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(54) **DISPLAY PANEL AND METHOD FOR MANUFACTURING THE SAME, AND DISPLAY APPARATUS**

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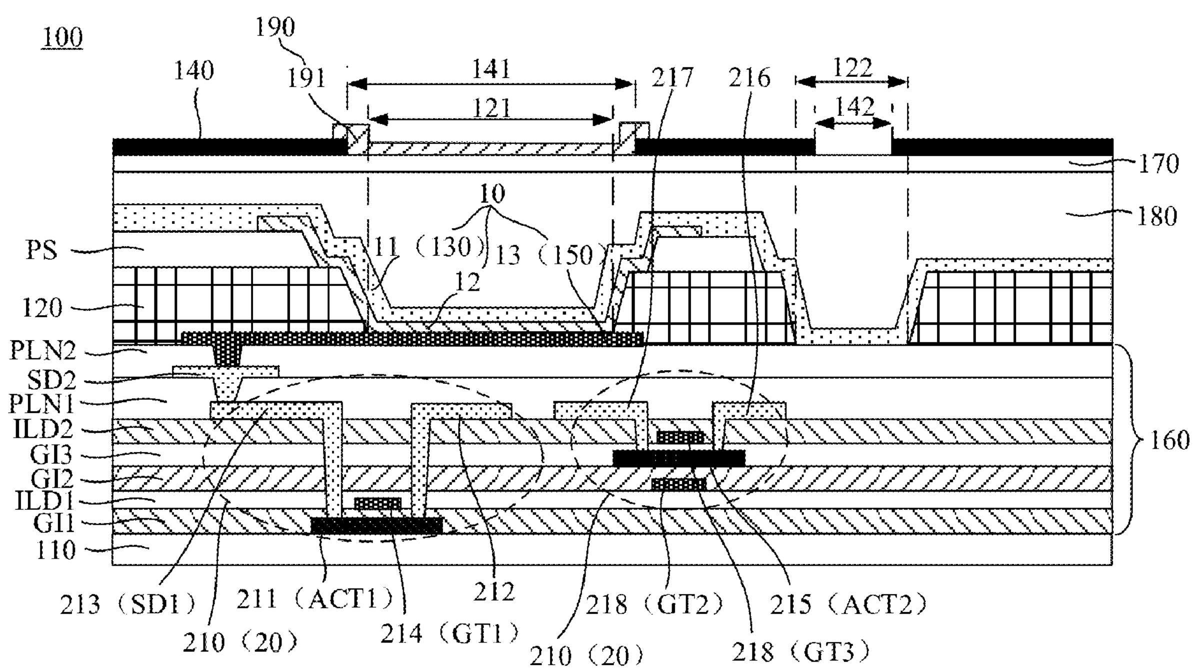
(57) **ABSTRACT**

A display panel includes a substrate, a pixel defining layer, a first electrode layer and a black matrix. The pixel defining layer is disposed on the substrate, and is provided with a plurality of first pixel openings and a plurality of first photosensitive openings. The first electrode layer is disposed on a side of the pixel defining layer away from the substrate. The black matrix is disposed on a side of the first electrode layer away from the substrate, and is provided with a plurality of second pixel openings and a plurality of second photosensitive openings. An orthogonal projection of at least one first pixel opening on the substrate is located within an orthographic projection of a second pixel opening on the substrate. An orthogonal projection of at least one second photosensitive opening on the substrate is located within an orthographic projection of a first photosensitive opening on the substrate.



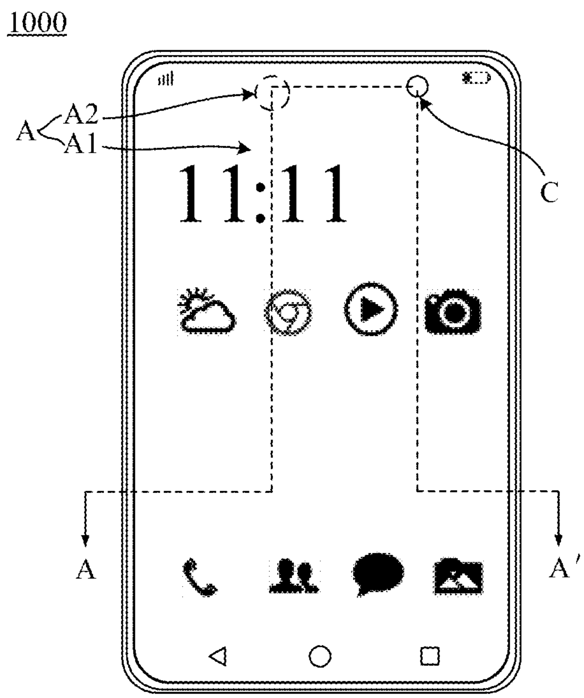


FIG. 1

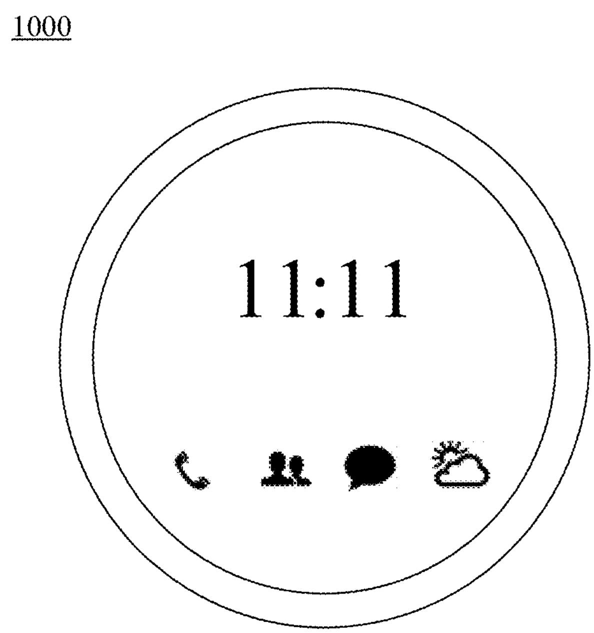


FIG. 2

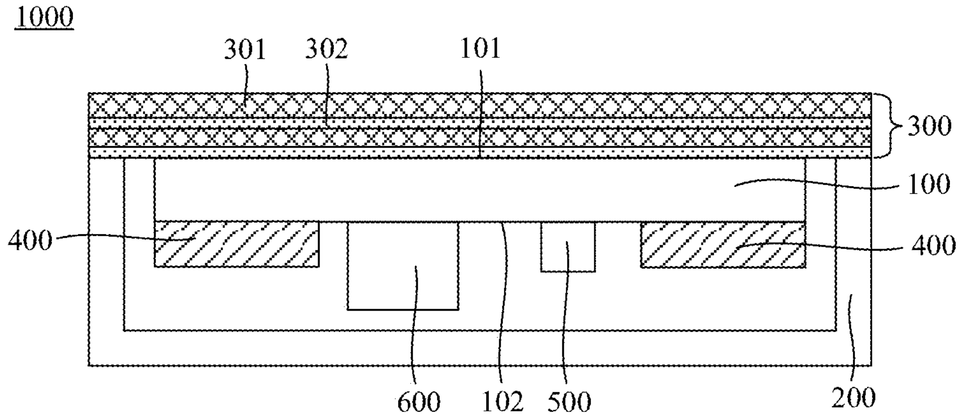


FIG. 3

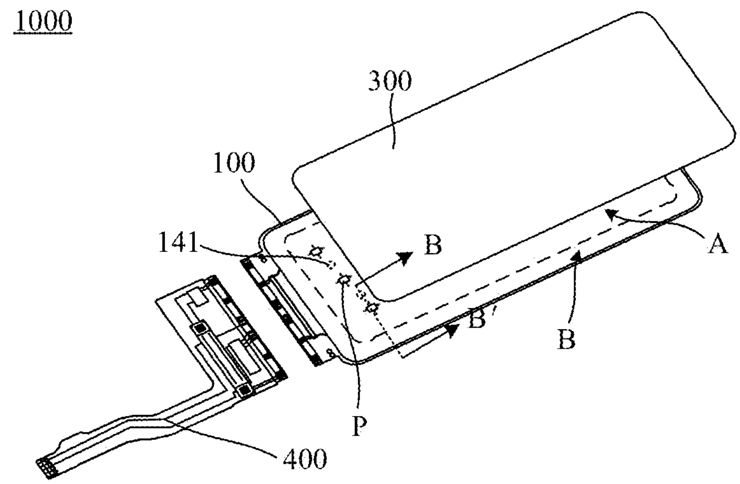


FIG. 4

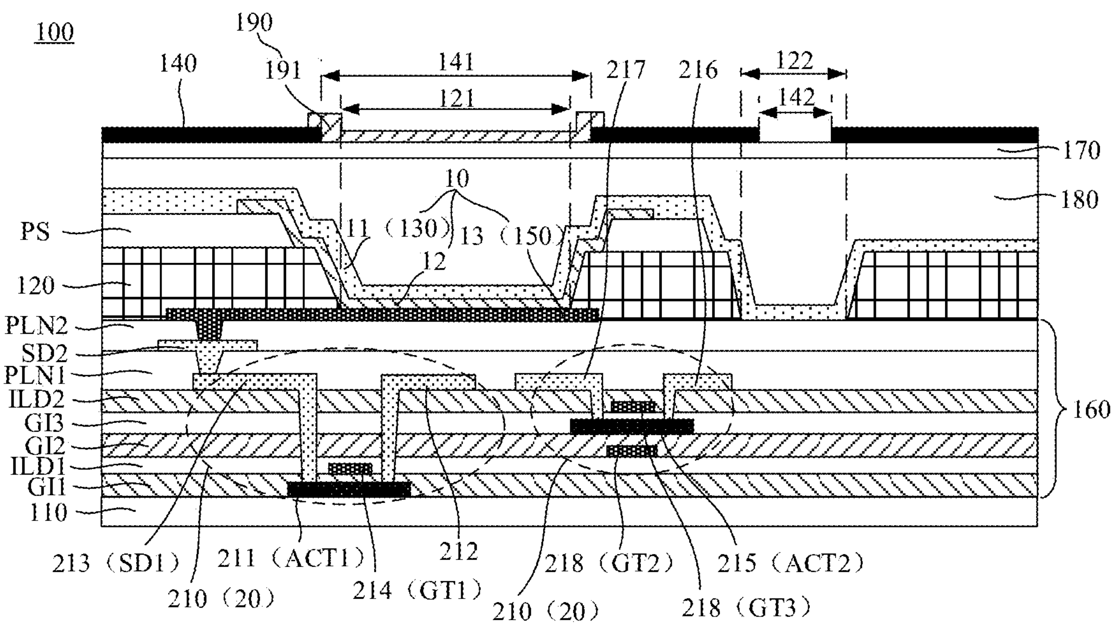


FIG. 5A

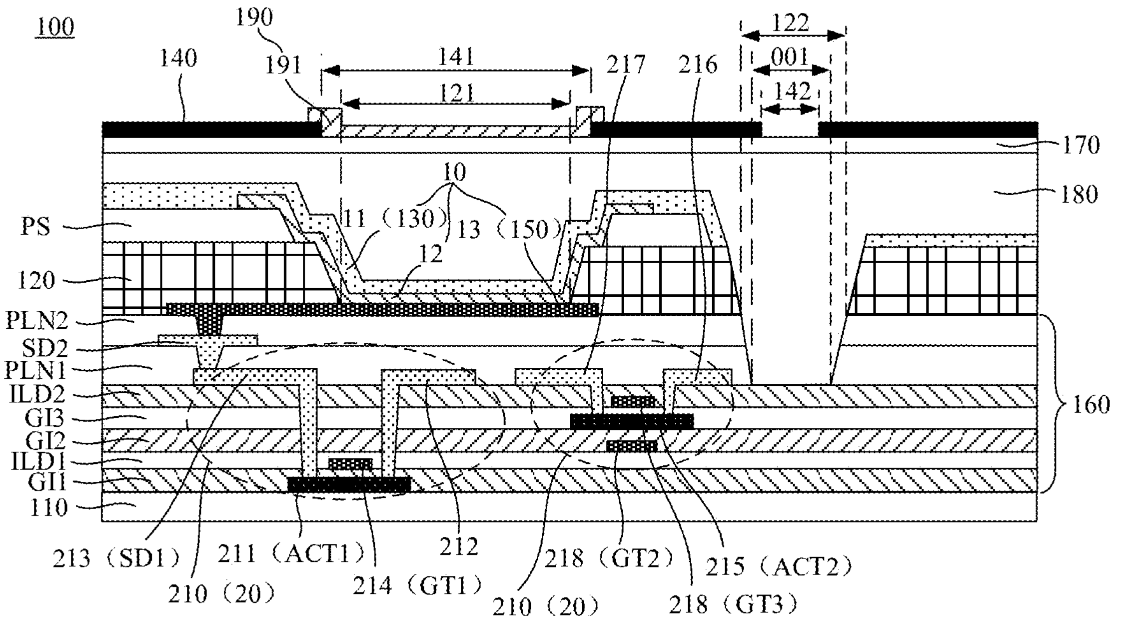

100
190
191
141
121
140
217
216
122
001
142
170
180
10
11（130）
13（150）
12
PS
120
PLN2
SD2
PLN1
ILD2
GI3
GI2
ILD1
GI1
110
160
213（SD1）
211（ACT1）
212
218（GT2）
215（ACT2）
210（20）
214（GT1）
210（20）
218（GT3）

