the second light-emitting cell and the third light-emitting cell, the plurality of pixels are arranged to be continuously adjacent to each other, and in each pixel, two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have equal inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have different inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have equal inclination angles.

The above structure exerts an effect on the structure where a non-light-emitting cell is not provided between each pair of adjacent pixels and ink is applied in the order of the first light-emitting cell, the second light-emitting cell and the third light-emitting cell in each pixel. That is to say, in the above structure, two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell to which ink is applied in the first round, have equal inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell to which ink is applied in the second round, have different inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell to which ink is applied in the third round, have equal inclination angles. With this structure, even in the case where different ink vapor concentrations occur because ink is applied to the light-emitting cells in sequence at different timings, it is possible to effectively prevent an uneven film thickness from occurring in the organic light-emitting layer formed in each of the first, second and third light-emitting cells by adjusting the relative pinning locations of the ink in the sidewalls of the banks.

In the above-described organic light-emitting panel, among two inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell, a sidewall of a bank located on a side of the third light-emitting cell may have a larger inclination angle than a sidewall of a bank located on a side of the first light-emitting cell. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the above-described organic light-emitting panel, the sidewall of the bank located on the side of the first light-

emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, may have equal inclination angles. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the above-described organic light-emitting panel, the sidewall of the bank located on the side of the first light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, may have equal inclination angles. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the organic light-emitting panel having the above structure, the inclination angles of the sidewalls of the banks can be set to the following ranges:

(a1) among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the third light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees,

(a2) among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the first light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees,

(a3) each of the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees, and

(a4) each of the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees.

In the above-described organic light-emitting panel, the plurality of light-emitting cells provided in each pixel may include 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, each organic light-emitting layer being formed by applying, for each pixel, three types of ink, which correspond one-to-one to the different colors of light, respectively to the three light-emitting cells in an order of the first light-emitting cell, the second light-emitting cell and the third light-emitting cell, a non-light-emitting cell is provided between each pair of adjacent pixels, a bank is provided between each pair of a pixel and a non-light-emitting cell that are adjacent to each other, the bank separating the pixel from the non-light-emitting cell, and in each pixel, two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have equal inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have different inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles.

The above structure exerts an effect on the structure where a non-light-emitting cell is provided between each pair of adjacent pixels and ink is applied in the order of the first light-emitting cell, the second light-emitting cell and the third light-emitting cell in each pixel. That is to say, in the above structure, two inner sidewalls, which face each other in two

adjacent banks defining the first light-emitting cell to which ink is applied in the first round, have equal inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell to which ink is applied in the second round, have different inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell to which ink is applied in the third round, have different inclination angles. With this structure, even in the case where different ink vapor concentrations occur because ink is applied to the light-emitting cells in sequence at different timings, it is possible to effectively prevent an uneven film thickness from occurring in the organic light-emitting layer formed in each of the first, second and third light-emitting cells by adjusting the relative pinning locations of the ink in the sidewalls of the banks.

In the above-described organic light-emitting panel, among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the third light-emitting cell may have a larger inclination angle than the sidewall of the bank located on the side of the first light-emitting cell, and among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has a larger inclination angle than the sidewall of the bank located on the side of the second light-emitting cell. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the above-described organic light-emitting panel, the sidewall of the bank located on the side of the third light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, and the sidewall of the bank located on the side of the non-light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, may have equal inclination angles. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the above-described organic light-emitting panel, the sidewall of the bank located on the side of the first light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, may have equal inclination angles. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the above-described organic light-emitting panel, the sidewall of the bank located on the side of the second light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, may have equal inclination angles.

In the organic light-emitting panel having the above structure, the inclination angles of the sidewalls of the banks can be set to the following ranges:

(b1) among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the third light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees,

(b2) among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees,

(b3) among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the first light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees,

(b4) among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the second light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees, and

(b5) each of the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees.

In the above-described organic light-emitting panel, the plurality of light-emitting cells provided in each pixel may include 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, each organic light-emitting layer being formed by applying, for each pixel, three types of ink, which correspond one-to-one to the different colors of light, respectively to the three light-emitting cells at the same time, a non-light-emitting cell is provided between each pair of adjacent pixels, a bank is provided between each pair of a pixel and a non-light-emitting cell that are adjacent to each other, the bank separating the pixel from the non-light-emitting cell, and in each pixel, two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have different inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have equal inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles.

The above structure exerts an effect on the structure where a non-light-emitting cell is provided between each pair of adjacent pixels and ink is applied at the same time to the first light-emitting cell, the second light-emitting cell and the third light-emitting cell in each pixel. That is to say, since the ink is applied at the same time and a non-light-emitting cell is provided between each pair of adjacent pixels, two regions located on both sides of the second light-emitting cell (located at the central portion of the alignment) have equal ink vapor concentrations and two regions located on both sides of each of the first and third light-emitting cells have different ink vapor concentrations, when ink is applied to the light-emitting cells. Based on this state of ink vapor concentration distribution, in the above structure, two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have different inclination angles, two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have equal inclination angles, and two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles. With this structure, even in the case where different ink vapor concentrations occur when ink is applied, it is possible to effectively prevent an uneven film thickness from occurring in the organic light-emitting layer formed in each of the first, second and third light-emitting cells by adjusting the relative pinning locations of the ink in the sidewalls of the banks.

In the above-described organic light-emitting panel, among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell may have a larger inclination angle than the sidewall of the bank located on the side of the second light-emitting cell, and among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has a larger inclination angle than the sidewall of the bank located on the side of the second light-emitting cell. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the above-described organic light-emitting panel, the sidewall of the bank located on the side of the non-light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, and the sidewall of the bank located on the side of the non-light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, may have equal inclination angles. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the above-described organic light-emitting panel, the sidewall of the bank located on the side of the second light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, may have equal inclination angles. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the above-described organic light-emitting panel, the sidewall of the bank located on the side of the second light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, may have equal inclination angles. With this structure, it is possible to prevent an uneven film thickness of the organic light-emitting layer from occurring in each of the first, second and third light-emitting cells.

In the organic light-emitting panel having the above structure, the inclination angles of the sidewalls of the banks can be set to the following ranges:

(c1) among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees,

(c2) among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees,

(c3) among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, the sidewall of the bank located on the side of the second light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees,

(c4) among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the

sidewall of the bank located on the side of the second light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees, and

(c5) each of the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees.

In the above-described organic light-emitting panel, each inclination angle may be an angle formed by a side wall of a bank and an upper surface of the underlying layer on which the bank is provided.

In the above-described organic light-emitting panel, the underlying layer may include a TFT layer formed below the first layer, and in the pixel that is structured such that the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell have different inclination angles, the first electrode and the TFT layer may be electrically connected with each other.

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, as described above, can prevent the organic light-emitting layer in the organic light-emitting panel from becoming uneven in film thickness and provide excellent light-emitting characteristics.

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 the manufacturing method comprises the following steps:

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

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

(third step) forming, for each pixel, a plurality of openings corresponding to a plurality of 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 define each light-emitting cell by separating the light-emitting cells one from another;

(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

(fifth step) forming a second electrode above each organic light-emitting layer.

In the manufacturing method of an organic light-emitting panel according to a further aspect of the present invention, in the third step, at least one pixel among the plurality of pixels is formed such that two inner sidewalls, which face each other in two adjacent banks defining a predetermined light-emitting cell among the plurality of light-emitting cells, have different inclination angles.

With the above manufacturing method of the organic light-emitting panel where two inner sidewalls, which face each other in two adjacent banks defining the predetermined light-emitting cell among the plurality of light-emitting cells, have different inclination angles, it is possible to adjust the pinning locations of the ink dripped during the manufacturing. To be more specific, the larger the inclination angle of a sidewall of a bank is, the higher the pinning location is; and the smaller the inclination angle of a sidewall of a bank is, the lower the pinning location is.

In the above manufacturing method of an organic light-emitting panel according to a further 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, based on the relationship that the film thickness of the organic light-emitting layer and the inclination angle of the bank sidewall have a reverse relationship after the ink is dried. It is thus possible to manufacture an organic light-emitting panel with excellent light-emitting characteristics.

In the above manufacturing method of an organic light-emitting panel according to a further aspect of the present invention, in the third step, the at least one pixel may be formed such that two inner sidewalls, which face each other in two adjacent banks defining a light-emitting cell other than the predetermined light-emitting cell, have equal inclination angles.

When the above structure is adopted, two inner sidewalls, which face each other in two adjacent banks defining the predetermined light-emitting cell, are formed to have different inclination angles. It is thus possible to form the organic light-emitting layer having an even film thickness in each light-emitting cell, and manufacture the organic light-emitting panel having excellent light-emitting characteristics, as described above. In addition, with the above-described structure where, in each of one or more light-emitting cells other than the predetermined light-emitting cell in the pixel, two inner sidewalls facing each other have equal inclination angles, it is possible to prevent the organic light-emitting layer from becoming uneven in film thickness and provide excellent light-emitting characteristics. This makes it possible to manufacture an organic light-emitting panel having excellent light-emitting characteristics in all pixels.

Note that the term "equal" above does not mean exact mathematical equivalence, but rather takes factors such as dimensional error during manufacturing of the display device into account. Specifically, the term "equal" refers to making the inclination angles equal within the range permitted in practice by the difference in luminous efficiency (uneven luminance) between the light-emitting cells in the central region and peripheral region of the panel.

In the above manufacturing method of an organic light-emitting panel according to a further aspect of the present invention, in the third step, when the exposure of the photoresist material is performed, the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell may be formed to have different inclination angles, by causing portions of the photoresist material corresponding to the sidewalls of the banks defining the predetermined light-emitting cell to be exposed to different amounts of light. With the above structure where the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell are formed to have different inclination angles, by causing portions of the photoresist material corresponding to the sidewalls of the banks defining the predetermined light-emitting cell to be exposed to different amounts of light, it is possible to form the organic light-emitting layer having an even film thickness in each light-emitting cell, by adjusting the pinning location. This makes it possible to manufacture an organic light-emitting panel having excellent light-emitting characteristics.

In the above manufacturing method of an organic light-emitting panel according to a further aspect of the present invention, in the third step, when the exposure of the photoresist material is performed, the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell may be formed to have different inclination angles, by using masks that are different in light transmissivity at portions of the photoresist material corresponding to the sidewalls of the banks defining the predeter-

mined light-emitting cell. With the above structure where the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell are formed to have different inclination angles, by causing portions of the photoresist material corresponding to the sidewalls of the banks defining the predetermined light-emitting cell to be exposed to different amounts of light, it is also possible to form the organic light-emitting layer having an even film thickness in each light-emitting cell, by adjusting the pinning location. This makes it possible to manufacture an organic light-emitting panel having excellent light-emitting characteristics.

In the above manufacturing method of an organic light-emitting panel according to a further aspect of the present invention, in the third step, after the photoresist material is exposed and developed, the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell may be formed to have different inclination angles, by additionally performing an exposure process onto a portion of the photoresist material corresponding to one of the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell. The organic display device obtained in this way produces the same advantageous effect as the organic light-emitting panel manufactured by the manufacturing method of the present invention. With the above structure where the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell are formed to have different inclination angles, by causing portions of the photoresist material corresponding to the sidewalls of the banks defining the predetermined light-emitting cell to be exposed to different amounts of light, it is also possible to form the organic light-emitting layer having an even film thickness in each light-emitting cell, by adjusting the pinning location. This makes it possible to manufacture an organic light-emitting panel having excellent light-emitting characteristics.

An organic display device according to a still further aspect of the present invention includes an organic light-emitting panel manufactured by any one of the above-described manufacturing methods of the present invention. The organic display device including the organic light-emitting panel manufactured by the above manufacturing method, as described above, can prevent the organic light-emitting layer in the organic light-emitting panel from becoming uneven in film thickness and provide excellent light-emitting characteristics.

[Embodiment]

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

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.

(Process by which the Embodiment According to the Present Invention was Achieved)

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.

Typically, as shown in FIG. 25A, an anode 902 and an electrode coating layer 903 covering the anode 902 are formed on a substrate 901, for each of sub-pixels 900a, 900b, and 900c. 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 906a, 906b, and 906c of different colors are formed one-to-one in sub-pixels 900a, 900b, and 900c. The organic light-emitting layers 906a, 906b, and 906c are separated from each other by banks 905a to 905d formed to stand on the hole injection layer 904.

As shown in FIG. 25A, in an organic light-emitting panel of a conventional technology, an uneven film thickness is observed in the organic light-emitting layer 906b of the sub-pixel 900b that is located in a central region of the array. Specifically, the following phenomenon occurs. That is to say, the surface level of the organic light-emitting layer 906b is higher at location C₃ in the bank 905c than at location C₂ in the bank 905b. Also, the surface level of the organic light-emitting layer 906b is higher than the surface level of the organic light-emitting layer 906a at location C₁ in the bank 905b.

Also, as another example, as shown in FIG. 25B, a phenomenon occurs in which the surface levels of the organic light-emitting layers 956b and 956c in the sub-pixels 950b and 950c at locations C₁₂ and C₁₄ in the banks 955c and 955d are higher than the surface levels of the organic light-emitting layers 956b and 956c at locations C₁₁ and C₁₃ in the banks 955b and 955c, respectively. Note that, as shown in FIG. 25B, the surface levels of the organic light-emitting layer 956a in the sub-pixel 950a at respective locations in the bank 955a and the bank 955b are approximately the same, and a large amount of unevenness in film thickness is not observed.

After repeated examination of the above phenomenon, the inventor determined that reduction in uniformity of film thickness in the organic light-emitting layer causes a non-uniform vapor concentration distribution during ink drying, as described below. That is to say, as shown in FIG. 26A, suppose a state in which ink 9060c for forming the organic light-emitting layer has been applied in an area between the bank 905b and the bank 905c, and the right-hand side of FIG. 26A 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.

As shown in FIG. 26A, a surface profile L₉₀ of ink 9060b has been swollen up in the central region of the sub-pixel immediately after the ink 9060b 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 L₉₁.

However, as shown in FIG. 26B, solvent in the ink 9061b flows during drying as shown by the dotted-line arrow L₉₂. 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. 26C, if the vapor concentration distribution is not uniform, the organic light-emitting layer 906b is formed to have a surface profile L₉₃ in which the closer to the right-hand side the layer is, the higher the layer is.

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

The inventor also discovered technology to vary, within the panel, the pinning location of ink on a bank side wall by varying the inclination angle of the bank side wall, which improves uniformity of film thickness in the organic light-emitting layer.

[Embodiment 1]

1. Configuration of Display Device 1

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

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.

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

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.

2. Structure of Display Panel 10

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.

As shown in FIG. 2, in the display panel **10**, anodes **102** are formed above a TFT substrate (hereinafter simply referred to as a "substrate") **101** in one-to-one correspondence with the sub-pixels **300a**, **300b** and **300c**, and on each of the anodes **102**, an electrode coating layer **103** is formed, and a hole injection transporting layer **104** is layered on the electrode coating layers **103**.