FIG. 5B

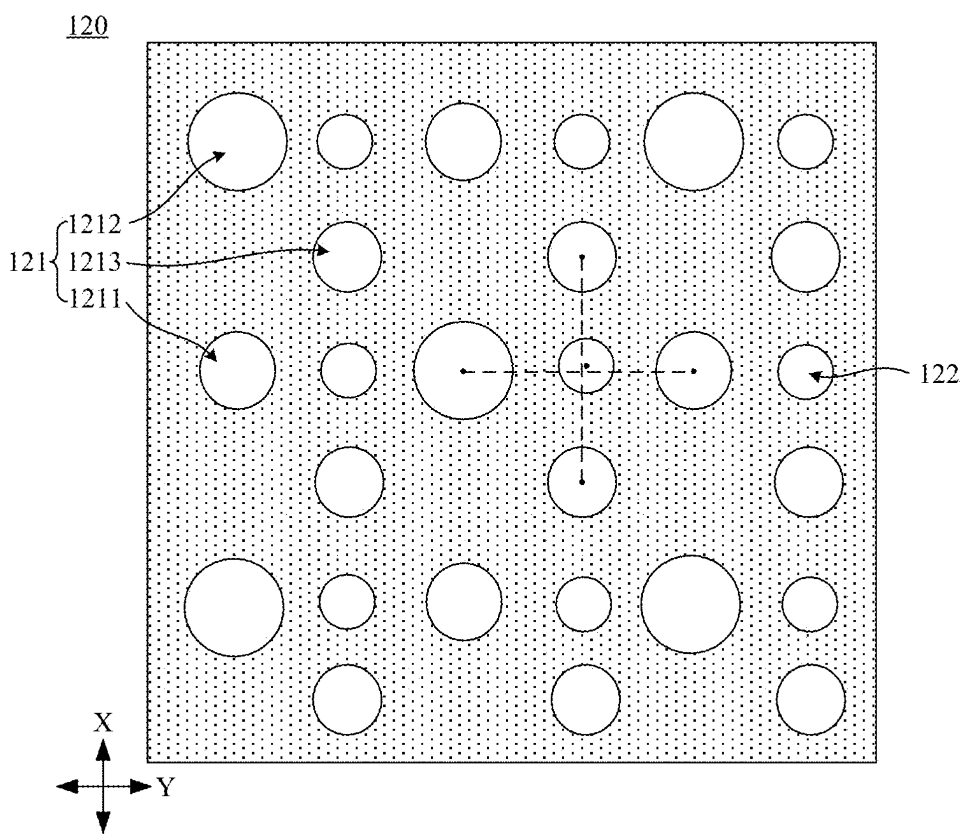

120
1212
121
1213
1211
122
X
Y

FIG. 6

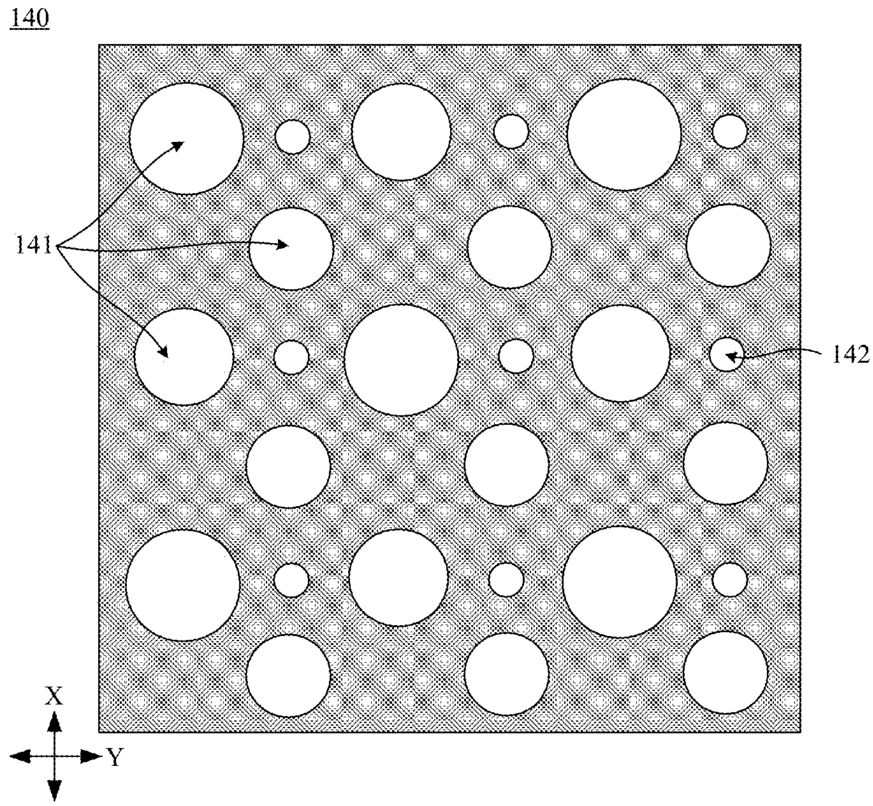


FIG. 7

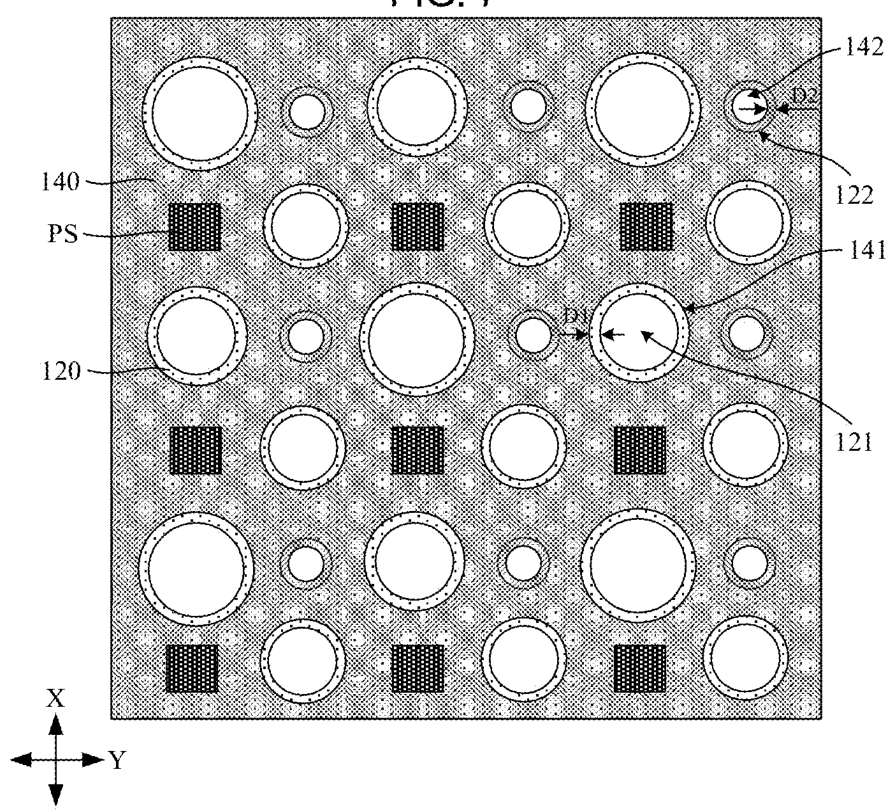


FIG. 8

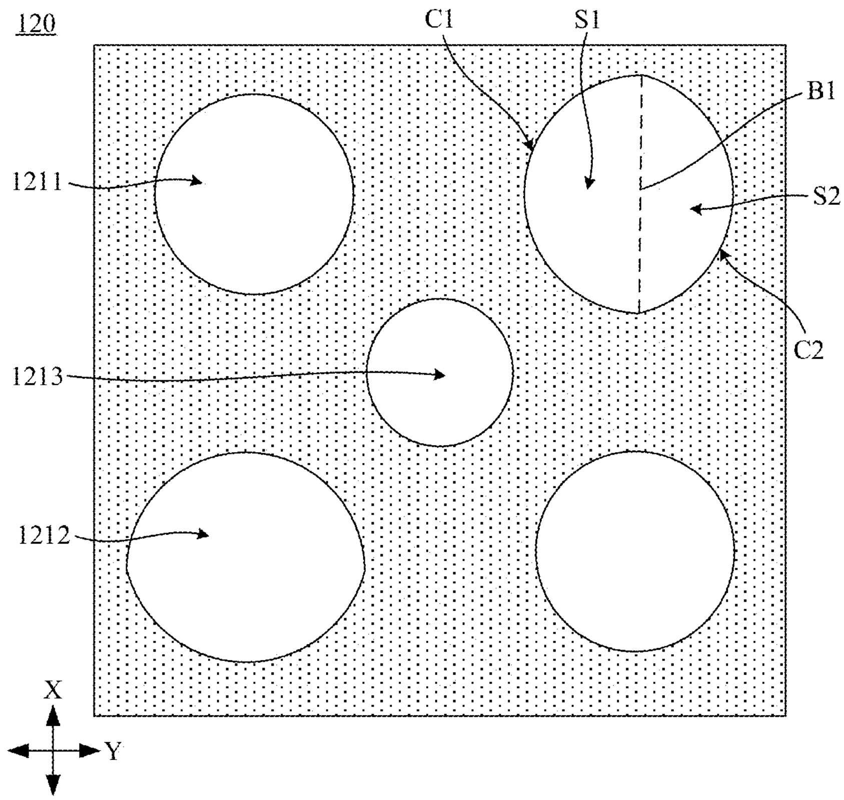

120
C1
S1
B1
S2
C2
1211
1213
1212
X
Y

FIG. 9

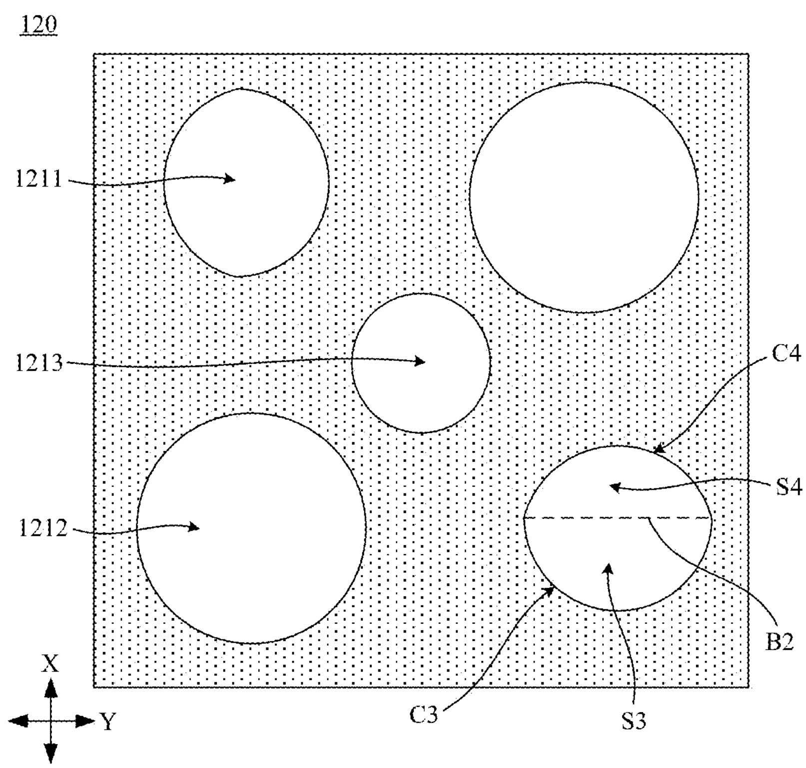

120
1211
1213
C4
S4
1212
B2
X
Y
C3
S3

FIG. 10

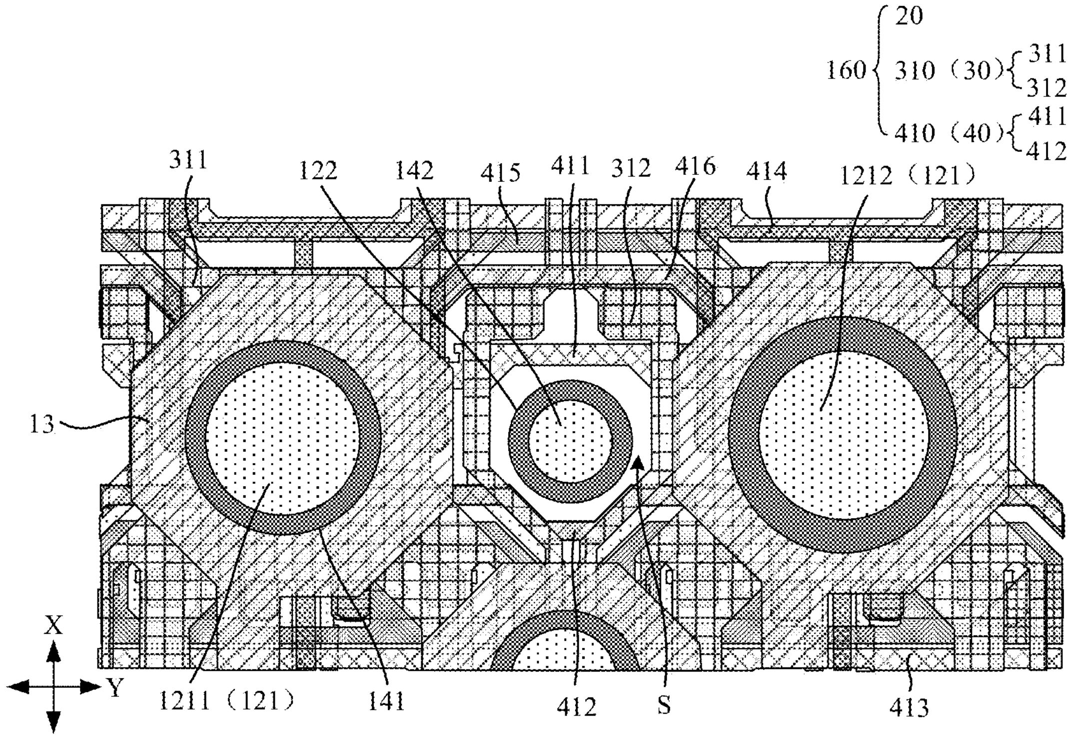

20
160
310 (30)
311
312
410 (40)
411
412
311
122
142
415
411
312
416
414
1212 (121)
13
X
Y
1211 (121)
141
412
S
413

FIG. 11

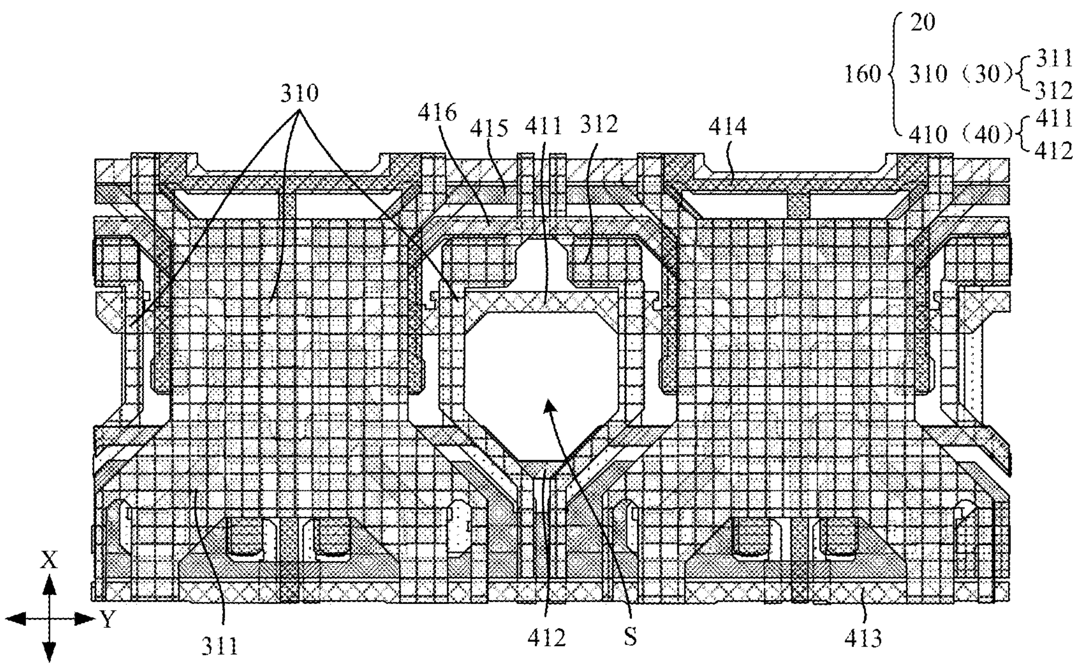
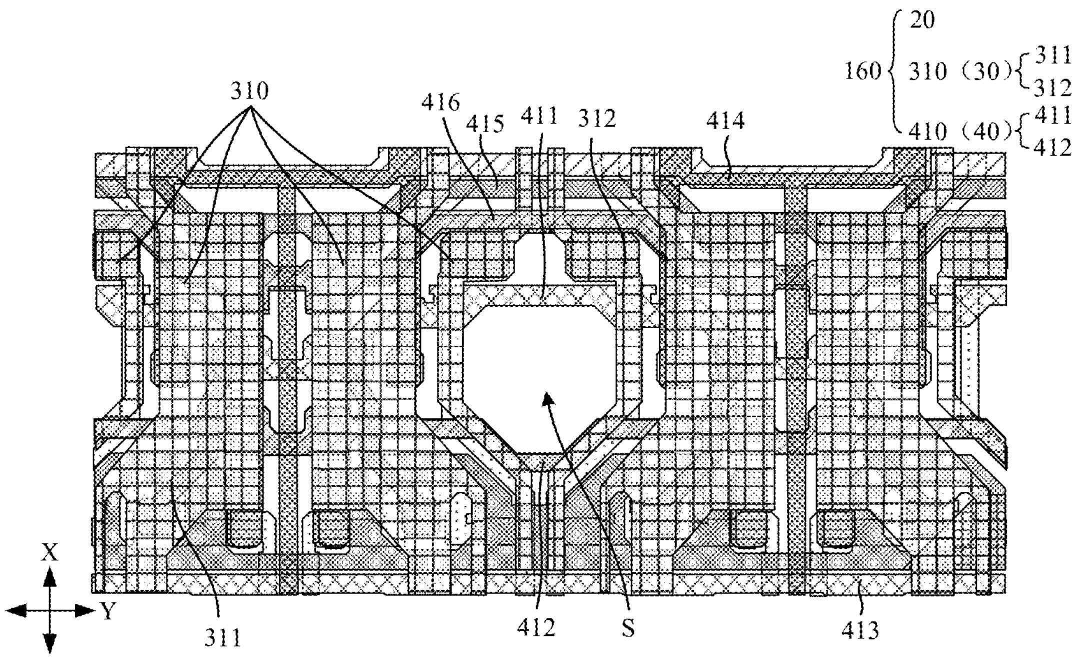
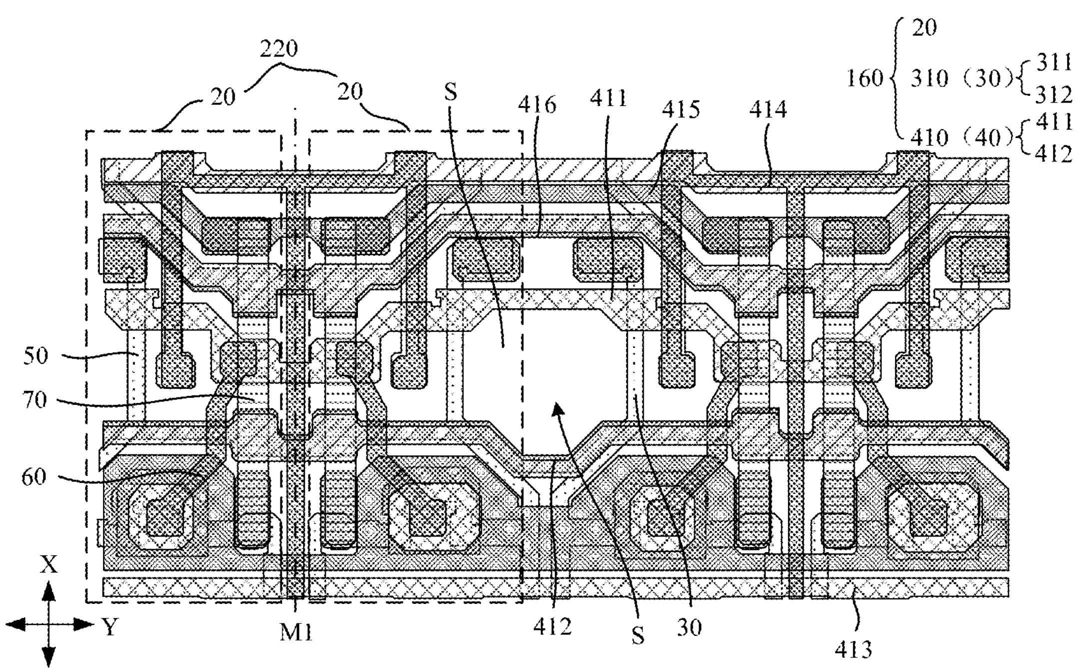

20
160
310 (30)
311
312
410 (40)
411
412
310
416
415
411
312
414
X
Y
311
412
S
413

FIG. 12



160
20
310 (30)
311
312
410 (40)
411
412
310
416
415
411
312
414
X
Y
311
412
S
413

FIG. 13



160
20
310 (30)
311
312
410 (40)
411
412
220
20
20
S
416
411
415
414
50
70
60
X
Y
M1
412
S
30
413

FIG. 14

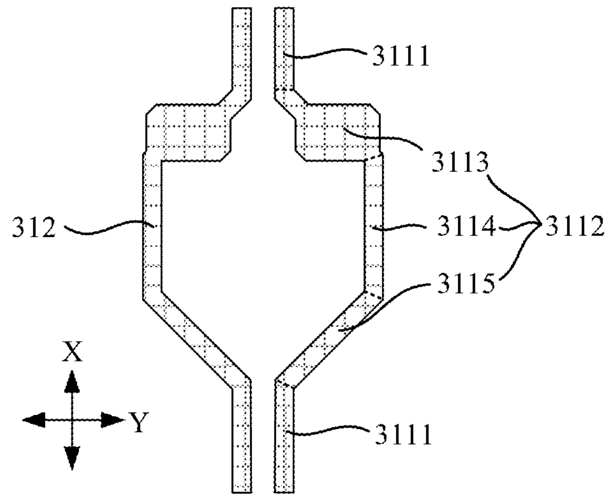


FIG. 15

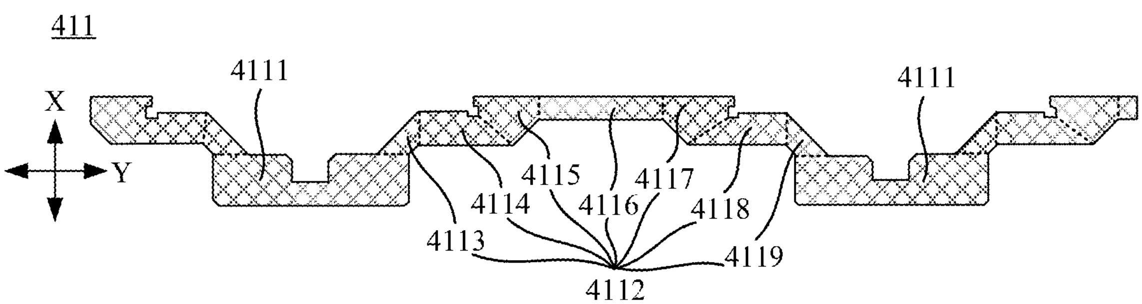


FIG. 16

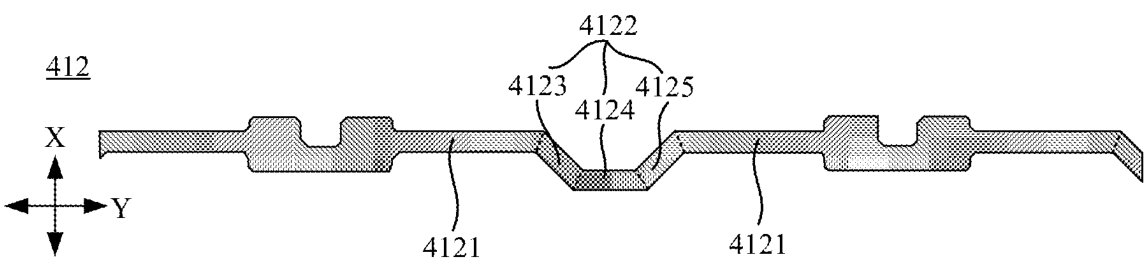


FIG. 17

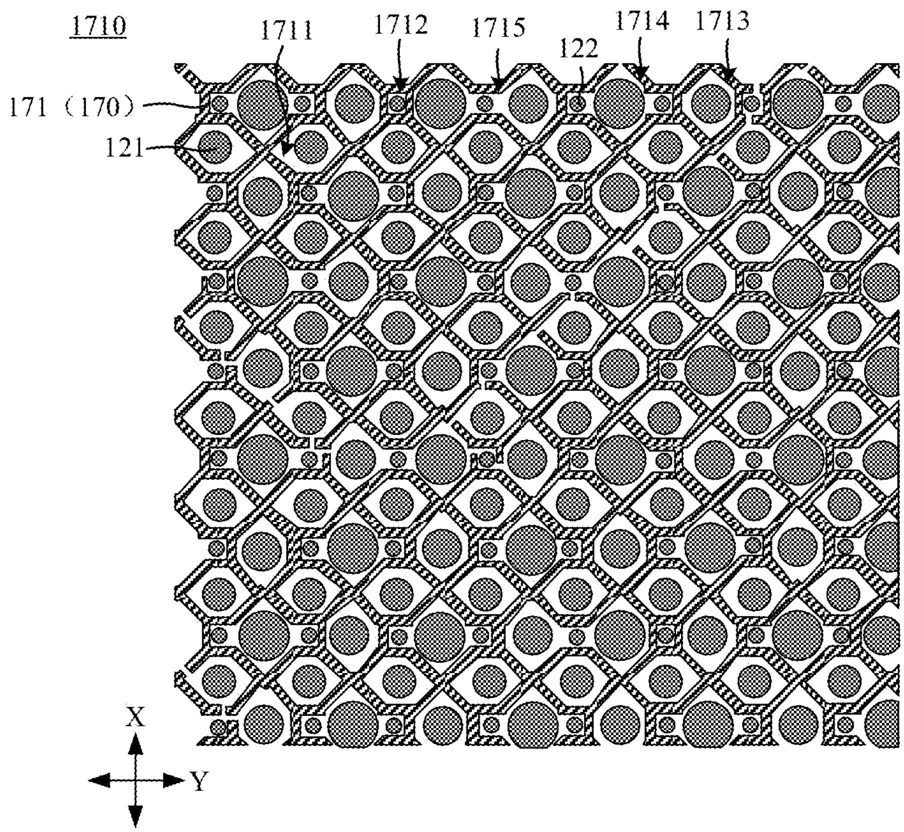

1710
1711
1712
1715
122
1714
1713
171（170）
121
X
Y

FIG. 18

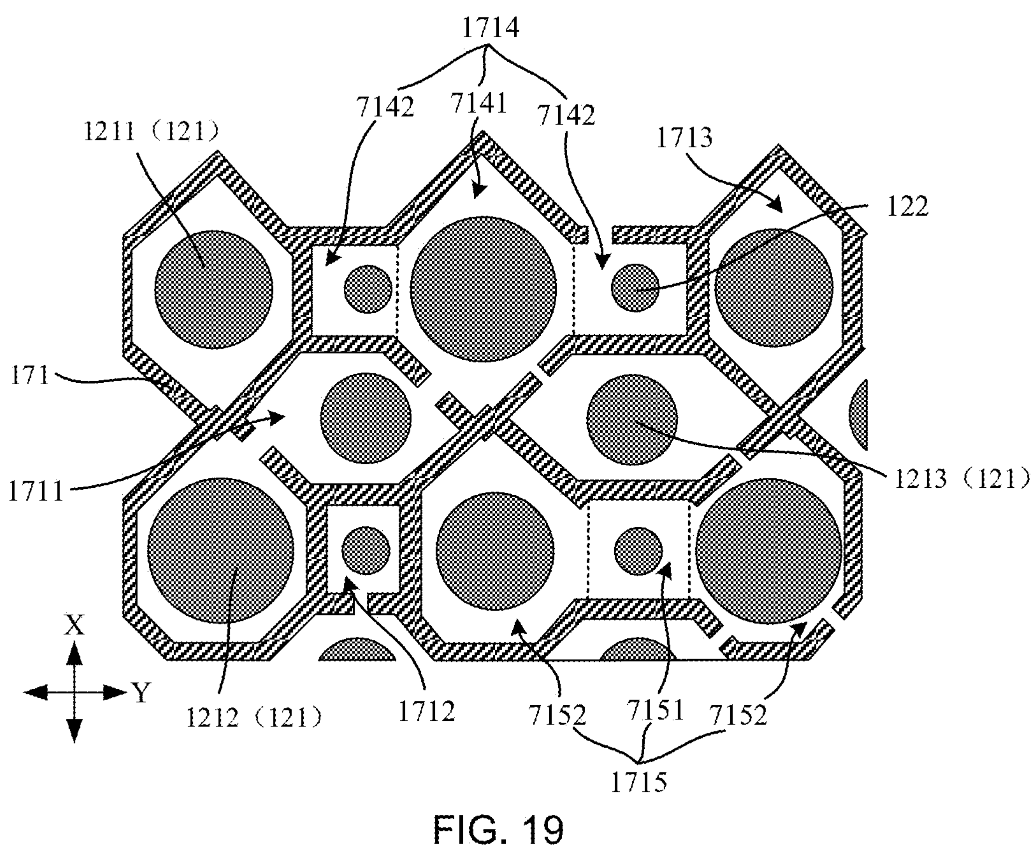

1714
7142
7141
7142
1211（121）
1713
122
171
1711
1213（121）
X
Y
1212（121）
1712
7152
7151
7152
1715

FIG. 19

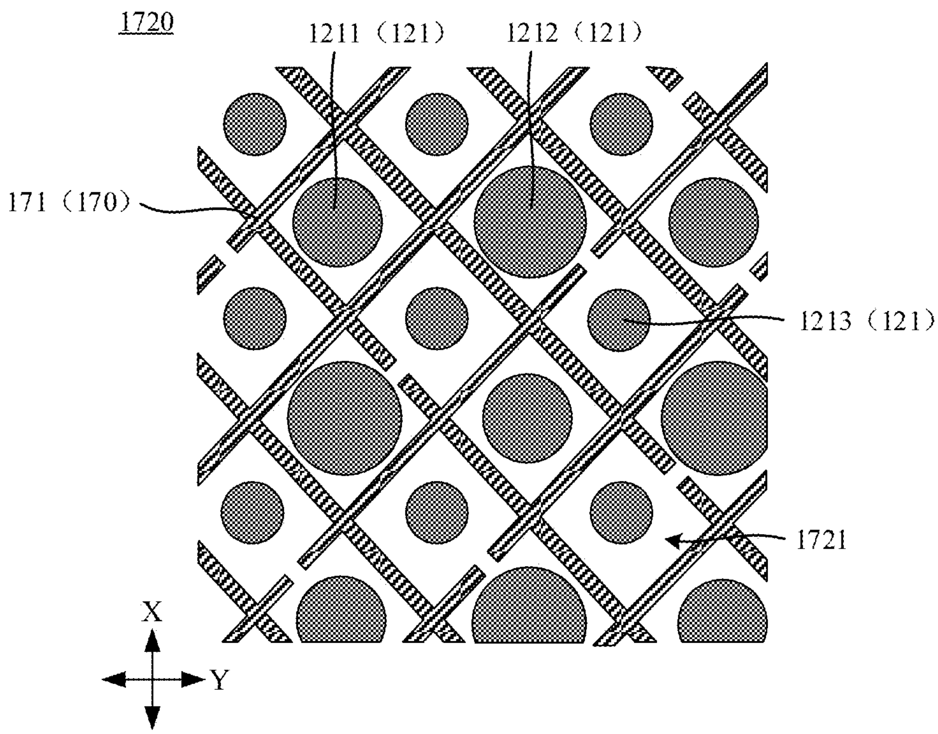


FIG. 20

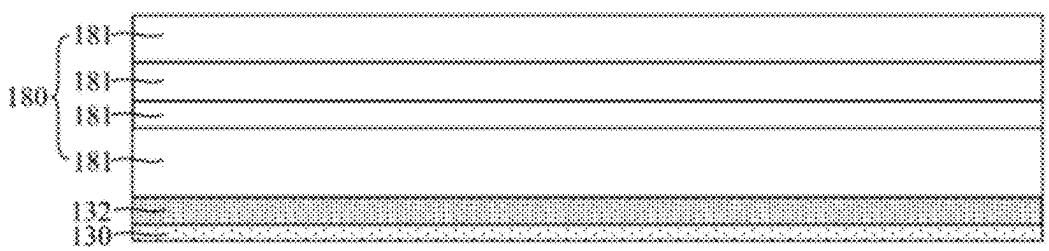


FIG. 21

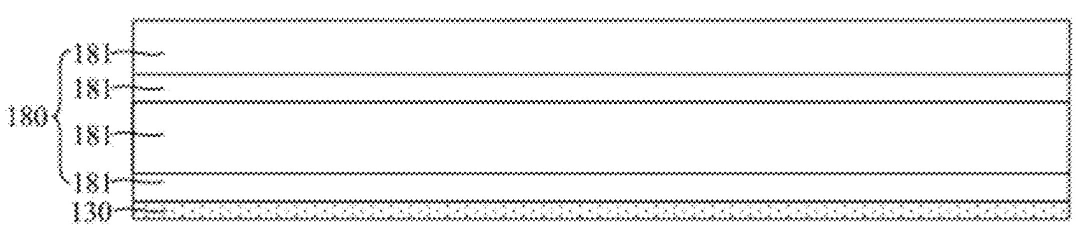


FIG. 22

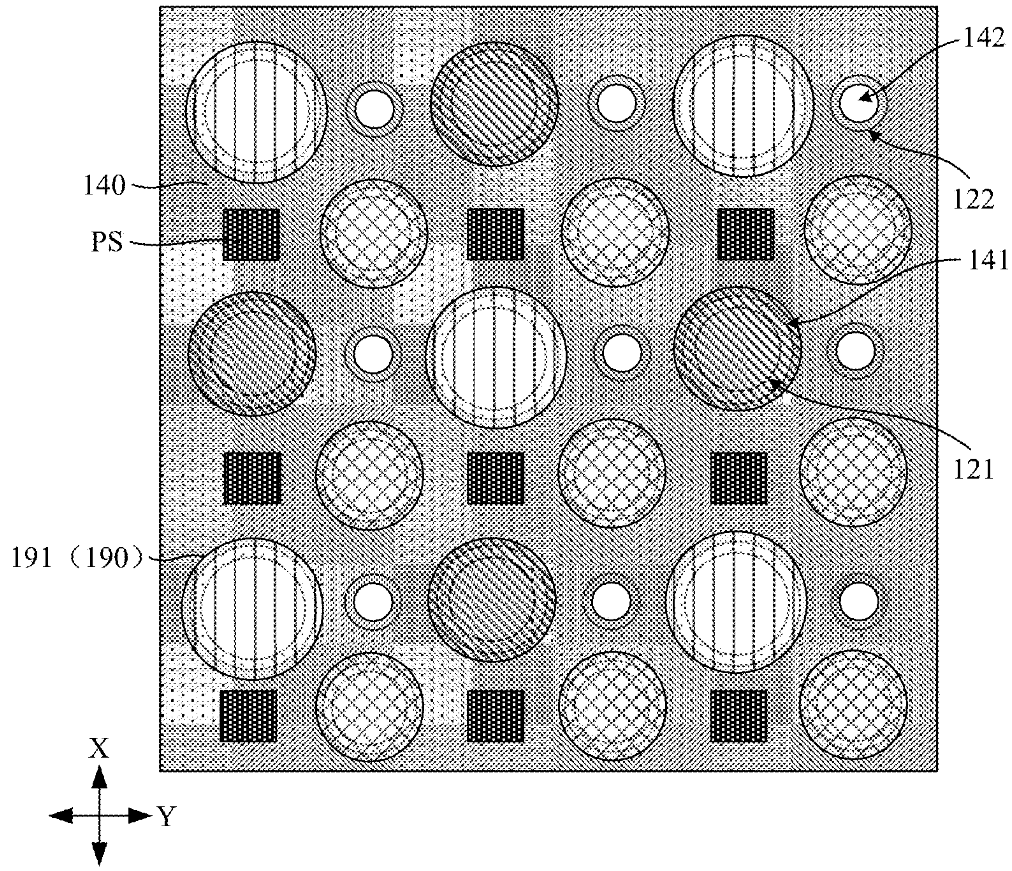

142
140
122
PS
141
121
191 (190)
X
Y

FIG. 23

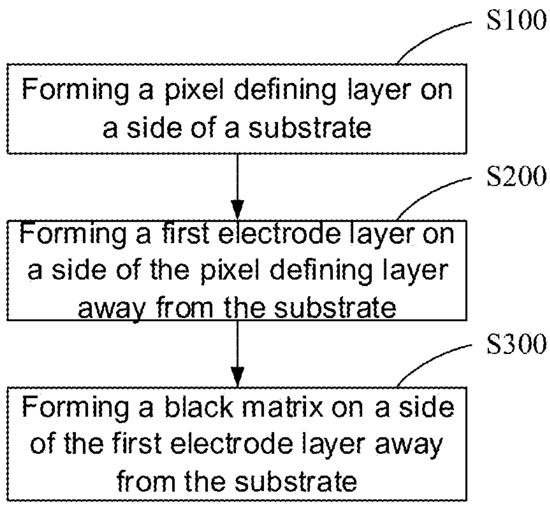

S100
Forming a pixel defining layer on a side of a substrate
S200
Forming a first electrode layer on a side of the pixel defining layer away from the substrate
S300
Forming a black matrix on a side of the first electrode layer away from the substrate

FIG. 24

DISPLAY PANEL AND METHOD FOR MANUFACTURING THE SAME, AND DISPLAY APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the United States national phase of International Patent Application No. PCT/CN2024/081535, filed Mar. 13, 2024, and claims priority to Chinese Patent Application No. 202310466502.2, filed Apr. 26, 2023, the disclosures of which are hereby incorporated by reference in their entireties.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present disclosure relates to the field of display technologies, and in particular, to a display panel and a method for manufacturing the same, and a display apparatus.

Description of Related Art

[0003] With rapid development of display technologies, display apparatuses have gradually come throughout people's lives. Organic light-emitting diodes (OLEDs) are widely used in smart products such as mobile phones, televisions and notebook computers due to advantages of self-luminescence, low power consumption, wide viewing angle, fast response speed, high contrast and flexible display.

SUMMARY OF THE INVENTION

[0004] In an aspect, a display panel is provided. The display panel includes a substrate, a pixel defining layer, a first electrode layer and a black matrix. The pixel defining layer is disposed on the substrate. The pixel defining layer is provided therein with a plurality of first pixel openings and a plurality of first photosensitive openings. The first electrode layer is disposed on a side of the pixel defining layer away from the substrate. The black matrix is disposed on a side of the first electrode layer away from the substrate. The black matrix is provided therein with a plurality of second pixel openings and a plurality of second photosensitive openings. An orthogonal projection of at least one first pixel opening on the substrate is located within an orthogonal projection of a second pixel opening on the substrate; and an orthogonal projection of at least one second photosensitive opening on the substrate is located within an orthogonal projection of a first photosensitive opening on the substrate.