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.

a) Substrate 101

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.

b) Anode 102

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.

c) Electrode Coating Layer 103

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.

d) Hole Injection Transporting Layer 104

The hole injection transporting layer **104** is a layer formed from an oxide of a metal such as silver (Ag), molybdenum (Mo), chromium (Cr), vanadium (V), tungsten (W), nickel (Ni), or iridium (Ir), or formed from a conductive polymer

material, such as PEDOT (a mixture of polythiophene and polystyrene sulfonate). The hole injection transporting layer **104** formed from such a metal oxide, among the above materials, has the function of assisting with generation of holes and injecting and transporting the holes stably into the organic light-emitting layer **106**. The hole injection transporting layer **104** has a high work function.

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.

e) Banks 105

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.

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 fluorinated.

Note that as the insulating material used in forming the banks **105**, any liquid repellent material with a resistivity of $10^5 \Omega\text{-cm}$ can be used, starting with the above materials. Using a material with a resistivity of less than $10^5 \Omega\text{-cm}$ 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.

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**.

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.

f) Organic Light-Emitting Layer 106

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.

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, telluropirylium 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.

g) Electron Injection Layer 107

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.

h) Cathode 108

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.

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.

i) Passivation Layer 109

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.

3. Structure of Banks 105

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.

4. Structure of Banks 105 in Each Region

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.

As shown in FIG. 4, sub-pixels 100a, 100b, and 100c are arranged continuously in this order from left to right along the X axis direction. Note that in the display panel 10 of the present embodiment, the sub-pixels are arranged to be continuously adjacent to each other.

The sub-pixel 100a is defined by banks 105a and 105b; the sub-pixel 100b is defined by banks 105b and 105c; and the sub-pixel 100c is defined by banks 105c and 105d. Sidewalls 105aa, 105ba, 105bb, 105cb, 105cc, and 105dc of the banks 105a, 105b, 105c and 105d respectively form angles θ_{aa} , θ_{ba} , θ_{bb} , θ_{cb} , θ_{cc} , and θ_{dc} with the surface of the hole injection transporting layer 104, which is an underlying layer.

In the present Embodiment, the angles θ_{aa} , θ_{ba} , θ_{bb} , θ_{cb} , θ_{cc} , and θ_{dc} satisfy the relationships indicated by the following expressions.

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

Note that in the present Embodiment, it is preferable that the angles θ_{aa} , θ_{ba} , θ_{bb} , θ_{cb} , θ_{cc} , and θ_{dc} satisfy the relationships indicated by the above Expression 1 and are set to the following ranges.

$$25^\circ < \theta_{aa} = \theta_{ba} = \theta_{bb} = \theta_{cc} = \theta_{dc} < 35^\circ \quad [\text{Expression 2}]$$

$$35^\circ < \theta_{cb} < 45^\circ \quad [\text{Expression 3}]$$

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

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.

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

$$\theta_y > \theta_x \quad [\text{Expression 4}]$$

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

$$H_y > H_x \quad [\text{Expression 5}]$$

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

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

The thicknesses Tx and Ty satisfy the following relationship.

$$T_x > T_y \quad [\text{Expression 6}]$$

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.

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

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.

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.

6. Manufacturing Method of Display Panel 10

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.

First, as shown in FIG. 9A, 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 1000a, 1000b, and 1000c are to be formed. Furthermore, a hole injection transporting layer 104 is then layered thereon so as to cover the entire surface. The anodes 102 is 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.

The electrode coating layers 103 is 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 surface of the electrode coating layer 103, by a method such as the sputtering method. Subsequently, the metal film is oxidized to form the hole injection transporting layer 104.

Next, as shown in FIG. 9B, 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.

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

Note that, as shown in FIG. 9C, in the mask 501, a width Wa of the opening 501a located on the left-hand side of a region 1000a 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 Pa1 and Pa2 positioned at the foot of the sidewalls 105aa, . . . of the bank 105a that is to be formed (see FIG. 4).

On the other hand, a width Wc1 of the opening 501c located between the planned sub-pixel formation regions 1000b and 1000c is defined by a point Pc1 being at the upper edge of the sidewall 105cb of the bank 105c that is to be formed (see FIG. 4) and a point Pc2 being at the foot of the sidewall 105cc of the bank 105c that is to be formed (see FIG. 4).

Next, as shown in FIG. 10A, a mask 502 is placed above the bank material layer 1050, the mask 502 having opening 502c at the location corresponding to the sidewall 105cb of the bank 105c (see FIG. 4). In this state, the second exposure is performed via the opening 502c of the mask 502.

Note that, as shown in FIG. 10A, in the mask 502, a width Wc2 of the opening 502c is defined by points Pc3 and Pc1 being at the foot and the upper edge of the sidewall 105cb of the bank 105c that is to be formed.

Next, the development and baking are performed to form the banks 105a, 105b, 105c, and 105d as shown in FIG. 10B.

As described above, the sidewall 105cb of the bank 105c on the planned sub-pixel formation region 1000b side is larger than the sidewalls 105aa, 105ba, 105bb, and 105dc of the banks 105a, 105b and 105d and the sidewall 105cc of the bank 105c on the planned sub-pixel formation region 1000c side.

After this, as shown in FIG. 10C, ink 1060a including an organic light-emitting material is applied to an opening (the planned sub-pixel formation region 1000a) defined by the banks 105a and 105b by the inkjet method or the like.

Subsequently, as shown in FIG. 11A, ink 1060b including an organic light-emitting material is applied to an opening (the planned sub-pixel formation region 1000b) defined by the banks 105b and 105c by the inkjet method or the like. Here, since, as described above, the inclination angle of the sidewall 105cb of the bank 105c is set to be larger than the inclination angles of the other sidewalls, the pinning location Qcb of the ink 1060b in the sidewall 105cb of the bank 105c becomes higher in position than the other pinning locations Qaa, Qba, and Qbb.

Subsequently, as shown in FIG. 11B, ink 1060c including an organic light-emitting material is applied to an opening (the planned sub-pixel formation region 1000c) defined by the banks 105c and 105d by the inkjet method or the like. Here, since ink has already been applied to the planned sub-pixel formation region adjacent, on the right-hand side, to the bank 105d, two ends of the applied ink 1060c in the X axis direction have the same ink vapor concentration, and the organic light-emitting layer has even film thickness without adjustment of the inclination angles of the sidewalls of the banks. This is clear from the above.

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.

7. Ink Applying Process and Drying Process

The following describes the relationships between the ink applying process and the ink drying process with reference to FIGS. 12A and 12B.

As illustrated in FIG. 12A, in the present embodiment, firstly red ink (the ink 1060a) is applied (step S1), then green ink (the ink 1060b) is applied (step S2), and blue ink (the ink 1060c) is applied (step S3). After this, ink drying process is performed to dry all the applied inks at once (step S4).

As an alternative to the above method, as illustrated in FIG. 12B, the following processes may be performed in sequence in the stated order: applying red ink (the ink 1060a) (step S11) and drying the applied red ink (step S12); applying green ink (the ink 1060b) (step S21) and drying the applied green ink (step S22); and applying blue ink (the ink 1060c) (step S31) and drying the applied blue ink (step S32). In this case, the relationships in inclination angle among the side walls 105aa, 105ba, 105bb, 105cb, 105cc, and 105dc of the banks 105a, 105b, 105c, and 105d may be the same as those described above. This structure also can restrict the film thickness of the formed organic light-emitting layer 106 from becoming uneven.