[0005] In some embodiments, a distance between an edge of the orthogonal projection of the first pixel opening on the substrate and an edge of the orthogonal projection of the corresponding second pixel opening on the substrate is in a range of 2 μm to 6 μm, inclusive; and/or a distance between an edge of the orthogonal projection of the first photosensitive opening on the substrate and an edge of the orthogonal projection of the corresponding second photosensitive opening on the substrate is in a range of 1.1 μm to 2 μm, inclusive.

[0006] In some embodiments, the display panel further includes a second electrode layer. The second electrode layer is disposed between the pixel defining layer and the substrate. The second electrode layer includes a plurality of second electrodes. An orthogonal projection of a first pixel opening on the substrate is located within an orthographic projection of a second electrode on the substrate; and an orthogonal projection of a second photosensitive opening on the substrate is located between orthographic projections of the plurality of second electrodes on the substrate.

[0007] In some embodiments, the display panel further includes a driving circuit layer. The driving circuit layer is disposed between the pixel defining layer and the substrate. An orthographic projection of the driving circuit layer on the substrate encloses a plurality of light-transmitting regions; and an orthogonal projection of a second photosensitive opening on the substrate substantially coincides with a light-transmitting region or is located within a light-transmitting region.

[0008] In some embodiments, the driving circuit layer includes a plurality of pixel circuits, a plurality of first signal line groups and a plurality of second signal line groups. The plurality of pixel circuits are arranged in a plurality of rows and a plurality of columns, a row of pixel circuits is divided into a plurality of pixel circuit groups, and a pixel circuit group includes two adjacent pixel circuits. Two pixel circuits in a same pixel circuit group are substantially symmetrical about a first axis, the first axis extends in a first direction, and the first direction is a column direction in which the plurality of pixel circuits are arranged.

[0009] Each first signal line group includes a plurality of first signal lines, and the plurality of first signal lines extend substantially in the first direction and are connected to two pixel circuits in the pixel circuit group. Each second signal line group includes a plurality of second signal lines, and the plurality of second signal lines extend substantially in a second direction and are each connected to a row of pixel circuits. The second direction is a row direction in which the plurality of pixel circuits are arranged. The light-transmitting region is located between two adjacent first signal lines belonging to different first signal line groups, and between two adjacent second signal lines belonging to a same second signal line group.

[0010] In some embodiments, the plurality of first signal lines in the first signal line group includes at least one power signal line and two data lines. The at least one power signal line is connected to at least one column of pixel circuits. The two data lines are each connected to a column of pixel circuits. The two data lines are located on opposite sides of the at least one power signal line. The light-transmitting region is located between two adjacent data lines belonging to different first signal line groups.

[0011] In some embodiments, the data lines each include first straight line segments and first bent segments that are alternately connected. In the two adjacent data lines belonging to different first signal line groups, two first bent segments are bent toward directions away from each other. The light-transmitting region is located between the two first bent segments.

[0012] In some embodiments, the plurality of second signal lines in the second signal line group include a first scanning signal line, a second scanning signal line, an enable signal line, a first initialization signal line, a second initialization signal line and a reset signal line arranged in sequence in the first direction. The light-transmitting region is located between the first scanning signal line and the second scanning signal line.

[0013] In some embodiments, the first scanning signal line includes second straight line segments and second bent segments that are alternately connected, and the second scanning signal line includes third straight line segments and third bent segments that are alternately connected. In the first scanning signal line and the second scanning signal line that are adjacent, a second bent segment and a third bent segment are bent toward directions away from each other. The light-transmitting region is located between the second bent segment and the third bent segment.

[0014] In some embodiments, the plurality of first pixel openings include a plurality of red pixel openings, a plurality of blue pixel openings and a plurality of green pixel openings. The plurality of red pixel openings and the plurality of blue pixel openings are arranged in an array of multiple rows and multiple columns, each row includes multiple red pixel openings and multiple blue pixel openings that are arranged alternately in a second direction, and each column includes multiple red pixel openings and multiple blue pixel openings that are arranged alternately in a first direction.

[0015] The plurality of green pixel openings are arranged in an array of multiple rows and multiple columns, each row includes multiple green pixel openings arranged in the second direction, and each column includes multiple green pixel openings arranged in the first direction. In the first direction, a green pixel opening is located between a red pixel opening and a blue pixel opening that are adjacent; and in the second direction, a green pixel opening is located between a red pixel opening and a blue pixel opening that are adjacent.

[0016] In some embodiments, in the first direction, a first photosensitive opening is located between two adjacent green pixel openings; and in the second direction, a first photosensitive opening is located between the red pixel opening and the blue pixel opening that are adjacent.

[0017] In some embodiments, the display panel further includes a touch layer. The touch layer includes a plurality of touch lines, and orthographic projections of the plurality of touch lines on the substrate are staggered from orthogonal projections of the second pixel openings and the second photosensitive openings on the substrate.

[0018] In some embodiments, the display panel has a display area. The display area includes a main display region and a photosensitive region, and the first photosensitive openings and the second photosensitive openings are located in the photosensitive region. In the photosensitive region, the plurality of touch lines are arranged crosswise to constitute a first mesh structure, and the first mesh structure includes a plurality of first grid rows and a plurality of second grid rows. A first grid row includes a plurality of first grids arranged in a second direction, and vertexes of two adjacent first grids are connected. A second grid row includes a plurality of second grids, a plurality of third grids, a plurality of fourth grids and a plurality of fifth grids arranged in the second direction.

[0019] A first grid is provided with a first pixel opening therein; a second grid is provided with a first photosensitive opening therein; a third grid is provided with a first pixel opening therein; a fourth grid is provided with a first pixel opening and two first photosensitive openings therein; and a fifth grid is provided with two first pixel openings and a first photosensitive opening therein.

[0020] In some embodiments, the first grid is substantially in a hexagonal shape; the second grid is substantially in a rectangular shape; and the third grid is substantially in a hexagonal shape. The fourth grid includes a first sub-grid and two second sub-grids. In a second direction, the two second sub-grids are disposed on opposite sides of the first sub-grid and communicated to the first sub-grid. The first sub-grid is substantially in a hexagonal shape, and the second sub-grids are each substantially in a rectangular shape. The fifth grid includes a third sub-grid and two fourth sub-grids. In the second direction, the two fourth sub-grids are disposed on opposite sides of the third sub-grid and communicated to the third sub-grid. The third sub-grid is substantially in a rectangular shape, and the fourth sub-grids are each in a hexagonal shape.

[0021] In some embodiments, the plurality of first pixel openings include a plurality of red pixel openings, a plurality of blue pixel openings and a plurality of green pixel openings. An orthogonal projection of a green pixel opening on the substrate is within an orthogonal projection of the first grid on the substrate. An orthogonal projection of a red pixel opening on the substrate is located in an orthogonal projection of any of the second grid, the third grid, the fourth grid and the fifth grid on the substrate; and an orthogonal projection of a blue pixel opening on the substrate is located in an orthogonal projection of any of the second grid, the third grid, the fourth grid and the fifth grid on the substrate.

[0022] In some embodiments, the display panel has a display area, the display area includes a main display region and a photosensitive region, and the first photosensitive openings and the second photosensitive openings are located in the photosensitive region. In the main display region, the plurality of touch lines are arranged crosswise to constitute a second mesh structure. The second mesh structure includes a plurality of sixth grids, the plurality of sixth grids are arranged in multiple rows and multiple columns, each row includes multiple sixth grids arranged in a second direction, and each column includes multiple sixth grids arranged in a first direction. Sixth grids of two adjacent rows are staggered, and a sixth grid is provided with a first pixel opening therein.

[0023] In some embodiments, the sixth grid is substantially in a rhombic shape.

[0024] In some embodiments, the display panel further includes an encapsulation layer. The encapsulation layer is disposed between the black matrix and the substrate. The encapsulation layer includes a plurality of encapsulation sub-films that are stacked, and any two adjacent encapsulation sub-films have different refractive indexes.

[0025] In some embodiments, the display panel further includes a color film. The color film is disposed on a side of the black matrix away from the substrate. The color film includes a plurality of filter patterns. The plurality of filter patterns and the plurality of second photosensitive openings are staggered, and the orthogonal projection of the second pixel opening on the substrate is located within an orthographic projection of a filter pattern on the substrate.

[0026] In some embodiments, an orthogonal projection of a first pixel opening on the substrate is located within the orthogonal projection of the second pixel opening on the substrate.

[0027] In another aspect, a method for manufacturing a display panel is provided. The method for manufacturing the display panel includes: forming a pixel defining layer on a substrate, the pixel defining layer being provided therein with a plurality of first pixel openings and a plurality of first photosensitive openings; forming a first electrode layer on a side of the pixel defining layer away from the substrate; and forming a black matrix on a side of the first electrode layer away from the substrate, wherein the black matrix is provided therein with a plurality of second pixel openings and a plurality of second photosensitive openings; an orthogonal projection of at least one first pixel opening on the substrate is located within an orthogonal projection of a second pixel opening on the substrate; and an orthogonal projection of at least one second photosensitive opening on the substrate is located within an orthogonal projection of a first photosensitive opening on the substrate.

[0028] In yet another aspect, a display apparatus is provided. The display apparatus includes the display panel according to any of the above embodiments and a photosensitive device. The display panel includes a light-exit side and a non-light-exit side that are opposite; and the photosensitive device is disposed on the non-light-exit side of the display panel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] In order to describe technical solutions in the present disclosure more clearly, accompanying drawings to be used in some embodiments of the present disclosure will be introduced briefly below. Obviously, the accompanying drawings to be described below are merely accompanying drawings of some embodiments of the present disclosure, and a person of ordinary skill in the art may obtain other drawings according to these drawings. In addition, the accompanying drawings to be described below may be regarded as schematic diagrams, but are not limitations on an actual size of a product, an actual process of a method and an actual timing of a signal to which the embodiments of the present disclosure relate.

[0030] FIG. **1** is a structural diagram of a display apparatus, in accordance with some embodiments;

[0031] FIG. **2** is a structural diagram of another display apparatus, in accordance with some embodiments;

[0032] FIG. **3** is a sectional view taken along a section line A-A' in FIG. **1**;

[0033] FIG. **4** is an exploded view of a display apparatus, in accordance with some embodiments;

[0034] FIG. **5**A is a sectional view taken along a section line B-B' in FIG. **4**;

[0035] FIG. **5**B is another sectional view taken along a section line B-B' in FIG. **4**;

[0036] FIG. **6** is a top view of a pixel defining layer of a display panel, in accordance with some embodiments;

[0037] FIG. **7** is a top view of a black matrix of a display panel, in accordance with some embodiments;

[0038] FIG. **8** is a structural diagram of stack of a pixel defining layer, a black matrix and spacers of a display panel, in accordance with some embodiments;

[0039] FIG. **9** is a partial enlarged view of a pixel defining layer of a display panel, in accordance with some embodiments;

[0040] FIG. **10** is a partial enlarged view of another pixel defining layer of a display panel, in accordance with some embodiments;

[0041] FIG. **11** is a partial enlarged view of a black matrix, a pixel defining layer, a second electrode layer and a driving circuit layer of a display panel, in accordance with some embodiments;

[0042] FIG. **12** is a partial enlarged view of a black matrix, a pixel defining layer and a driving circuit layer of a display panel, in accordance with some embodiments;

[0043] FIG. **13** is a partial enlarged view of a black matrix, a pixel defining layer and a driving circuit layer of another display panel, in accordance with some embodiments;

[0044] FIG. **14** is a partial enlarged view of a black matrix, a pixel defining layer and pixel circuits of a display panel, in accordance with some embodiments;

[0045] FIG. **15** is a partial enlarged view of two adjacent data lines belonging to different first signal line groups in FIG. **14**;

[0046] FIG. **16** is a partial enlarged view of a first scanning signal line in FIG. **14**;

[0047] FIG. **17** is a partial enlarged view of a second scanning signal line in FIG. **14**;

[0048] FIG. **18** is a structural diagram of a touch layer in a photosensitive region, in accordance with some embodiments;

[0049] FIG. **19** is a partial enlarged view of a touch layer in a photosensitive region, in accordance with some embodiments;

[0050] FIG. **20** is a structural diagram of a touch layer in a main display region, in accordance with some embodiments;

[0051] FIG. **21** is a structural diagram of equivalent stacked film layers of an anti-reflection system formed by a first electrode layer, a light extraction layer and an encapsulation layer, in accordance with some embodiments;

[0052] FIG. **22** is a structural diagram of equivalent stacked film layers of an anti-reflection system formed by a first electrode layer and an encapsulation layer, in accordance with some embodiments;

[0053] FIG. **23** is a structural diagram of stack of a pixel defining layer, a black matrix, spacers and a color film of a display panel, in accordance with some embodiments; and

[0054] FIG. **24** is a flow chart of a method for manufacturing a display panel, in accordance with some embodiments.

DESCRIPTION OF THE INVENTION

[0055] Technical solutions in some embodiments of the present disclosure will be described clearly and completely with reference to the accompanying drawings below. Obviously, the described embodiments are merely some but not all embodiments of the present disclosure. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present disclosure shall be included in the protection scope of the present disclosure.

[0056] Unless the context requires otherwise, throughout the description and the claims, the term "comprise" and other forms thereof such as the third-person singular form "comprises" and the present participle form "comprising" are construed as open and inclusive, i.e., "including, but not limited to". In the description of the specification, the terms such as "one embodiment", "some embodiments", "exemplary embodiments", "example", "specific example" or "some examples" are intended to indicate that specific features, structures, materials or characteristics related to the embodiment(s) or example(s) are included in at least one embodiment or example of the present disclosure. Schematic representations of the above terms do not necessarily refer to the same embodiment(s) or example(s). In addition, the specific features, structures, materials, or characteristics described herein may be included in any one or more embodiments or examples in any suitable manner.

[0057] Hereinafter, the terms such as "first" and "second" are used for descriptive purposes only, and are not to be construed as indicating or implying the relative importance or implicitly indicating the number of indicated technical features. Thus, features defined with "first" or "second" may explicitly or implicitly include one or more of the features. In the description of the embodiments of the present disclosure, the term "a plurality of" or "the plurality of" means two or more unless otherwise specified.

[0058] In the description of some embodiments, the expressions "coupled" and "connected" and derivatives thereof may be used. The term "connection" should be understood in a broad sense. For example, the "connection" may be a fixed connection, a detachable connection, or of an integrated structure; it may be a direct connection or an indirect connection by an intermediate medium. The term "coupled" indicates, for example, that two or more components are in direct physical or electrical contact. However, the term "coupled" or "communicatively coupled" may also mean that two or more components are not in direct contact with each other, but still cooperate or interact with each other. The embodiments disclosed herein are not necessarily limited to the content herein.

[0059] The phrase "at least one of A, B and C" has a same meaning as the phrase "at least one of A, B or C", and they both include the following combinations of A, B and C: only A, only B, only C, a combination of A and B, a combination of A and C, a combination of B and C, and a combination of A, B and C.

[0060] The phrase "A and/or B" includes the following three combinations: only A, only B, and a combination of A and B.

[0061] As used herein, the term "if" is optionally construed as "when" or "in a case where" or "in response to determining that" or "in response to detecting", depending on the context. Similarly, the phrase "if it is determined that" or "if [a stated condition or event] is detected" is optionally construed as "in a case where it is determined that" or "in response to determining that" or "in a case where [the stated condition or event] is detected" or "in response to detecting [the stated condition or event]", depending on the context.

[0062] The phrase "applicable to" or "configured to" as used herein indicates an open and inclusive expression, which does not exclude apparatuses that are applicable to or configured to perform additional tasks or steps.

[0063] In addition, the use of the phrase "based on" is meant to be open and inclusive, since a process, step, calculation or other action that is "based on" one or more of the stated conditions or values may, in practice, be based on additional conditions or values exceeding those stated.

[0064] In consideration of the measurement in question and errors associated with the measurement of a particular quantity (i.e., limitations of the measurement system), the term "about", "approximately" or "substantially" as used herein includes a stated value and mean within an acceptable range of deviation of a particular value, and the acceptable range of deviation is determined by a person of ordinary skill in the art. For example, the term "about" may mean within one or more standard deviations, or within ±30%, ±20%, ±10% or ±5% of the stated value.

[0065] The term such as "parallel", "perpendicular" or "equal" as used herein includes a stated condition and a condition similar to the stated condition. A range of the similar condition is within an acceptable range of deviation. The acceptable range of deviation is determined by a person of ordinary skill in the art in view of measurement in question and errors associated with the measurement of a particular quantity (i.e., limitations of the measurement system). For example, the term "parallel" includes absolute parallelism and approximate parallelism, and an acceptable range of deviation of the approximate parallelism may be a deviation within 5°; the term "perpendicular" includes absolute perpendicularity and approximate perpendicularity, and an acceptable range of deviation of the approximate perpendicularity may also be a deviation within 5°; and the term "equal" includes absolute equality and approximate equality, and an acceptable range of deviation of the approximate equality may be a difference between two equals being less than or equal to 5% of either of the two equals.

[0066] It will be understood that, in a case where a layer or an element is referred to as being on another layer or a substrate, it may be that the layer or the element is directly on the another layer or the substrate, or there may be a middle layer between the layer or the element and the another layer or the substrate.

[0067] Exemplary embodiments are described herein with reference to sectional views and/or plane views as idealized exemplary drawings. In the accompanying drawings, thicknesses of layers and sizes of areas/regions are enlarged for clarity. Variations in shapes relative to the accompanying drawings due to, for example, manufacturing technologies and/or tolerances may be envisaged. Therefore, the exemplary embodiments should not be construed to be limited to the shapes of areas/regions shown herein, but to include deviations in the shapes due to, for example, manufacturing. For example, an etched area/region shown in a rectangular shape generally has a feature of being curved. Therefore, the areas/regions shown in the accompanying drawings are schematic in nature, and their shapes are not intended to show actual shapes of the areas/regions in an apparatus, and are not intended to limit the scope of the exemplary embodiments.

[0068] In this specification, unless otherwise defined, all terms used herein (including technical terms and scientific terms) have the same meaning as commonly understood by those skilled in the art to which the present disclosure belongs. It will be further understood that unless explicitly defined here, terms (such as those defined in a general dictionary) should be interpreted as having a meaning consistent with their context in the relevant field and should not be interpreted as an ideal or overly formal meaning.

[0069] In the present disclosure, terms such as "lower", "below", "above", "upper" and the like are used to explain a relational association of components shown in the drawings. The terms may be relative concepts, and are described based on directions shown in the drawings, or described based on an order in which the process steps are formed, but are not limited thereto.

[0070] The term "opposite" means that a first element and a second element may be directly or indirectly opposite. In a case where a third element is provided between the first element and the second element, the first element and the second element may be understood as being indirectly opposite to each other although still opposite to each other.

[0071] As shown in FIGS. **1** and **2**, some embodiments of the present disclosure provide a display apparatus **1000**. The display apparatus **1000** may be any apparatus that displays images whether in motion (e.g., a video) or stationary (e.g., a still image), and regardless of text or image.

[0072] For example, the display apparatus **1000** may be any product or component having a display function, such as a television, a notebook computer, a tablet computer, a mobile phone, a personal digital assistant (PDA), a navigator, a wearable device, a virtual reality (VR) device.

[0073] For example, as shown in FIG. **1**, the display apparatus **1000** may be a portable display product; for example, the display apparatus **1000** is a mobile phone as shown in FIG. **1**. As another example, referring to FIG. **2**, the display apparatus **1000** may be a wearable device; for example, the display apparatus **1000** is a watch as shown in FIG. **2**.

[0074] Some embodiments of the present disclosure will be schematically described below by taking an example in which the display apparatus **1000** is the mobile phone as shown in FIG. **1**, but the implementations of the present disclosure are not limited thereto.

[0075] In some embodiments, referring to FIG. **3**, the display apparatus **1000** includes a display panel **100**.

[0076] The display panel **100** includes a light-exit side **101** and a non-light-exit side **102** that are opposite. The light-exit side refers to a side of the display panel **100** for display, that is, an upper side in FIG. **3**.

[0077] For example, as shown in FIG. **3**, the display apparatus **1000** may further include a housing **200**, a cover plate **300**, circuit boards **400**, a photosensitive device **500**, a camera **600** and other electronic components.

[0078] Referring to FIG. **3**, the cover plate **300** may be a single-layer glass cover plate, or may include stack of multi-layer cover sub-plates **301**. For example, as shown in FIG. **3**, the cover plate **300** includes multi-layer cover sub-plates **301** that are arranged sequentially.

[0079] It will be noted that the above multi-layer cover sub-plates **301** may be bonded together by transparent adhesive layers **302**, which is not specifically limited in the embodiments of the present disclosure. The light transmittance of the transparent adhesive layer **302** is greater than or equal to 90%.

[0080] As shown in FIG. **3**, the housing **200** may have, for example, a U-shaped longitudinal section. The display panel **100** and the circuit boards **400** are disposed in the housing **200**. The cover plate **300** is disposed at an opening of the housing **200**. The circuit board **400** is disposed on a side of the display panel **100** away from the cover plate **300**, and the circuit board **400** is connected to the display panel **100** to provide the display panel **100** with a required display signal.

[0081] As shown in FIGS. **1** and **3**, the photosensitive device **500** and the camera **600** may be, for example, integrated below the display panel **100**, that is, the photosensitive device **500** and the camera **600** are disposed on the non-light-exit side of the display panel **100**, so as to increase a screen-to-body ratio. Here, the photosensitive device **500** includes at least one of an infrared sensor, a distance sensor, a fingerprint identification module and a brightness adjustment module.

[0082] The type of the display panel **100** varies, and may be selected according to actual needs.

[0083] For example, the display panel **100** is an organic light-emitting diode (OLED) display panel, or a quantum dot light-emitting diode (QLED) display panel, which is not specifically limited in the embodiments of the present disclosure.

[0084] Some embodiments of the present disclosure will be schematically described below by taking an example in which the display panel **100** is the OLED display panel.

[0085] In some embodiments, referring to FIG. **4**, the display panel **100** has a display area A and a peripheral area B disposed on at least one side of the display area A. FIG. **4** illustrates an example in which the peripheral area B is disposed around the display area A.

[0086] Here, the display area A is an area for displaying images, and is configured to be provided with a plurality of sub-pixels P therein. The peripheral area B is an area without images displayed, and is configured to be provided therein with a display driver circuit, such as a gate driver circuit and a source driver circuit.

[0087] For example, as shown in FIGS. **4** and **5**A, the display panel **100** includes a substrate **110** and a plurality of sub-pixels P disposed on a side of the substrate **110** and located in the display area A.

[0088] The type of the substrate **110** varies, and may be selected according to actual needs.

[0089] For example, the substrate **110** may be a rigid substrate. For example, the rigid substrate is a glass substrate or a polymethyl methacrylate (PMMA) substrate.

[0090] For example, the substrate **110** may be a flexible substrate. For example, the flexible substrate is a polyethylene terephthalate (PET) substrate, a polyethylene naphthalate two formic acid glycol ester (PEN) substrate, or a polyimide (PI) substrate.

[0091] Referring to FIG. **4**, the plurality of sub-pixels P may include first sub-pixels for emitting light of first color, second sub-pixels for emitting light of second color and third sub-pixels for emitting light of third color.

[0092] It will be noted that the first color, the second color and the third color are three primary colors. For example, the first color is red, the second color is blue, and the third color is green.

[0093] Some embodiments of the present disclosure are schematically described below by taking an example in which the plurality of sub-pixels P include first sub-pixels for emitting red light, second sub-pixels for emitting blue light and third sub-pixels for emitting green light.

[0094] Referring to FIGS. **4** and **5**A, each sub-pixel P includes a light-emitting device **10** and a pixel circuit **20**. The pixel circuit **20** includes a plurality of thin film transistors **210**.

[0095] As shown in FIG. **5**A, the plurality of thin film transistors **210** include a low temperature polysilicon transistor and an oxide transistor. The low temperature polysilicon transistor includes a first semiconductor channel **211**, a first source **212**, a first drain **213** and a first gate **214**. The first source **212** and the first drain **213** are both in contact with the first semiconductor channel **211**. The oxide transistor includes a second semiconductor channel **215**, a second source **216**, a second drain **217** and second gates **218**. The second source **216** and the second drain **217** are both in contact with the second semiconductor channel **215**.

[0096] As shown in FIG. **5**A, the light-emitting device **10** includes a first electrode **11**, a light-emitting functional layer **12** and a second electrode **13**. The second electrode **13** is electrically connected to the first source **212** or the first drain **213** of the low temperature polysilicon transistor. FIG. **5**A illustrates an example in which the second electrode **13** is electrically connected to the first drain **213** of the low temperature polysilicon transistor.

[0097] It will be noted that the light-emitting functional layer **12** may include only a light-emitting layer; or may further include at least one of an electron transport layer (ETL), an electron injection layer (EIL), a hole transport layer (HTL) and a hole injection layer (HIL) in addition to the light-emitting layer.

[0098] In some embodiments, referring to FIG. **1**, the display area A may include a main display region A**1** and a photosensitive region A**2**, and the main display region A**1** may, for example, surround the photosensitive region A**2**. Here, as shown in FIGS. **1** and **3**, the photosensitive device **500** is located below the photosensitive region A**2** of the display panel **100**.

[0099] Referring to FIG. **1**, the photosensitive region A**2** may be located at the top of the display area A, that is, at a portion of the display area A relatively far away from a bonding portion of the display panel **100**. Alternatively, the photosensitive region A**2** may be located at other positions of the display area A. Limitations are not made specifically here in the embodiments of the present disclosure.

[0100] It will be noted that the photosensitive region A**2** may be substantially in a shape of any of a circle, a polygon and an irregular figure. For example, as shown in FIG. **1**, the photosensitive region A**2** is substantially in a shape of a circle. An area of the photosensitive region A**2** may be, for example, in a range of 7 mm^2 to 92 mm^2, inclusive. For example, the photosensitive region A**2** is substantially in a shape of a circle, and a diameter of the circle is 3 mm.

[0101] In addition, referring to FIGS. **1** and **3**, the display panel **100** may further have a camera area C, and a camera **600** is located below the camera area C of the display panel **100**.

[0102] The display area A may, for example, surround the camera area C, and the camera area C may be located at the top of the display area A, that is, at a portion of the display area A relatively far away from the bonding portion of the display panel **100**. Alternatively, the camera area C may be located at other positions of the display area A. Limitations are not made specifically here in the embodiments of the present disclosure.

[0103] In some related arts, there is a difference in reflectivity between the photosensitive region and the main display region, and thus an integrality of the display image may be destroyed, resulting in a poor display effect. In other related arts, the entire display area has a high reflectivity, and the external ambient light has a strong interference on the display image, resulting in a poor display effect.

[0104] In light of this, referring to FIG. **5**A, the display panel **100** provided by some embodiments of the present disclosure further includes a pixel defining layer **120**, a first electrode layer **130** and a black matrix **140**.

[0105] In some examples, as shown in FIGS. **5**A and **6**, the pixel defining layer **120** is disposed on the substrate **110**, that is, the pixel defining layer **120** is located on a side of the substrate **110** away from the photosensitive device **500** (referring to FIG. **3**). Further, the pixel defining layer **120** is provided therein with a plurality of first pixel openings **121** and a plurality of first photosensitive openings **122**.

[0106] Referring to FIGS. **1**, **5**A and **6**, the plurality of first pixel openings **121** are arranged in the entire display area A, that is, the pixel defining layer **120** is provided therein with a plurality of first pixel openings **121** in both the main display region A**1** and the photosensitive region A**2**. Here, a light-emitting device **10** is disposed in a first pixel opening **121**.

[0107] For example, as shown in FIG. **6**, the plurality of first pixel openings **121** include a plurality of red pixel openings **1211**, a plurality of blue pixel openings **1212** and a plurality of green pixel openings **1213**.

[0108] It will be noted that a light-emitting device **10** of the first sub-pixel is disposed in a red pixel opening **1211**, a light-emitting device **10** of the second sub-pixel is disposed in a blue pixel opening **1212**, and a light-emitting device **10** of the third sub-pixel is disposed in a green pixel opening **1213**.

[0109] It will be understood that human eyes have different sensitivities to red light, green light and blue light, that is, the human eyes are more sensitive to green light than to red light, and the human eyes are more sensitive to red light than to blue light. Therefore, an area of the red pixel opening **1211** is smaller than an area of the blue pixel opening **1212**, and larger than an area of the green pixel opening **1213**.

[0110] On this basis, as shown in FIG. **6**, the plurality of red pixel openings **1211** and the plurality of blue pixel openings **1212** may be, for example, arranged in an array of multiple rows and multiple columns. Each column includes multiple red pixel openings **1211** and multiple blue pixel openings **1212** that are arranged alternately in a first direction X. Each row includes multiple red pixel openings **1211** and multiple blue pixel openings **1212** that are arranged alternately in the second direction Y.

[0111] Moreover, the plurality of green pixel openings **1213** are arranged in an array of multiple rows and multiple columns. Each column includes multiple green pixel openings arranged in the first direction X. Each row includes multiple green pixel openings **1213** arranged in the second direction Y. A green pixel opening **1213** is located between red pixel openings **1211** and blue pixel openings **1212** of two adjacent rows and two adjacent columns. That is, in the first direction X, the green pixel opening **1213** is located between a red pixel opening **1211** and a blue pixel opening **1212** that are adjacent; and in the second direction Y, the green pixel opening **1213** is located between a red pixel opening **1211** and a blue pixel opening **1212** that are adjacent.

[0112] It will be noted that the first direction X may be, for example, a column direction in which the plurality of red pixel openings **1211** and the plurality of blue pixel openings **1212** are arranged, and the second direction Y may be, for example, a row direction in which the plurality of red pixel openings **1211** and the plurality of blue pixel openings **1212** are arranged. The first direction X is substantially perpendicular to the second direction Y.

[0113] In this case, the plurality of red pixel openings **1211**, the plurality of blue pixel openings **1212** and the plurality of green pixel openings **1213** are arranged in the above manner, so that the display effect of the display panel **100** may be effectively improved, the display fineness may be improved, and an edge jagginess feeling and a display graininess feeling may be reduced.

[0114] Some embodiments of the present disclosure will be schematically described below by taking an example in which the plurality of red pixel openings **1211**, the plurality of blue pixel openings **1212** and the plurality of green pixel openings **1213** are arranged in the above manner.

[0115] In some embodiments, as shown in FIG. **6**, an orthogonal projection of each of the red pixel opening **1211**, the blue pixel opening **1212** and the green pixel opening **1213** on the substrate **110** is substantially circular.

[0116] In some other embodiments, as shown in FIG. **9**, an orthogonal projection of each of the red pixel opening **1211** and the green pixel opening **1213** on the substrate **110** is substantially circular.

[0117] An outer contour of the blue pixel opening **1212** includes a first curved edge C**1** and a second curved edge C**2**. Both ends of the first curved edge C**1** are connected to both ends of the second curved edge C**2**, and two connection points of the first curved edge C**1** and the second curved edge C**2** are a first connection point and a second connection point.

[0118] With continued reference to FIG. **9**, a line for connecting the first connection point and the second connection point is a first line segment B**1**. The first line segment B**1** has a length of a maximum dimension of the blue pixel opening **1212**, and divides the blue pixel opening **1212** into a first sub-portion S**1** including the first curved edge C**1** and a second sub-portion S**2** including the second curved edge C**2**. An area of the first sub-portion S**1** is larger than an area of the second sub-portion S**2**.

[0119] In some other embodiments, as shown in FIG. **10**, an orthogonal projection of each of the blue pixel opening **1212** and the green pixel opening **1213** on the substrate **110** is substantially circular.

[0120] An outer contour of the red pixel opening **1211** includes a third curved edge C**3** and a fourth curved edge C**4**. Both ends of the third curved edge C**3** are connected to both ends of the fourth curved edge C**4**, and two connection points of the third curved edge C**3** and the fourth curved edge C**4** are a third connection point and a fourth connection point.

[0121] With continued reference to FIG. **10**, a line for connecting the third connection point and the fourth connection point is a second line segment B**2**. The second line segment B**2** has a length of a maximum dimension of the red pixel opening **1211**, and divides the red pixel opening **1211** into a third sub-portion S**3** including the third curved edge C**3** and a fourth sub-portion S**4** including the fourth curved edge C**4**. An area of the third sub-portion S**3** is larger than an area of the fourth sub-portion S**4**.

[0122] In this case, compared with the embodiments in which the outer contour of the blue pixel opening **1212** includes the first curved edge C**1** and the second curved edge C**2**, in the embodiments in which the outer contour of the red pixel opening **1211** includes the third curved edge C**3** and the fourth curved edge C**4**, an aperture ratio of the first pixel opening **121** (a total aperture ratio of the red pixel opening **1211**, the blue pixel opening **1212** and the green pixel opening **1213**) is relatively large.

[0123] It will be noted that the red pixel opening **1211**, the blue pixel opening **1212** and the green pixel opening **1213** may also be in other shapes, which are not illustrated one by one in the embodiments of the present disclosure.

[0124] In some embodiments, referring to FIGS. **1** and **6**, the plurality of first photosensitive openings **122** may be disposed in the entire display area A, that is, the pixel defining layer **120** is provided therein with a plurality of first photosensitive openings **122** in both the main display region A**1** and the photosensitive region A**2**. Alternatively, the plurality of first photosensitive openings **122** may be only disposed in the photosensitive region A**2**, that is, the pixel defining layer **120** is provided therein with the plurality of first photosensitive openings **122** only in the photosensitive region A**2**. The external ambient light may pass through the first photosensitive opening **122** to be transmitted to the photosensitive device **500** (referring to FIG. **3**) below the display panel **100** (referring to FIG. **3**).

[0125] It will be understood that the first photosensitive opening **122** is disposed in a region between the plurality of first pixel openings **121**.

[0126] For example, as shown in FIG. **6**, in a case where the plurality of first pixel openings **121** include a plurality of red pixel openings **1211**, a plurality of blue pixel openings **1212** and a plurality of green pixel openings **1213**, in the first direction X, the first photosensitive opening **122** is located between two adjacent green pixel openings **1213**; and in the second direction Y, the first photosensitive opening **122** is located between the red pixel opening **1211** and the blue pixel opening **1212** that are adjacent.

[0127] Here, in the first direction X, a line for connecting center points of two adjacent first photosensitive openings **122** and a line for connecting center points of two adjacent green pixel openings **1213** may be in the same straight line or may not be in the same straight line.

[0128] For example, as shown in FIG. **6**, in the first direction X, the line for connecting the center points of two adjacent first photosensitive openings **122** and the line for connecting the center points of two adjacent green pixel openings **1213** may not be in the same straight line.

[0129] In addition, in the second direction Y, a line for connecting center points of two adjacent first photosensitive openings **122** and a line for connecting center points of a red pixel opening **1211** and a blue pixel opening **1212** that are adjacent may be in the same straight line or may not be in the same straight line.

[0130] For example, as shown in FIG. **6**, in the second direction Y, the line for connecting the center points of two adjacent first photosensitive openings **122** and the line for connecting the center points of the red pixel opening **1211** and the blue pixel opening **1212** that are adjacent may not be in the same straight line.

[0131] In some examples, as shown in FIG. **5**A, the first electrode layer **130** is disposed on a side of the pixel defining layer **120** away from the substrate **110**. The first electrode layer **130** has a continuous whole layer structure. A portion of the first electrode layer **130** located in the first pixel opening **121** forms the first electrode **11** of the light-emitting device **10**.