8. Advantageous Effects

As shown in FIG. 4, in the display panel 10 of the display device 1 according to the present Embodiment, inclination angle θ_{cb} of the sidewall 105cb of the bank 105c positioned on the sub-pixel 100c side is set larger than the inclination angles θ_{aa} , θ_{ba} , θ_{bb} , θ_{cc} , and θ_{dc} of other sidewalls 105aa, 105ba, 105bb, 105cc, and 105dc. As a result, as shown in FIG. 11A, when the ink 1060b is applied in the planned sub-pixel formation region 1000b, the pinning location Qcb is higher in position than the other pinning locations Qaa, Qba, and Qbb.

On the other hand, the inclination angles θ_{aa} , θ_{ba} , θ_{bb} , θ_{cc} , and θ_{dc} of the other sidewalls **105aa**, **105ba**, **105bb**, **105cc**, and **105dc** are equal.

This enables sub-pixels **100a**, **100b**, and **100c** 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.

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.

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 **100a**, **100b**, and **100c**, which correspond to the inclination angles, falls in an acceptable range.

[Modification 1]

Next, with reference to FIG. **13**, Modification 1 of the manufacturing method of the display device **1** is described. FIG. **13** illustrates processes corresponding to processes illustrated in FIGS. **9C** to **10A**.

As shown in FIG. **13**, 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 **503a**, **503b**, **503c1**, **503c2**, and **503d**. The light transmissive portions **503a**, **503b**, **503c1**, **503c2**, and **503d** are provided at locations corresponding to portions in which the banks **105a**, **105b**, **105c**, and **105d** are to be formed.

In the manufacturing method of the display device **1** in Modification 1, width W_a of the light transmissive portion **503a**, which corresponds to the left-hand side of the planned sub-pixel formation region **1000a**, is defined by points Pa_1 and Pa_2 at the feet of the sidewalls **105aa**, . . . of the bank **105a** (see FIG. **4**) that is to be formed.

On the other hand, width W_{c2} of the light transmissive portion **503c1**, which corresponds to a region between the planned sub-pixel formation regions **1000b** and **1000c**, is defined by points Pc_2 and Pc_1 that are respectively positioned at the foot and upper edge of the bank **105c** to be formed (see FIG. **4**). Also, the light transmissive portion **503c2** is defined by points Pc_3 and Pc_1 that are respectively positioned at the foot and upper edge of the sidewall **105cb** of the bank **105c** to be formed (see FIG. **4**).

The mask **503** is made from a half-tone or the like, and the light transmissive portions **503a**, **503b**, **503c1**, and **503d** differ from the light transmissive portion **503c2** in light transmissivity. More specifically, the light transmissive portion **503c2** is larger than the light transmissive portions **503a**, **503b**, **503c1**, and **503d** in light transmissivity.

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 **105a**, **105b**, **105c**, and **105d** as shown in FIG. **10B**. That is to say, sidewalls having larger inclination angles are formed at locations which are exposed to light via the light transmissive portion **503c2** having a larger light transmissivity than the light transmissive portions **503a**, **503b**, **503c1**, and **503d**, in accordance with the relationship indicated by the above-described Expression 1.

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

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

[Modification 2]

Next, with reference to FIGS. **14A** to **15B**, Modification 2 of the manufacturing method of the display device **1** is described. FIGS. **14A** to **15B** illustrate processes corresponding to the processes illustrated in FIGS. **9C** to **10B**.

As shown in FIG. **14A**, 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 **504a**, **504b**, **504c**, and **504d** corresponding to the portions at which banks **105** are to be formed.

The openings **504a**, **504b**, and **504d** are formed to have the same width as the opening **501a** in the mask **501** used in the manufacturing method of the above Embodiment.

On the other hand, a width W_{c3} of the opening **504c** located between the planned sub-pixel formation regions **1000b** and **1000d** in correspondence with the bank **105c** that is to be formed (see FIG. **4**) is set to be larger than a width that is defined by points Pc_3 and Pc_2 being at the feet of the bank **105c** that is to be formed (see FIG. **4**), as indicated by the two-dot chain line in FIG. **14A**. More specifically, the width is made larger at the portions where the inclination angles are to be larger.

In the state where the mask **504** is set in place as shown in FIG. **14A**, the exposure and development in the first round are performed. After this process is performed, as shown in FIG. **14B**, bank material layers **1051a**, **1051b**, **1051c**, and **1051d** remain in the locations corresponding to the openings **504a**, **504b**, **504c**, and **504d**.

Note that, as shown in FIG. **14B**, the inclination angles of the sidewalls in the bank material layers **1051a**, **1051b**, **1051c**, and **1051d** are uniform after the first exposure and development are performed. In Modification 2, the baking is not performed at this point in time.

As shown in FIG. **15A**, a mask **505** is placed above the bank material layers **1051a**, **1051b**, **1051c**, and **1051d** after they are formed. In the mask **505**, an opening **505c** is provided only at the location where the inclination angle is to be larger (sidewall **105cb** of the bank **105c**) among the locations in the mask **505** corresponding to the sidewalls of the banks **105a**, **105b**, **105c**, and **105d** that are to be formed.

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 **105a**, **105b**, **105c**, and **105d** as shown in FIG. **15B**.

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]

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 FIGS. **16A** and **16B**.

As shown in FIG. **16A**, 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. **16B**.

Furthermore, as shown in FIGS. **16A** and **16B**, 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.

Note that in FIG. 16B, the horizontal axis represents the horizontal direction, and the vertical axis represents the direction of height.

[Embodiment 2]

The following describes an overall structure of the display device in Embodiment 2 with reference to FIGS. 17 and 18.

1. Structure of Display Panel 30

As shown in FIG. 17, in the display panel 30, as in the display panel 10 in Embodiment 1, anodes 102 are formed above a TFT substrate (hereinafter simply referred to as a "substrate") 101 in one-to-one correspondence with the sub-pixels 300a, 300b and 300c, and on each of the anodes 102, an electrode coating layer 103 is formed, and a hole injection transporting layer 104 is layered on the electrode coating layers 103.

Above the hole injection transporting layer 104, banks 305a, 305b, 305c, and 305d are formed from insulating material to define the sub-pixels 300a, 300b, and 300c. An organic light-emitting layer is formed in each region of the sub-pixels 300a, 300b, and 300c defined by the banks 305a, 305b, 305c, 305d, and an electron injection layer, a cathode, and a passivation layer are layered above the organic light-emitting layer in this order (illustration of these is omitted in FIG. 17).

In the display panel 30 of the present embodiment, as is the case with the display panel 10 in the above-described Embodiment 1, a pixel is composed of three sub-pixels 300a, 300b, and 300c. In addition, in the display panel 30 of the present embodiment, non-light-emitting cells 300d and 300e are provided between the pixel and the adjacent pixels on both sides.

More specifically, as illustrated in FIG. 17, each of the non-light-emitting cells 300d and 300e has an electrode (bus bar) 302, which is made of the same material as the anode 102, and an electrode coating layer 303 covering the electrode 302. A hole injection transporting layer 104 is formed to cover each stack of the layers including the electrode coating layer 303. A cathode 108 (not illustrated) is formed on the hole injection transporting layer 104 such that the electrode 302 and the cathode 108 are electrically connected. Note that the organic light-emitting layer 106 is not formed in the non-light-emitting cells 300d and 300e. The above structure makes it possible to lower the electric resistance of the cathode 108 that is composed of ITO and the like, thereby preventing a voltage drop from occurring.

As illustrated in FIG. 17, in the display panel 30 of the present embodiment, side walls 305aa, 305ba, 305bb, 305cb, 305cc, and 305dc of the banks 305a, 305b, 305c, and 305d respectively form angles $\theta 3aa$, $\theta 3ba$, $\theta 3bb$, $\theta 3cb$, $\theta 3cc$, and $\theta 3dc$ with the surface of the hole injection transporting layer 104 as an underlying layer.

Here, in the present embodiment, the angles $\theta 3aa$, $\theta 3ba$, $\theta 3bb$, $\theta 3cb$, $\theta 3cc$, and $\theta 3dc$ satisfy the relationships represented by the following expressions.

$$\theta 3cb > \theta 3aa = \theta 3ba = \theta 3bb = \theta 3cc \quad [\text{Expression 7}]$$

$$\theta 3dc > \theta 3aa = \theta 3ba = \theta 3bb = \theta 3cc \quad [\text{Expression 8}]$$

Note that, in the present embodiment, the angles $\theta 3aa$, $\theta 3ba$, $\theta 3bb$, $\theta 3cb$, $\theta 3cc$, and $\theta 3dc$ are preferably set to the following ranges.

$$25^\circ < \theta 3aa = \theta 3ba = \theta 3bb = \theta 3cc < 35^\circ \quad [\text{Expression 9}]$$

$$35^\circ < \theta 3cb < 45^\circ \quad [\text{Expression 10}]$$

$$35^\circ < \theta 3dc < 45^\circ \quad [\text{Expression 11}]$$

The reason why the inclination angles $\theta 3aa$, $\theta 3ba$, $\theta 3bb$, $\theta 3cb$, $\theta 3cc$, and $\theta 3dc$ of the side walls 305aa, 305ba, 305bb, 305cb, 305cc, and 305dc of the banks 305a, 305b, 305c, and 305d are defined by the above-described Expressions 7 to 11 is that the non-light-emitting cells 300d and 300e are provided between a pixel and the adjacent pixels on both sides. Description of this is provided in connection with application of inks 3060a, 3060b, and 3060c.

2. Manufacturing Method of Display Panel 30

The following describes the characteristic steps of the manufacturing method of the display panel 30 according to the present Embodiment with reference to FIGS. 18A to 18C. Note that the steps other than those illustrated in FIGS. 18A to 18C are the same as those of Embodiment 1.

As shown in FIG. 18A, ink 3060a that includes an organic light-emitting material is dripped into the opening (planned sub-pixel formation region 3000a) defined by the banks 305a and 305b by the inkjet method or other method. When the ink 3060a is applied to the region between the banks 305a and 305b, ink has not been applied to the left-hand side of the bank 305a and the right-hand side of the bank 305b, and thus the vapor concentration distribution is substantially uniform.

Following this, as shown in FIG. 18B, ink 3060b that includes an organic light-emitting material is dripped into the opening (planned sub-pixel formation region 3000b) defined by the banks 305b and 305c by the inkjet method or other method. Here, as described above, inclination angle $\theta 3cb$ of the sidewall 305cb of the bank 305c (see FIG. 17) is set to satisfy the relationships represented by the above-described Expression 7 (to be relatively larger than the other inclination angles). As a result, the pinning location Q3cb of the ink 3060b in the side wall 305cb of the bank 305c is higher in position than the pinning locations Q3aa, Q3ba, and Q3bb.

Subsequently, as shown in FIG. 18C, ink 3060c that includes an organic light-emitting material is dripped into the opening (planned sub-pixel formation region 3000c) defined by the banks 305c and 305d by the inkjet method or other method. Here, in the present embodiment, the non-light-emitting cell 3000d, to which ink is not applied, is present on the right-hand side of the planned sub-pixel formation region 3000c. Accordingly, the vapor concentration is lower in the right-hand side of the planned sub-pixel formation region 3000c than in the left-hand side. For this reason, as is the case with the inclination angle $\theta 3cb$ of the sidewall 305cb of the bank 305c, the inclination angle $\theta 3dc$ of the sidewall 305dc of the bank 305d on the planned sub-pixel formation region 3000c side (see FIG. 17) is set to satisfy the relationships represented by the above-described Expressions 7 and 8 (to be relatively larger than the other inclination angles). As a result, the pinning location Q3dc of the ink 3060c in the side wall 305dc of the bank 305d, as well as the pinning location Q3cb of the ink 3060b, is higher in position than the other pinning locations.

Note that, although omitted from the drawings, subsequently, the display panel 30 is formed by layering, in order, the electron injection layer, cathode, passivation layer, etc.

With the above-described structure, even in the case where the non-light-emitting cells 300d and 300e are provided between a pixel and the adjacent pixels on both sides, it is possible to prevent the organic light-emitting layer from becoming uneven in film thickness in all sub-pixels 300a, 300b, and 300c, and thus it is possible to provide the display panel 30 having high light transmissivity.

Note that the structures other than those described in the present embodiment are the same as those of Embodiment 1.

[Embodiment 3]

The following describes an overall structure of the display device in Embodiment 3 with reference to FIGS. 19 and 20.

1. Structure of Display Panel 40

As shown in FIG. 19, in the display panel 40, as in the display panel 10 in Embodiment 1, anodes 102 are formed above a TFT substrate (hereinafter simply referred to as a “substrate”) 101 in one-to-one correspondence with the sub-pixels 400a, 400b and 400c, and on each of the anodes 102, an electrode coating layer 103 is formed, and a hole injection transporting layer 104 is layered on the electrode coating layers 103.

Above the hole injection transporting layer 104, banks 405a, 405b, 405c, and 405d are formed from insulating material to define the sub-pixels 400a, 400b, and 400c. An organic light-emitting layer is formed in each region of the sub-pixels 400a, 400b, and 400c defined by the banks 405a, 405b, 405c, 405d, and an electron injection layer, a cathode, and a passivation layer are layered above the organic light-emitting layer in this order (illustration of these is omitted in FIG. 19).

In the display panel 40 of the present embodiment, as is the case with the display panel 30 in the above-described Embodiment 2, a pixel is composed of three sub-pixels 400a, 400b, and 400c. In addition, in the display panel 40 of the present embodiment, non-light-emitting cells 400d and 400e are provided between the pixel and the adjacent pixels on both sides. With regard to the points described above, the display panel 40 is the same as the display panel 30 of Embodiment 2.

As illustrated in FIG. 19, as is the case with Embodiment 2, each of the non-light-emitting cells 400d and 400e has an electrode (bus bar) 402, which is made of the same material as the anode 102, and an electrode coating layer 403 covering the electrode 402. Furthermore, a hole injection transporting layer 104 is formed to cover each stack of the layers including the electrode coating layer 403. A cathode (not illustrated) is formed on the hole injection transporting layer 104 such that the electrode 402 and the cathode are electrically connected. Note that the organic light-emitting layer is not formed in the non-light-emitting cells 400d and 400e. As is the case with Embodiment 2, this structure makes it possible to lower the electric resistance of the cathode that is composed of ITO and the like, thereby preventing a voltage drop from occurring.

As illustrated in FIG. 19, in the display panel 40 of the present embodiment, side walls 405aa, 405ba, 405bb, 405cb, 405cc, and 405dc of the banks 405a, 405b, 405c, and 405d respectively form angles $\theta 4aa$, $\theta 4ba$, $\theta 4bb$, $\theta 4cb$, $\theta 4cc$, and $\theta 4dc$ with the surface of the hole injection transporting layer 104, which is an underlying layer.