[0132] In some other examples, as shown in FIG. **5**B, the first electrode layer **130** is disposed on a side of the pixel defining layer **120** away from the substrate **110**. The first electrode layer **130** includes a patterned hollow structure. For example, the first electrode layer **130** has a mesh structure, and is hollowed out in a region corresponding to the first photosensitive opening **122** to reduce the reflectivity of the display panel **100**.

[0133] It will be noted that a thickness of the first electrode layer **130** may be in a range of 60 Å to 200 Å, inclusive. For example, the thickness of the first electrode layer **130** is any of 60 Å, 70 Å, 80 Å, 90 Å, 100 Å, 110 Å, 120 Å, 124 Å, 130 Å, 140 Å and 150 Å.

[0134] In some example, as shown in FIG. **5**A, the black matrix **140** is disposed on a side of the first electrode layer **130** away from the substrate **110**. In addition, as shown in FIG. **7**, the black matrix **140** is provided therein with a plurality of second pixel openings **141** and a plurality of second photosensitive openings **142**.

[0135] It will be noted that the black matrix **140** is used to separate light emitted from different sub-pixels P, and has a function of reducing reflection of light after the external ambient light enters the display panel **100**.

[0136] As shown in FIGS. **5**A and **8**, an orthogonal projection of a first pixel opening **121** on the substrate **110** is located within an orthogonal projection of a second pixel opening **141** on the substrate **110**. That is, an area of the second pixel opening **141** is larger than an area of the first pixel opening **121**. That is, each first pixel opening **121** in the pixel defining layer **120** defines a light-exit area of a light-emitting device **10**.

[0137] It will be noted that the shape of the first pixel opening **121** and the shape of the second pixel opening **141** may be substantially the same, so as to control a distance between an edge of the orthogonal projection of the first pixel opening **121** on the substrate **110** and an edge of the orthogonal projection of the second pixel opening **141** on the substrate **110**.

[0138] For example, a distance D**1** between an edge of the orthogonal projection of the first pixel opening **121** on the substrate **110** and an edge of the orthogonal projection of the second pixel opening **141** on the substrate **110** is in a range of 2 μm to 6 μm, inclusive. In this way, it is conducive to design of a wide viewing angle of the display panel **100**.

[0139] For example, the distance between the edge of the orthogonal projection of the first pixel opening **121** on the substrate **110** and the edge of the orthogonal projection of the second pixel opening **141** on the substrate **110** is any of 2 μm, 2.5 μm, 3 μm, 3.5 μm, 4 μm, 4.5 μm, 5.5 μm and 6 μm.

[0140] In addition, as shown in FIGS. **5**A and **8**, an orthogonal projection of a second photosensitive opening **142** on the substrate **110** is located within an orthogonal projection of a first photosensitive opening **122** on the substrate **110**. That is, an area of the first photosensitive opening **122** is larger than an area of the second photosensitive opening **142**. That is, each second photosensitive opening **142** in the black matrix **140** defines an area of a region, through which the external ambient light passes, of the display panel **100**.

[0141] For example, a ratio of an area of the second pixel opening **141** to an area of the first pixel opening **121** is R1, and R1 is in a range of 1.1 to 1.5, inclusive. A ratio of an area of the first photosensitive opening **122** to an area of the second photosensitive opening **142** is R2, and R2 is in a range of 1.1 to 1.6, inclusive. R1 is less than or equal to R2. Thus, the design of the wide viewing angle of the display panel **100** may be ensured, and the area of the region, through which the external ambient light passes, of the display panel **100** may be limited.

[0142] In this case, in a case of the same areas of the external ambient light passing through the display panel **100**, compared with each first photosensitive opening **122** in the pixel defining layer **120** limiting the area of the external ambient light passing through the display panel **100**, each second photosensitive opening **142** in the black matrix **140** limiting the area of the external ambient light passing through the display panel **100** may reduce an area of the external ambient light passing through the second photosensitive opening **142** to the first electrode layer **130**, and reduce an area of the external ambient light reflected by the first electrode layer **130**.

[0143] In a case where the plurality of first photosensitive openings **122** are disposed in the entire display area A, each second photosensitive opening **142** in the black matrix **140** limits the area of external ambient light passing through the display panel **100** may reduce the reflectivity of the entire display panel **100** and improve the display effect.

[0144] In a case where the plurality of first photosensitive openings **122** are only disposed in the photosensitive region A**2**, each second photosensitive opening **142** in the black matrix **140** limits the area of external ambient light passing through the display panel **100** may reduce a difference in reflectivity between the photosensitive region A**2** and the main display region A**1** and improve the display effect.

[0145] It will be noted that the shape of the first photosensitive opening **122** and the shape of the second photosensitive opening **142** may be substantially the same, so as to control a distance between an edge of the orthogonal projection of the first photosensitive opening on the substrate **110** and an edge of the orthogonal projection of the second photosensitive opening on the substrate **110**.

[0146] For example, a distance D**2** between an edge of the orthogonal projection of the first photosensitive opening **122** on the substrate **110** and an edge of the orthogonal projection of the corresponding second photosensitive opening **142** on the substrate **110** is in a range of 1.1 μm to 2 μm, inclusive. In this way, it is beneficial for the pixel defining layer **120** to separate the light emitted from different sub-pixels P.

[0147] For example, the distance between the edge of the orthogonal projection of the first photosensitive opening **122** on the substrate **110** and the edge of the orthogonal projection of the corresponding second photosensitive opening **142** on the substrate **110** is any of 1.1 μm, 1.2 μm, 1.3 μm, 1.4 μm, 1.5 μm, 1.6 μm, 1.7 μm, 1.8 μm, 1.9 μm and 2 μm.

[0148] In some embodiments, as shown in FIG. **5**A, the display panel **100** further includes a second electrode layer **150**, and the second electrode layer **150** is disposed between the pixel defining layer **120** and the substrate **110**.

[0149] In some examples, as shown in FIGS. **5**A and **11**, the second electrode layer **150** includes a plurality of second electrode **13**. An orthogonal projection of a first pixel opening **121** on the substrate **110** is located within an orthographic projection of a second electrode **13** on the substrate **110**. Moreover, an orthogonal projection of a second photosensitive opening **142** on the substrate **110** is located between orthographic projections of the plurality of second electrodes **13** on the substrate **110**.

[0150] It will be noted that the second electrode **13** may be substantially in a shape of any of a polygon, a circle or an irregular figure. For example, the second electrode **13** may be in a shape of any of a rhombus, a regular hexagon, a regular octagon, a regular dodecagon and a circle. For example, the second electrode **13** is substantially in a shape of a regular octagon.

[0151] An orthogonal projection of a second pixel opening **141** on the substrate **110** may be located within an orthographic projection of a second electrode **13** on the substrate **110**. Alternatively, an orthogonal projection of a second pixel opening **141** on the substrate **110** may be partially located within an orthographic projection of a second electrode **13** on the substrate **110**, and partially located outside the orthographic projection of the second electrode **13** on the substrate **110**. Limitations are not made specifically here in the embodiments of the present disclosure. FIG. **11** shows an example where the orthogonal projection of the second pixel opening **141** on the substrate **110** is located within the orthographic projection of the second electrode **13** on the substrate **110**.

[0152] In addition, an orthogonal projection of a first photosensitive opening **122** on the substrate **110** may be located between orthographic projections of the plurality of second electrodes **13** on the substrate **110**. Alternatively, an orthogonal projection of a first photosensitive opening **122** on the substrate **110** may be partially located between orthographic projections of the plurality of second electrodes **13** on the substrate **110**, and partially located on the orthographic projections of the plurality of second electrodes **13** on the substrate **110**. Limitations are not made specifically here in the embodiments of the present disclosure.

[0153] In this case, in a process that the external ambient light passes through the second photosensitive opening **142** to be transmitted to the photosensitive device **500** below the display panel **100**, the external ambient light will not be affected by the second electrode **13**, and the transmittance of the external ambient light at the second photosensitive opening **142** may be improved, thereby improving the photosensitivity of the display apparatus **1000** (referring to FIG. **1**).

[0154] In some embodiments, as shown in FIG. **5**A, the display panel **100** further includes a driving circuit layer **160**, and the driving circuit layer **160** is disposed between the pixel defining layer **120** and the substrate **110**. In a case where the display panel **100** includes the second electrode layer **150**, the driving circuit layer **160** is located between the second electrode layer **150** and the substrate **110**.

[0155] In some examples, as shown in FIGS. **5**A and **11**, an orthographic projection of the driving circuit layer **160** on the substrate **110** encloses a plurality of light-transmitting regions S. An orthogonal projection of a second photosensitive opening **142** on the substrate **110** substantially coincides with a light-transmitting region S. Alternatively, an orthogonal projection of a second photosensitive opening **142** on the substrate **110** is located within a light-transmitting region S.

[0156] In this case, referring to FIGS. **3**, **8** and **11**, in a process that the external ambient light passes through the second photosensitive opening **142** to be transmitted to the photosensitive device **500** below the display panel **100**, the external ambient light will not be affected by the wiring in the driving circuit layer **160**, and the transmittance of the external ambient light at the second photosensitive opening **142** may be improved, thereby improving the photosensitivity of the display apparatus **1000**.

[0157] For example, referring to FIG. **11**, an orthogonal projection of a second photosensitive opening **142** on the substrate **110** is located within a light-transmitting region S, and a minimum distance between an edge of the orthogonal projection of the second photosensitive opening **142** on the substrate **110** and an edge of the light-transmitting region S is greater than or equal to 1 μm.

[0158] For example, the distance between the edge of the orthogonal projection of the second photosensitive opening **142** on the substrate **110** and the edge of the light-transmitting region S is in a range of 1 μm to 2 μm, inclusive. For example, the distance between the edge of the orthogonal projection of the second photosensitive opening **142** on the substrate **110** and the edge of the light-transmitting region S is any of 1 μm, 1.2 μm, 1.5 μm, 1.7 μm, 1.8 μm, 1.9 μm and 2 μm.

[0159] In this case, the black matrix **140** (referring to FIG. **5**A) may cover edges of the plurality of light-transmitting regions S enclosed by the orthographic projection of the driving circuit layer **160** on the substrate **110** to prevent light leakage at the second photosensitive opening **142** and make an area of the second photosensitive opening **142** designed to be relatively large.

[0160] In addition, an orthogonal projection of a first photosensitive opening **122** on the substrate **110** may also be located within a light-transmitting region S, and a minimum distance between an edge of the orthogonal projection of the first photosensitive opening **122** on the substrate **110** and an edge of the light-transmitting region S is greater than or equal to 1 μm.

[0161] For example, the distance between the edge of the orthogonal projection of the first photosensitive opening **122** on the substrate **110** and the edge of the light-transmitting region S is in a range of 1 μm to 2 μm, inclusive. For example, the distance between the edge of the orthogonal projection of the first photosensitive opening **122** on the substrate **110** and the edge of the light-transmitting region S is any of 1 μm, 1.2 μm, 1.5 μm, 1.7 μm, 1.8 μm, 1.9 μm and 2 μm.

[0162] In this case, the pixel defining layer **120** (referring to FIG. **5**A) may also cover edges of the plurality of light-transmitting regions S enclosed by the orthographic projection of the driving circuit layer **160** on the substrate **110** to prevent light leakage at the first photosensitive opening **122** and make an area of the first photosensitive opening **122** designed to be relatively large.

[0163] In some embodiments, as shown in FIGS. **5**A and **11** to **14**, the driving circuit layer **160** includes a plurality of pixel circuits **20**, a plurality of first signal line groups **30** and a plurality of second signal line groups **40**.

[0164] As shown in FIG. **14**, the plurality of pixel circuits **20** are arranged in a plurality of rows and a plurality of columns. A row of pixel circuits **20** is divided into a plurality of pixel circuit groups **220**, and a pixel circuit group **220** includes two adjacent pixel circuits **20**.

[0165] As shown in FIG. **14**, the two pixel circuits **20** in the same pixel circuit group **220** are substantially symmetrical about a first axis M**1**, and the first axis M**1** extends in the first direction X. The first direction X may also be a column direction in which the plurality of pixel circuits **20** are arranged.

[0166] As shown in FIGS. **12**, **13** and **14**, each first signal line group **30** includes a plurality of first signal lines **310**. The plurality of first signal lines **310** extend substantially in the first direction X and are connected to two pixel circuits **20** in the pixel circuit group **220**. That is, a first signal line **310** is connected to a column of pixel circuits **20**.

[0167] As shown in FIGS. **11** to **14**, each second signal line group **40** includes a plurality of second signal lines **410**. The plurality of second signal lines **410** extend substantially in the second direction Y and are each connected to a row of pixel circuits **20**. The second direction Y may also be a row direction in which the plurality of pixel circuits **20** are arranged.

[0168] As shown in FIG. **11**, the light-transmitting region S is located between two adjacent first signal lines **310** belonging to different first signal line groups **30**, and between two adjacent second signal lines **410** belonging to the same second signal line group **40**.

[0169] In some examples, as shown in FIGS. **12** and **13**, the plurality of first signal lines **310** in the first signal line group **30** include at least one power signal line **311** and two data lines **312**.

[0170] As shown in FIGS. **12**, **13** and **14**, at least one power signal line **311** is connected to at least one column of pixel circuits **20**.

[0171] For example, as shown in FIGS. **12** and **14**, the plurality of first signal lines **310** in the first signal line group **30** include one power signal line **311**, and the power signal line **311** is connected to two pixel circuits **20** in the same pixel circuit group **220**. In this case, the power signal line **311** may be substantially symmetrical about the first axis M1.

[0172] As another example, as shown in FIGS. **13** and **14**, the plurality of first signal lines **310** in the first signal line group **30** include two power signal lines **311**, and the two power signal lines **311** are respectively connected to two pixel circuits **20** in the same pixel circuit group **220**. In this case, the two power signal lines **311** may be substantially symmetrical about the first axis M1.

[0173] As shown in FIGS. **12**, **13** and **14**, the two data lines **312** are each connected to a column of pixel circuits **20**. That is, the two data lines **312** are respectively connected to two pixel circuits **20** in the same pixel circuit group **220**. In this case, the two data lines **312** may also be substantially symmetrical about the first axis M1.

[0174] As shown in FIGS. **12** and **13**, the two data lines **312** are located on opposite sides of all the power signal line(s) **311** in the first signal line group **30**. In this case, there is no pixel circuit **20** between two adjacent data lines **312** belonging to different first signal line groups **30**.

[0175] On this basis, as shown in FIGS. **12** and **13**, the light-transmitting region S may be located, for example, between two adjacent data lines **312** belonging to different first signal line groups **30**. In this way, an area of the light-transmitting region S may be designed to be relatively large, so that an area of the second photosensitive opening **142** may increase, thereby enhancing the transmittance of the photosensitive region A2 (referring to FIG. **1**), and improving the photosensitivity of the display apparatus **1000** (referring to FIG. **1**).

[0176] In addition, by changing the routing of the two adjacent data lines **312** belonging to different first signal line groups **30**, an area of the light-transmitting region S that can be designed may further be increased.

[0177] For example, referring to FIGS. **12** and **15**, the data line **312** includes first straight line segments **3111** and first bent segments **3112** that are alternately connected. In the two adjacent data lines **312** belonging to different first signal line groups **30**, two first bent segments **3112** are bent toward directions away from each other.

[0178] In this case, the light-transmitting region S may be located between the two first bent segments **3112**. With such a provision, in the two adjacent data lines **312** belonging to different first signal line groups **30**, the first bent segments **3112** are bent toward directions away from each other to forming avoidance, so that an area of the light-transmitting region S may be designed to be relatively large, and thus an area of the second photosensitive opening **142** may increase, thereby enhancing the transmittance of the photosensitive region A2 (referring to FIG. **1**), and improving the photosensitivity of the display apparatus **1000** (referring to FIG. **1**).

[0179] Referring to FIG. **15**, the first bent segment **3112** may, for example, include a first data trace segment **3113**, a second data trace segment **3114** and a third data trace segment **3115** that are connected in sequence.

[0180] As shown in FIGS. **12** and **15**, the first data trace segment **3113** and the third data trace segment **3115** are respectively connected to first straight line segments **3111** on both sides of the first bent segment **3112**. An extending direction of the second data trace segment **3114** is substantially the same as an extending direction of the first straight line segments **3111**, and the second data trace segment **3114** is farther away from another adjacent data line **312** belonging to different first signal line groups **30** than the first straight line segment **3111**.

[0181] In some examples, as shown in FIG. **14**, the plurality of second signal lines **410** in the second signal line group **40** include a first scanning signal line **411**, a second scanning signal line **412**, an enable signal line **413**, a first initialization signal line **414**, a second initialization signal line **415** and a reset signal line **416** that are arranged sequentially in the first direction X.

[0182] It will be noted that, the first initialization signal line **414** may, for example, reset a second electrode **13** of a light-emitting device **10**; and the second initialization signal line **415** may, for example, reset a control electrode of a driving transistor.

[0183] As shown in FIG. **14**, the first scanning signal line **411**, the second scanning signal line **412**, the enable signal line **413**, the first initialization signal line **414**, the second initialization signal line **415** and the reset signal line **416** are arranged circularly in the first direction X.

[0184] As shown in FIGS. **11**, **13** and **14**, between two adjacent data lines **312** belonging to different first signal line groups **30**, and in the plurality of second signal lines **410** arranged in the first direction X, the first scanning signal line **411** and the second scanning signal line **412** have a large spacing therebetween, and there is no obstruction by other conductive structures (e.g., the second electrode **13** and the pixel circuit **20**).

[0185] On this basis, as shown in FIG. **14**, the light-transmitting region S may be located, for example, between the first scanning signal line **411** and the second scanning signal line **412** that are adjacent. In this way, the area of the light-transmitting region S may be designed to be relatively large, so that the area of the second photosensitive opening **142** may increase, thereby enhancing the transmittance of the photosensitive region A2 (referring to FIG. **1**), and improving the photosensitivity of the display apparatus **1000** (referring to FIG. **1**).

[0186] In addition, by changing the routing of the first scanning signal line **411** and the second scanning signal line **412** that are adjacent, the area of the light-transmitting region S that can be designed may further be increased.

[0187] For example, referring to FIGS. **16** and **17**, the first scanning signal line **411** includes second straight line segments **4111** and second bent segments **4112** that are alternately connected; and the second scanning signal line **412** includes third straight line segments **4121** and third bent segments **4122** that are alternately connected.

[0188] In combination with FIGS. **14**, **16** and **17**, in the first scanning signal line **411** and the second scanning signal line **412** that are adjacent, the second bent segment **4112** and the third bent segment **4122** are bent toward directions away from each other.

[0189] In this case, the light-transmitting region S is located between the second bent segment **4112** and the third bent segment **4122**. With such a provision, in the first scanning signal line **411** and the second scanning signal line **412** that are adjacent, the second bent segment **4112** and the third bent segment **4122** are bent toward directions away from each other to forming avoidance, so that an area of the light-transmitting region S may be designed to be relatively large, and thus an area of the second photosensitive opening **142** may increase, thereby enhancing the transmittance of the photosensitive region A**2** (referring to FIG. **1**), and improving the photosensitivity of the display apparatus **1000** (referring to FIG. **1**).

[0190] Referring to FIG. **16**, the second bent segment **4112** may, for example, include a first scanning trace segment **4113**, a second scanning trace segment **4114**, a third scanning trace segment **4115**, a fourth scanning trace segment **4116**, a fifth scanning trace segment **4117**, a sixth scanning trace segment **4118** and a seventh scanning trace segment **4119** that are connected in sequence.

[0191] As shown in FIGS. **14** and **16**, the first scanning trace segment **4113** and the seventh scanning trace segment **4119** are respectively connected to second straight line segments **4111** on both sides of the second bent segment **4112**. Extending directions of the second scanning trace segment **4114**, the fourth scanning trace segment **4116** and the sixth scanning trace segment **4118** are substantially the same as an extending direction of the second straight line segments **4111**, and the second scanning trace segment **4114** and the sixth scanning trace segment **4118** are farther away from the second scanning signal line **412** than the second straight line segments **4111**. The fourth scanning trace segment **4116** is farther away from the adjacent second scanning signal line **412** than the second scanning trace segment **4114** and the sixth scanning trace segment **4118**.

[0192] In addition, referring to FIG. **17**, the third bent segment **4122** may include, for example, an eighth scanning trace segment **4123**, a ninth scanning trace segment **4124** and a tenth scanning trace segment **4125**.

[0193] As shown in FIGS. **14** and **17**, the eighth scanning trace segment **4123** and the tenth scanning trace segment **4125** are respectively connected to third straight line segments **4121** on both sides of the third bent segment **4122**. An extending direction of the ninth scanning trace segment **4124** is substantially the same as an extending direction of the third straight line segments **4121**, and the ninth scanning trace segment **4124** is farther away from the adjacent first scanning signal line **411** than the third straight line segments **4121**.

[0194] In some embodiments, as shown in FIGS. **5**A and **14**, the driving circuit layer **160** further includes first semiconductor patterns **50**, transfer lines **60** and second semiconductor patterns **70**.

[0195] On this basis, the first scanning signal line **411**, the enable signal line **413**, the first initialization signal line **414**, the second initialization signal line **415** and the reset signal line **416** may, for example, overlap with the first semiconductor patterns **50** to form low temperature polysilicon transistors. The second scanning signal line **412** may, for example, overlap with the second semiconductor pattern **70** to form an oxide transistor.

[0196] In addition, a plurality of thin film transistors **210** of a plurality of pixel circuits **20** may be electrically connected by transfer lines **60** and conductive portions in the first semiconductor patterns **50** and/or the second semiconductor patterns **70**.

[0197] On this basis, referring to FIG. **14**, the light-transmitting region S may also be located, for example, between first semiconductor patterns **50** of the adjacent pixel circuits **20** belonging to different pixel circuit groups **220**.

[0198] The driving circuit layer **160** mentioned above will be exemplarily introduced below in combination with the film layer structure of the display panel **100**.

[0199] In some embodiments, as shown in FIG. **5**A, in a direction perpendicular to the substrate **110** and away from the substrate **110**, the display panel **100** includes a first semiconductor layer ACT**1**, a first gate conductive layer GT**1**, a second gate conductive layer GT**2**, a second semiconductor layer ACT**2**, a third gate conductive layer GT**3**, a first source-drain conductive layer SD**1** and a second source-drain conductive layer SD**2** sequentially.

[0200] It can be understood that referring to FIG. **5**A, in the first semiconductor layer ACT**1**, the first gate conductive layer GT**1**, the second gate conductive layer GT**2**, the second semiconductor layer ACT**2**, the third gate conductive layer GT**3**, the first source-drain conductive layer SD**1** and the second source-drain conductive layer SD**2**, every two adjacent layers are provided with an insulating layer therebetween, such as a first gate insulating layer GI**1**, a first interlayer insulating layer ILD**1**, a second gate insulating layer GI**2**, a third gate insulating layer GI**3**, a second interlayer insulating layer ILD**2**, a first planarization layer PLN**1** and a second planarization layer PLN**2**, which are not specifically limited in the embodiments of the present disclosure.

[0201] Here, referring to FIG. **5**B, the first planarization layer PLN**1** and the second planarization layer PLN**2** may also include a third photosensitive opening **001** extending through the first planarization layer PLN**1** and the second planarization layer PLN**2**.

[0202] As shown in FIG. **5**B, an orthogonal projection of the third photosensitive opening **001** on the substrate **110** is within an orthogonal projection of the first photosensitive opening **122** on the substrate **110**, so that the first planarization layer PLN**1** and the second planarization layer PLN**2** provide support at the lower side of the pixel defining layer **120**.

[0203] In addition, as shown in FIG. **5**B, an orthogonal projection of the second photosensitive opening **142** on the substrate **110** is located within an orthogonal projection of the third photosensitive opening **001** on the substrate **110**, so as to avoid adverse effects such as a decrease in transmittance caused by colors (e.g., light yellow) of the first planarization layer PLN**1** and the second planarization layer PLN**2** themselves, and color cast caused by reception of the external ambient light by the photosensitive device **500**.

[0204] Of course, in some embodiments, the third photosensitive opening **001** may not be designed, and only the second photosensitive opening **142** and the first photosensitive opening **122** are included.

[0205] On this basis, in combination with FIGS. **5**A and **14**, the first semiconductor patterns **50** may be located in the first semiconductor layer ACT**1**. The first scanning signal lines **411** and the enable signal lines **413** may be located in the first gate conductive layer GT**1**. The second initialization signal lines **415** may be located in the second gate conductive layer GT**2**. The first initialization signal lines **414** may be located in the third gate conductive layer GT**3**. The second scanning signal line **412** may include two scanning signal sub-lines, where one scanning signal sub-line may be located in the second gate conductive layer GT**2**, and the other scanning signal sub-line may be located in the third gate conductive layer GT**3**. The reset signal line **416** may include two reset signal sub-lines, where one reset signal sub-line may be located in the second gate conductive layer GT**2**, and the other reset signal sub-line may be located in the third gate conductive layer GT**3**.

[0206] In some embodiments, referring to FIG. **5**A, the display panel **100** further includes a touch layer **170**. The touch layer **170** may be disposed on a side of the black matrix **140** away from the substrate **110**, or may be disposed between the black matrix **140** and the pixel defining layer **120**. For example, as shown in FIG. **5**A, the touch layer **170** is disposed between the black matrix **140** and the pixel defining layer **120**.

[0207] Here, the touch layer **170** may be directly formed on a side of an encapsulation layer **180** mentioned below away from the substrate **110** through a semiconductor process, that is, there is no other film layers disposed between the touch layer **170** and the encapsulation layer **180**. With such a provision, the display apparatus **1000** (referring to FIG. **1**) has a relatively small thickness, which is conducive to achieving lightness and thinness.

[0208] In some examples, as shown in FIG. **18**, the touch layer **170** includes a plurality of touch lines **171**, and orthographic projections of the plurality of touch lines **171** on the substrate **110** are staggered from orthogonal projections of the second pixel openings **141** on the substrate **110**, so as to avoid blocking the light exit from the light-emitting device **10** caused by the touch lines **171** blocking part of the second pixel openings **141**.

[0209] Moreover, the orthographic projections of the plurality of touch lines **171** on the substrate **110** are staggered from orthogonal projections of the second photosensitive openings **142** on the substrate **110**, so as to avoid blocking the external ambient light received by the photosensitive device **500** through the second photosensitive openings **142** caused by the touch lines **171** blocking part of the second photosensitive openings **142**.

[0210] The plurality of touch lines **171** form a plurality of driving electrodes and sensing electrodes that are insulated from each other, and a driving electrode and a sensing electrode may generate a capacitive node therebetween.

[0211] In this case, a pulsed or alternating voltage applied to the driving electrodes through a touch chip on the circuit board **400** (referring to FIG. **3**) may induce charges on the sense electrode, and the amount of the induced charges is susceptible to external influences (e.g., touch or proximity of a finger). That is, when a finger touches or approaches the capacitive node, capacitance may change at the capacitive node, and the touch chip on the circuit board **400** (referring to FIG. **3**) may measure the capacitance change through the sensing electrode, and determine a location where the finger touches or approaches by measuring the capacitance changes of the entire touch layer **170**.

[0212] It will be noted that the driving electrodes and the sensing electrodes may be disposed in a same layer or in different layers.

[0213] For example, referring to FIGS. **1**, **8** and **18**, the first photosensitive opening **122** and the second photosensitive opening **142** are located in the photosensitive region A**2**. In this case, in the photosensitive region A**2**, the plurality of touch lines **171** are arranged crosswise to constitute a first mesh structure **1710**. The first mesh structure **1710** includes a plurality of first grid rows and a plurality of second grid rows, and the plurality of second grid rows and the plurality of first grid rows are arranged alternately in the first direction X.

[0214] The first grid row includes a plurality of first grids **1711** arranged in the second direction Y, and vertexes of two adjacent first grids **1711** are connected. The second grid row includes a plurality of second grids **1712**, a plurality of third grids **1713**, a plurality of fourth grids **1714** and a plurality of fifth grids **1715** arranged in the second direction Y.

[0215] It will be noted that the arrangement of the second grids **1712**, the third grids **1713**, the fourth grids **1714** and the fifth grids **1715** is not unique, and is not described in detail in the embodiments of the present disclosure.

[0216] On this basis, as shown in FIG. **18**, a first grid **1711** may be provided with a first pixel opening **121** therein. A second grid **1712** may be provided with a first photosensitive opening **122** therein. A third grid **1713** may be provided with a first pixel opening **121** therein. A fourth grid **1714** may be provided with a first pixel opening **121** and two first photosensitive openings **122** therein. A fifth grid **1715** may be provided with two first pixel openings **121** and a first photosensitive opening **122** therein.

[0217] It will be noted that part of edges of the first grids **1711**, the second grids **1712**, the third grids **1713**, the fourth grids **1714** and the fifth grids **1715** may be disconnected, so that the driving electrodes and the sensing electrodes formed by the touch lines **171** are disconnected and insulated.

[0218] In this case, the plurality of touch lines **171** may be provided in the same layer and with the same material, that is, the plurality of driving electrodes and sensing electrodes that are insulated from each other may be provided in the same layer and with the same material. Moreover, the plurality of touch lines **171** are arranged crosswise to form the first mesh structure **1710**, which is conducive to adapting to first pixel openings **121** of various shapes. Thus, it may facilitate the disconnection of driving electrodes and sensing electrodes to be insulation, and a structure is simple.

[0219] For example, as shown in FIGS. **18** and **19**, the first grid **1711** is substantially in a hexagonal shape. The second grid **1712** is substantially in a rectangular shape. The third grid **1713** is substantially in a hexagonal shape.

[0220] In this case, the first grid **1711** may be provided therein with a first pixel opening **121**, such as a green pixel opening **1213**. The second grid **1712** may be provided therein with a first photosensitive opening **122**. The third grid **1713** may be provided therein with a first pixel opening **121**, such as a red pixel opening **1211** or a blue pixel opening **1212**.

[0221] The fourth grid **1714** includes a first sub-grid **7141** and two second sub-grids **7142**. In the second direction Y, the two second sub-grids **7142** are disposed on opposite sides of the first sub-grid **7141** and are communicated to the first sub-grid **7141**. The first sub-grid **7141** is substantially in a hexagonal shape, and the second sub-grid **7142** is substantially in a rectangular shape.

[0222] In this case, the first sub-grid **7141** may be provided therein with a first pixel opening **121**, such as a red pixel opening **1211** or a blue pixel opening **1212**. The second sub-grid **7142** may be provided therein with a first photosensitive opening **122**.

[0223] In addition, the fifth grid **1715** includes a third sub-grid **7151** and two fourth sub-grids **7152**. In the second direction Y, the two fourth sub-grids **7152** are disposed on opposite sides of the third sub-grid **7151** and are communicated to the third sub-grid **7151**. The third sub-grid **7151** is substantially in a rectangular shape, and the fourth sub-grid **7152** is substantially in a hexagonal shape.

[0224] In this case, the third sub-grid **7151** may be provided therein with a first photosensitive opening **122**. The fourth sub-grid **7152** may be provided therein with a first pixel opening **121**, such as a red pixel opening **1211** or a blue pixel opening **1212**.

[0225] It can be seen from the above that in a case where the plurality of first pixel openings **121** include a plurality of red pixel openings **1211**, a plurality of blue pixel openings **1212** and a plurality of green pixel openings **1213**, an orthogonal projection of a green pixel opening **1213** on the substrate **110** is located within an orthogonal projection of the first grid **1711** on the substrate **110**; an orthogonal projection of a red pixel opening **1211** on the substrate **110** is located in an orthogonal projection of any of the second grid **1712**, the third grid **1713**, the fourth grid **1714** and the fifth grid **1715** on the substrate **110**; and an orthogonal projection of a blue pixel opening **1212** on the substrate **110** is located in an orthogonal projection of any of the second grid **1712**, the third grid **1713**, the fourth grid **1714** and the fifth grid **1715** on the substrate **110**.

[0226] For example, referring to FIGS. **1** and **8**, the first photosensitive opening **122** and the second photosensitive opening **142** are located in the photosensitive region A**2**. In this case, referring to FIGS. **1**, **8** and **20**, in the main display region A**1**, the plurality of touch lines **171** are arranged crosswise to constitute a second mesh structure **1720**. The second mesh structure **1720** includes a plurality of sixth grids **1721**, and the plurality of sixth grids **1721** are arranged in multiple rows and multiple columns. Each row includes multiple sixth grids **1721** arranged in the second direction Y, and each column includes multiple sixth grids **1721** arranged in the first direction X.

[0227] As shown in FIG. **20**, the sixth grids **1721** of two adjacent rows are staggered, and a sixth grid **1721** is provided with a first pixel opening **121** therein. Here, the sixth grid **1721** is substantially in a shape of any of a rectangle, a rhombus, a regular hexagon, a regular octagon, and other polygons. For example, the sixth grid **1721** is substantially in a shape of a rhombus.

[0228] It will be noted that part of edges of the sixth grids **1721** may be disconnected, so that the driving electrodes and the sensing electrodes formed by the touch lines **171** are disconnected and insulated.

[0229] In this case, the plurality of touch lines **171** may be provided in the same layer and with the same material, that is, the plurality of driving electrodes and sensing electrodes that are insulated from each other may be provided in the same layer and with the same material. Moreover, the plurality of touch lines **171** are arranged crosswise to form the second mesh structure **1720**, which is conducive to adapting to first pixel openings **121** of various shapes. Thus, it may facilitate the disconnection of driving electrodes and sensing electrodes to be insulation, and a structure is simple.

[0230] In some embodiments, referring to FIG. **5**A, the display panel **100** further includes an encapsulation layer **180**. The encapsulation layer **180** is disposed between the black matrix **140** and the pixel defining layer **120** to reduce the risk of corrosion of moisture and oxygen.

[0231] In this case, in a case where the display panel **100** further includes a touch layer **170**, the touch layer **170** may be located between the black matrix **140** and the encapsulation layer **180**.

[0232] In some examples, referring to FIGS. **5**A and **21**, the encapsulation layer **180** includes a plurality of encapsulation sub-films **181** that are stacked, and any two adjacent encapsulation sub-films **181** have different refractive indexes. Moreover, the encapsulation layer **180** is configured to reduce the reflectivity to the external ambient light.

[0233] The refractive index of the encapsulation sub-film **181** is in a range of 1.52 to 1.8, inclusive. For example, the refractive index of the encapsulation sub-film **181** is any of 1.52, 1.55, 1.6, 1.63, 1.68, 1.73, 1.75 and 1.8.

[0234] In addition, a thickness of the encapsulation sub-film **181** is in a range of **50** nm to 1000 nm, inclusive. For example, the thickness of the encapsulation sub-film **181** is any of 50 nm, 60 nm, 100 nm, 120 nm, 130 nm, 150 nm, 185 nm, 200 nm, 300 nm, 350 nm, 500 nm, 600 nm, 660 nm, 800 nm, 900 nm, 960 nm and 1000 nm.

[0235] Since the human eye perceives light with a wavelength of about 380 nm to 780 nm, and is more sensitive to light with a wavelength of about 550 nm, the reflectivity and transmittance of the display panel **100** are tested below using the light with a wavelength of 550 nm.

[0236] In addition, as the thickness of the first electrode layer **130** increases, the reflectivity to the light with a wavelength of about 380 nm and about 780 nm increases, and the transmittance decreases. In this case, the cooperation between the plurality of encapsulation sub-films **181** of the encapsulation layer **180** and the first electrode layer **130** may make the transmittance of the photosensitive region A2 of the display panel **100** greater than or equal to 0.6%, and a difference in reflectivity between the photosensitive region A2 and the main display region A**1** less than or equal to 0.6%.