Here, in the present embodiment, the angles $\theta 4aa$, $\theta 4ba$, $\theta 4bb$, $\theta 4cb$, $\theta 4cc$, and $\theta 4dc$ satisfy the relationships represented by the following expressions.

$$\theta 4aa > \theta 4ba = \theta 4bb = \theta 4cb = \theta 4cc \quad [\text{Expression 12}]$$

$$\theta 4dc > \theta 4ba = \theta 4bb = \theta 4cb = \theta 4cc \quad [\text{Expression 13}]$$

Note that, in the present embodiment, the angles $\theta 4aa$, $\theta 4ba$, $\theta 4bb$, $\theta 4cb$, $\theta 4cc$, and $\theta 4dc$ are preferably set to the following ranges.

$$25^\circ < \theta 4ba = \theta 4bb = \theta 4cb = \theta 4cc < 35^\circ \quad [\text{Expression 14}]$$

$$35^\circ < \theta 4aa < 45^\circ \quad [\text{Expression 15}]$$

$$35^\circ < \theta 4dc < 45^\circ \quad [\text{Expression 16}]$$

The reason why the inclination angles $\theta 4aa$, $\theta 4ba$, $\theta 4bb$, $\theta 4cb$, $\theta 4cc$, and $\theta 4dc$ of the side walls 405aa, 405ba, 405bb, 405cb, 405cc, and 405dc of the banks 405a, 405b, 405c, and 405d are defined by the above Expressions 12 to 16 is that the

non-light-emitting cells 400d and 400e are provided between a pixel and the adjacent pixels on both sides, and in connection with this, an appropriate method for applying inks 4060a, 4060b, and 4060c is adopted as described below.

2. Manufacturing Method of Display Panel 40

The following describes the characteristic steps of the manufacturing method of the display panel 40 according to the present Embodiment with reference to FIG. 20. Note that the steps other than those illustrated in FIG. 20 are the same as those of Embodiment 1.

As shown in FIG. 20, the following inks are applied to the following openings at the same time by the inkjet method or the like: ink 4060a to the planned sub-pixel formation region 4000a; ink 4060b to the planned sub-pixel formation region 4000b; and ink 4060c to the planned sub-pixel formation region 4000c. At the time when the inks 4060a, 4060b and 4060c are applied, the vapor concentration distribution is uniform between the left-hand and right-hand sides in the X-axis direction only in the planned sub-pixel formation region 4000b which is located at the central region of the pixel.

On the other hand, in the planned sub-pixel formation region 4000a, the vapor concentration distribution is lower on the left-hand side than on the right-hand side due to the presence of the non-light-emitting cell 400d on the left-hand side of the region 4000a in the X-axis direction. Similarly, in the planned sub-pixel formation region 4000c, the vapor concentration distribution is lower on the right-hand side than on the left-hand side due to the presence of the non-light-emitting cell 400e on the right-hand side of the region 4000c in the X-axis direction.

In the present embodiment, the non-light-emitting cells 400d and 400e are present on the left-hand and right-hand sides of the planned sub-pixel formation regions 4000a and 4000c, respectively. In view of this, in the present embodiment, the inclination angles $\theta 4aa$ and $\theta 4dc$ of the respective side walls 405aa and 405dc of the banks 405a and 405d are set to be larger than the other inclination angles $\theta 4ba$, $\theta 4bb$, $\theta 4cb$ and $\theta 4cc$. With this structure, the pinning locations Q4aa and Q4dc of the inks 4060a and 4060c in the respective sidewalls 405aa and 405dc of the banks 105a and 105d become higher in position than the other pinning locations Q4ba, Q4bb, Q4cb and Q4cc.

Note that, although not illustrated, subsequently the ink is dried, and the electron injection layer, cathode, passivation layer, etc. are layered in this order to form the display panel 40.

With the above-described structure, even in the case where the non-light-emitting cells 400d and 400e are each provided between adjacent pixels and the inks 4060a, 4060b and 4060c are applied at the same time, it is possible to restrict the film thickness of the organic light-emitting layer from becoming uneven in each of the sub-pixels 400a, 400b and 400c, and provide the display panel 40 having excellent light-emitting characteristics.

Note that, with regard to the structural elements that are not described in the present embodiment, corresponding structural elements of Embodiment 1 may be applied.

[Other Considerations]

Firstly, in the above Embodiments 1, 2 and 3 and Modifications 1 and 2, it is schematically illustrated that the surface of each sidewall of the banks 105, 105a-105d, 105x, 105y, 305a-305e, and 405a-405e is planar. However, the surface of each sidewall of the banks may not necessarily be planar. For example,

FIG. 19A illustrates a bank 605 whose sidewall has two surfaces: a surface extending from a point P₆₁ to a point P₆₂; and a surface extending from the point P₆₂ to a point P₆₃. In this case, a pinning location Qy1 during ink application is present on the surface between the points P₆₂ and P₆₃. Here,

an inclination angle $\theta y2$ formed between this the surface and a virtual straight line L_1 passing through the point P_6 , is important in the relationship with the pinning location.

However, the angle $\theta y2$ can be controlled by controlling an angle $\theta y1$, 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_6 , 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 $\theta y1$. For example, if a bank **705** is formed such that an angle $\theta y11$ 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 $\theta y1$ shown in FIG. **21A** (see FIG. **21B**), then, as shown in FIG. **21B**, an angle $\theta y12$ formed between a surface between points P_{72} and P_{73} and a virtual straight line L_2 also becomes larger than the angle $\theta y2$ shown in FIG. **21A**.

Secondly, in the above Embodiments 1, 2 and 3 and Modifications 1 and 2, it is not specified to what part of the region of the display panel **10**, **30** or **40** 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. **22**, the display panel **10** can be divided formally into areas **10a** and **10b** in a direction along the surface of the display panel **10**, wherein the area **10a** is located at the center, and the area **10b** surrounds the area **10a**. The area **10a** 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 **10b** 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 **10a** is further divided formally into a central area **10a1** and a surrounding area **10a2**, the uneven film thickness in the organic light-emitting layers of the sub-pixels in the surrounding area **10a2** would be more prominent due to the state of vapor concentration distribution during the application of ink.

Note that the combined area of the surrounding area **10a2** and the area **10b** 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.

In the above Embodiments 1, 2 and 3 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.

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**.

Furthermore, the above Embodiments 1, 2 and 3 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. **23**, 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.

Also, in the above Embodiments 1, 2 and 3 and Modifications 1 and 2, a so-called line bank structure is adopted for the banks **105**, **105a-105f**, **105x**, **105y**, **305a-305e**, **405a-405e**, **605**, and **705**, as shown in FIG. **3**. However, not limited to this, the structure of pixel bank **805** shown in FIG. **24** may be adopted. In this structure, a display panel **80** includes the pixel bank **805** which is composed of bank elements **805a** and bank elements **805b**, wherein the bank elements **805a** extend in the Y axis direction and the bank elements **805b** extend in the X axis direction.

As shown in FIG. **24**, 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 **800a**, **800b**, and **800c**. 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 .

Also, the inclination angles of the sidewalls of the banks adopted in the above Embodiments 1, 2 and 3 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.

In the above Embodiments 1, 2 and 3 and in Modifications 1 and 2, the inclination angle (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]

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

- 1** display device
- 10, 30, 40, 80** display panel
- 10a1** light-emitting central area
- 10a2** light-emitting surrounding area
- 10b** dummy area
- 20** drive control unit
- 21-24** drive circuit
- 25** control circuit
- 100, 100a-100c, 300a-300c, 400a-400c** sub-pixel
- 101** substrate
- 102** anode
- 103** electrode coating layer
- 104** hole injection layer
- 105, 105a-105d, 105x, 105y, 305a-305e, 405a-405e, 605, 705, 805** bank

106, 106a, 106c, 106x, 106y organic light-emitting layer
 107 electron injection layer
 108 cathode
 109 passivation layer
 300d, 300e, 400d, 400e non-light-emitting cell 5
 501-505 mask
 1000a-1000c, 3000a-3000c, 4000a-4000c region in which sub-pixel is to be formed
 1050, 1051a, 1051b, 1051e, 1051f bank material layer
 1060a-1060c, 1060x, 1060y, 3060a-3060c, 4060a-4060c 10
 ink
 3000d, 3000e, 4000d, 4000e region in which non-light-emitting cell is to be formed
 The invention claimed is:
 1. An organic light-emitting panel, comprising: 15
 an array of a plurality of pixels;
 a plurality of light-emitting cells which, provided in each pixel and arranged in an alignment, emit light of different colors,
 each light-emitting cell including an underlying layer, a 20
 first electrode provided in the underlying layer, an organic light-emitting layer, and a second electrode formed on an opposite side of the organic light-emitting layer from the underlying layer; and
 a plurality of banks which, formed above the underlying 25
 layer, define each light-emitting cell by separating the light-emitting cells one from another,
 wherein the plurality of pixels includes a pixel that is structured such that two inner sidewalls, which face each other in two adjacent banks defining a predetermined light-emitting cell among the plurality of light-emitting 30
 cells, have different inclination angles that are both acute angles, and
 each of the different inclination angles of the two inner sidewalls of the two adjacent banks is an angle formed 35
 by a corresponding one of the two inner sidewalls and the underlying layer from which each of the two inner sidewalls inclines.
 2. The organic light-emitting panel of claim 1, wherein in each of one or more light-emitting cells other than the 40
 predetermined light-emitting cell in the pixel that is structured such that the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell have the different inclination angles that are both the acute angles, two inner sidewalls 45
 facing each other have equal inclination angles that are both acute angles.
 3. The organic light-emitting panel of claim 1, wherein the plurality of light-emitting cells in each pixel include at 50
 least 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,
 the plurality of pixels are arranged to be continuously 55
 adjacent to each other, and
 the plurality of pixels include a pixel that is structured such that
 two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have equal inclination angles that are both acute angles, 60
 two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have different inclination angles that are both acute angles, and
 two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have 65
 equal inclination angles that are both acute angles.

4. The organic light-emitting panel of claim 1, wherein the plurality of light-emitting cells in each pixel include at least 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,
 a non-light-emitting cell is provided between each pair of adjacent pixels,
 a bank is provided between each pair of a pixel and a non-light-emitting cell that are adjacent to each other, the bank separating the pixel from the non-light-emitting cell, and
 the plurality of pixels include a pixel that is structured such that
 two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have equal inclination angles that are both acute angles,
 two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have different inclination angles that are both acute angles, and
 two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles that are both acute angles.
 5. The organic light-emitting panel of claim 1, wherein the plurality of light-emitting cells in each pixel include at least 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,
 a non-light-emitting cell is provided between each pair of adjacent pixels,
 a bank is provided between each pair of a pixel and a non-light-emitting cell that are adjacent to each other, the bank separating the pixel from the non-light-emitting cell, and
 the plurality of pixels include a pixel that is structured such that
 two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have different inclination angles that are both acute angles,
 two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have equal inclination angles that are both acute angles, and
 two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles that are both acute angles.
 6. The organic light-emitting panel of claim 4, wherein each non-light-emitting cell includes none of the organic light-emitting layers and includes the second electrode and a third electrode that is made of a same material as the first electrodes, the third electrode and the second electrode being electrically connected with each other.
 7. The organic light-emitting panel of claim 1, wherein two regions adjacent to the predetermined light-emitting cell have different ink vapor concentrations when ink is applied to the predetermined light-emitting cell, and among the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell, a sidewall of a bank, which is located on a side of a region having a lower ink vapor concentration among the two regions, has an inclination angle that is an acute angle and larger than an inclination angle of a sidewall of a bank, which is located on a side of a region having a higher ink vapor concentration among the two regions.

8. The organic light-emitting panel of claim 1, wherein a type of ink corresponding to the predetermined light-emitting cell is applied to the predetermined light-emitting cell in a state where a type of ink corresponding to one light-emitting cell among two light-emitting cells that are, in a same pixel, adjacent to the predetermined light-emitting cell, has been applied to the one light-emitting cell and before another type of ink corresponding to the other light-emitting cell among the two light-emitting cells starts to be applied to the other light-emitting cell, and
 a sidewall of a bank located on a side of the other light-emitting cell has an inclination angle that is an acute angle and larger than an inclination angle of a sidewall of a bank located on a side of the one light-emitting cell.
9. The organic light-emitting panel of claim 1, wherein two regions adjacent to the predetermined light-emitting cell have different ink vapor concentrations when ink is applied to the predetermined light-emitting cell, and two regions adjacent to a light-emitting cell, which is different from the predetermined light-emitting cell, have equal ink vapor concentrations when ink is applied to the light-emitting cell.
10. The organic light-emitting panel of claim 1, wherein the plurality of light-emitting cells provided in each pixel include at least 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, each organic light-emitting layer being formed by applying, for each pixel, at least three types of ink, which correspond one-to-one to the different colors of light, respectively to the at least three light-emitting cells in an order of the first light-emitting cell, the second light-emitting cell and the third light-emitting cell, the plurality of pixels are arranged to be continuously adjacent to each other, and in each pixel,
 two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have equal inclination angles that are both acute angles,
 two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have different inclination angles that are both acute angles, and
 two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have equal inclination angles that are both acute angles.
11. The organic light-emitting panel of claim 10, wherein among two inner sidewalls facing each other in two adjacent banks defining the second light-emitting cell, a sidewall of a bank located on a side of the third light-emitting cell has an inclination angle that is an acute angle and larger than an inclination angle of a sidewall of a bank located on a side of the first light-emitting cell.
12. The organic light-emitting panel of claim 11, wherein the sidewall of the bank located on the side of the first light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, have equal inclination angles that are acute angles.
13. The organic light-emitting panel of claim 12, wherein the sidewall of the bank located on the side of the first light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, and the two inner sidewalls facing

- each other in the two adjacent banks defining the third light-emitting cell, have equal inclination angles that are acute angles.
14. The organic light-emitting panel of claim 13, wherein among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the third light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees,
 among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the first light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees,
 each of the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees, and
 each of the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees.
15. The organic light-emitting panel of claim 1, wherein the plurality of light-emitting cells provided in each pixel include at least 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, each organic light-emitting layer being formed by applying, for each pixel, at least three types of ink, which correspond one-to-one to the different colors of light, respectively to the at least three light-emitting cells in an order of the first light-emitting cell, the second light-emitting cell and the third light-emitting cell,
 a non-light-emitting cell is provided between each pair of adjacent pixels,
 a bank is provided between each pair of a pixel and a non-light-emitting cell that are adjacent to each other, the bank separating the pixel from the non-light-emitting cell, and
 in each pixel,
 two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have equal inclination angles that are both acute angles,
 two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have different inclination angles that are both acute angles, and
 two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles that are both acute angles.
16. The organic light-emitting panel of claim 15, wherein among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the third light-emitting cell has an inclination angle that is an acute angle and larger than an inclination angle of the sidewall of the bank located on the side of the first light-emitting cell, and
 among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle that is an acute angle and larger than an inclination angle of the sidewall of the bank located on the side of the second light-emitting cell.

17. The organic light-emitting panel of claim 16, wherein the sidewall of the bank located on the side of the third light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, and the sidewall of the bank located on the side of the non-light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, have equal inclination angles that are both acute angles.

18. The organic light-emitting panel of claim 15, wherein the sidewall of the bank located on the side of the first light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, have equal inclination angles that are acute angles.

19. The organic light-emitting panel of claim 18, wherein the sidewall of the bank located on the side of the second light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, have equal inclination angles that are acute angles.

20. The organic light-emitting panel of claim 18, wherein among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the third light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees, among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees, among the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, the sidewall of the bank located on the side of the first light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees, among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the second light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees, and each of the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees.

21. The organic light-emitting panel of claim 1, wherein the plurality of light-emitting cells provided in each pixel include at least 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, each organic light-emitting layer being formed by applying, for each pixel, at least three types of ink, which correspond one-to-one to the different colors of light, respectively to the at least three light-emitting cells at the same time,

a non-light-emitting cell is provided between each pair of adjacent pixels,

a bank is provided between each pair of a pixel and a non-light-emitting cell that are adjacent to each other, the bank separating the pixel from the non-light-emitting cell, and

in each pixel,

two inner sidewalls, which face each other in two adjacent banks defining the first light-emitting cell, have different inclination angles that are both acute angles,

two inner sidewalls, which face each other in two adjacent banks defining the second light-emitting cell, have equal inclination angles that are both acute angles, and

two inner sidewalls, which face each other in two adjacent banks defining the third light-emitting cell, have different inclination angles that are both acute angles.

22. The organic light-emitting panel of claim 21, wherein among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle that is an acute angle and larger than an inclination angle of the sidewall of the bank located on the side of the second light-emitting cell, and among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle that is an acute angle and larger than an inclination angle of the sidewall of the bank located on the side of the second light-emitting cell.

23. The organic light-emitting panel of claim 22, wherein the sidewall of the bank located on the side of the non-light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, and the sidewall of the bank located on the side of the non-light-emitting cell among the inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, have equal inclination angles that are both acute angles.

24. The organic light-emitting panel of claim 21, wherein the sidewall of the bank located on the side of the second light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, have equal inclination angles that are acute angles.

25. The organic light-emitting panel of claim 24, wherein the sidewall of the bank located on the side of the second light-emitting cell among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, and the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell, have equal inclination angles that are acute angles.

26. The organic light-emitting panel of claim 25, wherein among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees, among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the non-light-emitting cell has an inclination angle of at least 35 degrees and at most 45 degrees, among the two inner sidewalls facing each other in the two adjacent banks defining the first light-emitting cell, the sidewall of the bank located on the side of the second light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees,

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among the two inner sidewalls facing each other in the two adjacent banks defining the third light-emitting cell, the sidewall of the bank located on the side of the second light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees, and

each of the two inner sidewalls facing each other in the two adjacent banks defining the second light-emitting cell has an inclination angle of at least 25 degrees and at most 35 degrees.

27. The organic light-emitting panel of claim 1, wherein each of the different inclination angles is an angle formed by a side wall of a bank and an upper surface of the underlying layer on which the bank is provided.

28. The organic light-emitting panel of claim 1, wherein the underlying layer includes a TFT layer formed below the first layer, and

in the pixel that is structured such that the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell have the different inclination angles, the first electrode and the TFT layer are electrically connected with each other.

29. An organic display device including the organic light-emitting panel defined in claim 1.

30. The organic light-emitting panel of claim 1, wherein an inclination angle of each of the two inner sidewalls of the two adjacent banks is uniform from the underlying layer to an upper surface of a corresponding one of the two adjacent banks.

31. The organic light-emitting panel of claim 1, wherein each of the two inner sidewalls of the two adjacent banks includes at least two surfaces that form different inclination angles with respect to the underlying layer on which the two adjacent banks are formed.

32. A manufacturing method of an organic light-emitting panel including an array of a plurality of pixels, the manufacturing method comprising:

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

layering a photoresist material on the underlying layer;

forming, for each pixel of the plurality of pixels, a plurality of openings corresponding to a plurality of 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 define each light-emitting cell by separating the light-emitting cells one from another;

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 forming a second electrode above each organic light-emitting layer, wherein

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in the forming of the plurality of openings, at least one pixel among the plurality of pixels is formed such that two inner sidewalls, which face each other in two adjacent banks defining a predetermined light-emitting cell among the plurality of light-emitting cells, have different inclination angles that are both acute angles, and each of the different inclination angles of the two inner sidewalls of the two adjacent banks is an angle formed by a corresponding one of the two inner sidewalls and the underlying layer from which each of the two inner sidewalls inclines.

33. The manufacturing method of claim 32, wherein in the forming of the plurality of openings, the at least one pixel is formed such that two inner sidewalls, which face each other in two adjacent banks defining a light-emitting cell other than the predetermined light-emitting cell, have equal inclination angles that are both acute angles.

34. The manufacturing method of claim 32, wherein in the forming of the plurality of openings, when the exposure of the photoresist material is performed, the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell are formed to have the different inclination angles, by causing portions of the photoresist material corresponding to the two inner sidewalls of the two adjacent banks defining the predetermined light-emitting cell to be exposed to different amounts of light.

35. The manufacturing method of claim 32, wherein in the forming of the plurality of openings, when the exposure of the photoresist material is performed, the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell are formed to have the different inclination angles, by using masks that are different in light transmissivity at portions of the photoresist material corresponding to the two inner sidewalls of the two adjacent banks defining the predetermined light-emitting cell.

36. The manufacturing method of claim 32, wherein in the forming of the plurality of openings, after the photoresist material is exposed and developed, the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell are formed to have the different inclination angles, by additionally performing an exposure process onto a portion of the photoresist material corresponding to one of the two inner sidewalls facing each other in the two adjacent banks defining the predetermined light-emitting cell.

37. An organic display device including the organic light-emitting panel manufactured by the manufacturing method defined in claim 32.

* * * * *

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	US8907358	公开(公告)日	2014-12-09
申请号	US13/716744	申请日	2012-12-17
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)	JOLED INC		
[标]发明人	MATSUSHIMA HIDEAKI		
发明人	MATSUSHIMA, HIDEAKI		
IPC分类号	H01L51/56 H01L51/50 H01L21/00 H01L33/08 H01L33/00 H01L29/20 H01L51/00 H01L27/32 H01L29/08 H01L51/52 H01L29/18		
CPC分类号	H01L27/3246 H01L51/0005 H01L51/5234 H01L51/56 H01L51/50 H01L33/08 H01L27/3211 H01L51/5228		
代理机构(译)	GREENBLUM与伯恩斯坦，P.L.C.		
助理审查员(译)	灰色，AARON		
其他公开文献	US20130105782A1		
外部链接	Espacenet USPTO		

摘要(译)

面板中的像素包括子像素100a，100b和100c。堤105a分离子像素100a的有机发光层和与子像素100a相邻的像素的子像素的有机发光层。堤105d分离子像素100c的有机发光层和与子像素100c相邻的像素的子像素的有机发光层。堤105b分离子像素100a的有机发光层和子像素100b的有机发光层。堤105c分离子像素100b的有机发光层和子像素100c的有机发光层。位于子像素100c侧的堤105c的侧壁105cb的倾斜角 θ_{cb} 设定为大于其他倾斜角 θ_{aa} ， θ_{ba} ， θ_{bb} ， θ_{cc} 和 θ_{dc} 。