[0237] In some examples, as shown in FIG. **21**, the display panel **100** further includes a light extraction layer **132**, and the light extraction layer **132** is disposed between the first electrode layer **130** and the encapsulation layer **180** to protect the first electrode layer **130** and adjust light extraction, so as to improve the light extraction efficiency. The light extraction layer **132** may include a lithium fluoride layer.

[0238] For example, referring to FIG. **21**, a thickness of the first electrode layer **130** is 110 Å. In this case, the transmittance of the first electrode layer **130** is approximately 60.82%, and the reflectivity thereof is approximately 24.66%.

[0239] On this basis, a thickness of the lithium fluoride layer is 60 nm. In this case, the encapsulation layer **180** includes four encapsulation sub-films **181**. In a direction away from the first electrode layer **130** to the encapsulation layer **180**, the refractive indexes of the four encapsulation sub-films **181** are 1.73, 1.63, 1.63 and 1.83 sequentially, and the thicknesses of the four encapsulation sub-films **181** are 960 nm, 120 nm, 185 nm and 350 nm sequentially.

[0240] In this case, for light with a wavelength of 550 nm, the difference in reflectivity between the photosensitive region A2 and the main display region A1 of the display panel **100** is less than or equal to 0.51%, and the transmittance of the photosensitive region A2 of the display panel **100** is greater than or equal to 0.6%.

[0241] As another example, referring to FIG. **21**, a thickness of the first electrode layer **130** is 100 Å. In this case, the transmittance of the first electrode layer **130** is approximately 64.61%, and the reflectivity thereof is approximately 21.49%.

[0242] On this basis, a thickness of the lithium fluoride layer is 60 nm. In this case, the encapsulation layer **180** includes four encapsulation sub-films **181**. In a direction away from the first electrode layer **130** to the encapsulation layer **180**, the refractive indexes of the four encapsulation sub-films **181** are 1.73, 1.63, 1.63 and 1.83 sequentially, and the thicknesses of the four encapsulation sub-films **181** are 960 nm, 120 nm, 185 nm and 350 nm sequentially.

[0243] In this case, for light with a wavelength of 550 nm, the difference in reflectivity between the photosensitive region A2 and the main display region A1 of the display panel **100** is less than or equal to 0.49%, and the transmittance of the photosensitive region A2 of the display panel **100** is greater than or equal to 0.61%.

[0244] In some other examples, as shown in FIG. **22**, there is no light extraction layer provided on the first electrode layer **130**. In this case, the encapsulation layer **180** includes four encapsulation sub-films **181**.

[0245] For example, referring to FIG. **22**, a thickness of the first electrode layer **130** is 124 Å. In this case, the transmittance of the first electrode layer **130** is approximately 55.74%, and the reflectivity thereof is approximately 29.05%.

[0246] On this basis, in a direction away from the first electrode layer **130** to the encapsulation layer **180**, the refractive indexes of the four encapsulation sub-films **181** are 1.52, 1.73, 1.63 and 1.83 sequentially, and the thicknesses of the four encapsulation sub-films **181** are 100 nm, 960 nm, 100 nm and 660 nm sequentially.

[0247] In this case, for light with a wavelength of 550 nm, the difference in reflectivity between the photosensitive region A2 and the main display region A1 of the display panel **100** is less than or equal to 0.6%, and the transmittance of the photosensitive region A2 of the display panel **100** is greater than or equal to 0.6%.

[0248] As another example, referring to FIG. **22**, a thickness of the first electrode layer **130** is 110 Å. In this case, the transmittance of the first electrode layer **130** is approximately 64.61%, and the reflectivity thereof is approximately 21.49%.

[0249] On this basis, in a direction away from the first electrode layer **130** to the encapsulation layer **180**, the refractive indexes of the four encapsulation sub-films **181** are 1.52, 1.73, 1.63 and 1.83 sequentially, and the thicknesses of the four encapsulation sub-films **181** are 50 nm, 960 nm, 130 nm and 660 nm sequentially.

[0250] In this case, for light with a wavelength of 550 nm, the difference in reflectivity between the photosensitive region A2 and the main display region A1 of the display panel **100** is less than or equal to 0.5%, and the transmittance of the photosensitive region A2 of the display panel **100** is greater than or equal to 0.6%.

[0251] As another example, referring to FIG. **22**, a thickness of the first electrode layer **130** is 100 Å. In this case, the transmittance of the first electrode layer **130** is approximately 64.61%, and the reflectivity thereof is approximately 21.49%.

[0252] On this basis, in a direction away from the first electrode layer **130** to the encapsulation layer **180**, the refractive indexes of the four encapsulation sub-films **181** are 1.52, 1.73, 1.63 and 1.83 sequentially, and the thicknesses of the four encapsulation sub-films **181** are 50 nm, 960 nm, 130 nm and 660 nm sequentially.

[0253] In this case, for light with a wavelength of 550 nm, the difference in reflectivity between the photosensitive region A2 and the main display region A1 of the display panel **100** is less than or equal to 0.48%, and the transmittance of the photosensitive region A2 of the display panel **100** is greater than or equal to 0.61%.

[0254] In some embodiments, referring to FIG. **5**A, the display panel **100** further includes a color film **190**, and the color film **190** is disposed on a side of the black matrix **140** away from the substrate **110**.

[0255] It will be noted that the color film **190** can filter out light with most wavelength bands of the external ambient light, thereby reducing the reflection intensity of the external ambient light on the display panel **100**.

[0256] As shown in FIGS. **5**A and **23**, the color film **190** includes a plurality of filter patterns **191**, and the plurality of filter patterns **191** and the plurality of second photosensitive openings **142** are arranged in a staggered manner.

[0257] It will be noted that the "staggered arrangement" here not only includes a case that orthographic projections of the filter patterns **191** on the substrate **110** has no overlap with orthogonal projections of the second photosensitive openings **142** on the substrate **110**, but also includes a case that an orthographic projection of the filter pattern **191** on the substrate **110** is adjacent to an orthogonal projection of the second photosensitive opening **142** on the substrate **110**, and parts of edges that are close to each other coincide.

[0258] For example, a distance between an edge of an orthographic projection of the filter pattern **191** on the substrate **110** and an edge of an orthogonal projection of the second photosensitive opening **142** on the substrate **110** is in a range of 0 μm to 1.8 μm, inclusive. For example, the distance between the edge of the orthographic projection of the filter pattern **191** on the substrate **110** and the edge of the orthogonal projection of the second photosensitive opening **142** on the substrate **110** is any of 0 μm, 0.4 μm, 0.8 μm, 0.9 μm, 1.4 μm, 1.6 μm and 1.8 μm.

[0259] In addition, as shown in FIGS. **5**A and **23**, an orthogonal projection of a second pixel opening **141** on the substrate **110** is located within an orthographic projection of a filter pattern **191** on the substrate **110**.

[0260] A distance between an edge of an orthographic projection of the filter pattern **191** on the substrate **110** and an edge of an orthogonal projection of the second pixel opening **141** on the substrate **110** is greater than or equal to 4.5 μm, so that the filter pattern **191** and the black matrix **140** have relatively high adhesiveness, thereby reducing the risk of the filter pattern **191** falling off from the black matrix **140**.

[0261] Here, referring to FIG. **23**, the shape of the filter pattern **191** may be substantially the same as the shape of the second pixel opening **141**, or may be different from the shape of the second pixel opening **141**.

[0262] It will be noted that a material of the filter pattern **191** includes an organic material. For example, the material of the filter pattern **191** includes at least one of polymethyl methacrylate, general polymers of polystyrene, polymer derivatives with phenolic groups, acryloyl polymers, imide polymers, aryl ether polymers, amide polymers, fluorine polymers, paraxylene polymers or vinyl alcohol polymers.

[0263] In some embodiments, referring to FIGS. **5**A and **8**, the display panel **100** further includes spacers PS, and the spacers PS are disposed between the pixel defining layer **120** and the first electrode layer **130**.

[0264] It will be noted that the spacer PS may be used to support a mask during the process, so that the mask and the pixel defining layer **120** have a uniform gap therebetween.

[0265] As shown in FIGS. **6** and **8**, in a case where the plurality of first pixel openings **121** include a plurality of red pixel openings **1211**, a plurality of blue pixel openings **1212** and a plurality of green pixel openings **1213**, in the first direction X, the spacer PS is located between a red pixel opening **1211** and a blue pixel opening **1212** that are adjacent; and in the second direction Y, the spacer PS is located between two adjacent green pixel openings **1213**, and thus is staggered from the first photosensitive openings **122**.

[0266] Some embodiments of the present disclosure further provide a method for manufacturing a display panel **100**. As shown in FIG. **24**, the method includes steps S**100** to S**300**.

[0267] In S**100**, referring to FIGS. **5**A and **5**B, a pixel defining layer **120** is formed on a side of the substrate **110**.

[0268] In the above step, the pixel defining layer **120** is provided therein with a plurality of first pixel openings **121** and a plurality of first photosensitive openings **122**.

[0269] In S**200**, referring to FIGS. **5**A and **5**B, a first electrode layer **130** is formed on a side of the pixel defining layer **120** away from the substrate **110**.

[0270] In the above step, the structure of the first electrode layer **130** may refer to the above text, and the embodiments of the present disclosure are not described in detail here.

[0271] In S**300**, referring to FIGS. **5**A and **5**B, a black matrix **140** is formed on a side of the first electrode layer **130** away from the substrate **110**.

[0272] In the above step, the black matrix **140** is provided therein with a plurality of second pixel openings **141** and a plurality of second photosensitive openings **142**. An orthogonal projection of at least one first pixel opening **121** on the substrate **110** is located within an orthogonal projection of a second pixel opening **141** on the substrate **110**; and an orthogonal projection of at least one second photosensitive opening **142** on the substrate **110** is located within an orthogonal projection of a first photosensitive opening **122** on the substrate **110**.

[0273] Beneficial effects of the method for manufacturing the display panel **100** provided in the embodiments of the present disclosure are the same as beneficial effects of the display panel **100** provided in the above technical solutions, and details are not repeated here in the embodiments of the present disclosure.

[0274] The foregoing descriptions are merely specific implementations of the present disclosure, but the protection scope of the present disclosure is not limited thereto. Changes or replacements that any person skilled in the art could conceive of within the technical scope of the present disclosure shall be included in the protection scope of the present disclosure. Therefore, the protection scope of the present disclosure shall be subject to the protection scope of the claims.

1. A display panel, comprising:

a substrate;

a pixel defining layer disposed on the substrate, wherein the pixel defining layer is provided therein with a plurality of first pixel openings and a plurality of first photosensitive openings;

a first electrode layer disposed on a side of the pixel defining layer away from the substrate; and

a black matrix disposed on a side of the first electrode layer away from the substrate, wherein the black matrix is provided therein with a plurality of second pixel openings and a plurality of second photosensitive openings; an orthogonal projection of at least one first pixel opening on the substrate is located within an orthogonal projection of a second pixel opening on the substrate; and an orthogonal projection of at least one second photosensitive opening on the substrate is located within an orthogonal projection of a first photosensitive opening on the substrate.

2. The display panel according to claim **1**, wherein a distance between an edge of the orthogonal projection of the first pixel opening on the substrate and an edge of the orthogonal projection of the corresponding second pixel opening on the substrate is in a range of 2 μm to 6 μm, inclusive; and/or

a distance between an edge of the orthogonal projection of the first photosensitive opening on the substrate and an edge of the orthogonal projection of the corresponding second photosensitive opening on the substrate is in a range of 1.1 μm to 2 μm, inclusive.

3. The display panel according to claim **1**, further comprising:

a second electrode layer disposed between the pixel defining layer and the substrate, wherein the second electrode layer includes a plurality of second electrodes, an orthogonal projection of a first pixel opening on the substrate is located within an orthographic projection of a second electrode on the substrate; and an orthogonal projection of a second photosensitive opening on the substrate is located between orthographic projections of the plurality of second electrodes on the substrate.

4. The display panel according to claim **1**, further comprising:

a driving circuit layer disposed between the pixel defining layer and the substrate, wherein an orthographic projection of the driving circuit layer on the substrate encloses a plurality of light-transmitting regions; and an orthogonal projection of a second photosensitive opening on the substrate substantially coincides with a light-transmitting region or is located within a light-transmitting region.

5. The display panel according to claim **4**, wherein the driving circuit layer includes:

a plurality of pixel circuits arranged in a plurality of rows and a plurality of columns, wherein a row of pixel circuits is divided into a plurality of pixel circuit groups, and a pixel circuit group includes two adjacent pixel circuits; two pixel circuits in a same pixel circuit group are substantially symmetrical about a first axis, the first axis extends in a first direction, and the first direction is a column direction in which the plurality of pixel circuits are arranged;

a plurality of first signal line groups, wherein each first signal line group includes a plurality of first signal lines, the plurality of first signal lines extend substantially in the first direction and are connected to two pixel circuits in the pixel circuit group; and

a plurality of second signal line groups, wherein each second signal line group includes a plurality of second signal lines, the plurality of second signal lines extend substantially in a second direction and are each connected to a row of pixel circuits; the second direction is a row direction in which the plurality of pixel circuits are arranged; wherein

the light-transmitting region is located between two adjacent first signal lines belonging to different first signal line groups, and between two adjacent second signal lines belonging to a same second signal line group.

6. The display panel according to claim **5**, wherein the plurality of first signal lines in the first signal line group includes:

at least one power signal line connected to at least one column of pixel circuits; and

two data lines each connected to a column of pixel circuits, wherein the two data lines are located on opposite sides of the at least one power signal line; and the light-transmitting region is located between two adjacent data lines belonging to different first signal line groups.

7. The display panel according to claim **6**, wherein the data lines each include first straight line segments and first bent segments that are alternately connected; in the two adjacent data lines belonging to different first signal line groups, two first bent segments are bent toward directions away from each other; and the light-transmitting region is located between the two first bent segments.

8. The display panel according to claim **5**, wherein the plurality of second signal lines in the second signal line group include a first scanning signal line, a second scanning signal line, an enable signal line, a first initialization signal line, a second initialization signal line and a reset signal line arranged in sequence in the first direction; and the light-transmitting region is located between the first scanning signal line and the second scanning signal line.

9. The display panel according to claim **8**, wherein the first scanning signal line includes second straight line segments and second bent segments that are alternately connected, and the second scanning signal line includes third straight line segments and third bent segments that are alternately connected; and

in the first scanning signal line and the second scanning signal line that are adjacent, a second bent segment and a third bent segment are bent toward directions away from each other; and the light-transmitting region is located between the second bent segment and the third bent segment.

10. The display panel according to claim **1**, wherein the plurality of first pixel openings include a plurality of red pixel openings, a plurality of blue pixel openings and a plurality of green pixel openings;

the plurality of red pixel openings and the plurality of blue pixel openings are arranged in an array of multiple rows and multiple columns, each row includes multiple red pixel openings and multiple blue pixel openings that are arranged alternately in a second direction, and each column includes multiple red pixel openings and multiple blue pixel openings that are arranged alternately in a first direction; and

the plurality of green pixel openings are arranged in an array of multiple rows and multiple columns, each row includes multiple green pixel openings arranged in the second direction, and each column includes multiple green pixel openings arranged in the first direction;

in the first direction, a green pixel opening is located between a red pixel opening and a blue pixel opening that are adjacent; and in the second direction, a green pixel opening is located between a red pixel opening and a blue pixel opening that are adjacent.

11. The display panel according to claim **10**, wherein in the first direction, a first photosensitive opening is located between two adjacent green pixel openings; and in the second direction, a first photosensitive opening is located between the red pixel opening and the blue pixel opening that are adjacent.

12. The display panel according to claim **1**, further comprising:

a touch layer including a plurality of touch lines, wherein orthographic projections of the plurality of touch lines on the substrate are staggered from orthogonal projections of the second pixel openings and the second photosensitive openings on the substrate.

13. The display panel according to claim **12**, wherein the display panel has a display area, the display area includes a main display region and a photosensitive region, and the first photosensitive openings and the second photosensitive openings are located in the photosensitive region;

in the photosensitive region, the plurality of touch lines are arranged crosswise to constitute a first mesh structure, and the first mesh structure includes:

a plurality of first grid rows, a first grid row including a plurality of first grids arranged in a second direction, and vertexes of two adjacent first grids are connected; and

a plurality of second grid rows each including a plurality of second grids, a plurality of third grids, a plurality of fourth grids and a plurality of fifth grids arranged in the second direction, wherein

a first grid is provided with a first pixel opening therein; a second grid is provided with a first photosensitive opening therein; a third grid is provided with a first pixel opening therein; a fourth grid is provided with a first pixel opening and two first photosensitive openings therein; and a fifth grid is provided with two first pixel openings and a first photosensitive opening therein.

14. The display panel according to claim **13**, wherein the first grid is substantially in a hexagonal shape; the second grid is substantially in a rectangular shape; and the third grid is substantially in a hexagonal shape; the fourth grid includes a first sub-grid and two second sub-grids; in a second direction, the two second sub-grids are disposed on opposite sides of the first sub-grid and communicated to the first sub-grid; the first sub-grid is substantially in a hexagonal shape, and the second sub-grids are each substantially in a rectangular shape; and the fifth grid includes a third sub-grid and two fourth sub-grids; in the second direction, the two fourth sub-grids are disposed on opposite sides of the third sub-grid and communicated to the third sub-grid; the third sub-grid is substantially in a rectangular shape, and the fourth sub-grids are each in a hexagonal shape; and/or

the plurality of first pixel openings include a plurality of red pixel openings, a plurality of blue pixel openings and a plurality of green pixel openings; an orthogonal projection of a green pixel opening on the substrate is within an orthogonal projection of the first grid on the substrate; an orthogonal projection of a red pixel opening on the substrate is located in an orthogonal projection of any of the second grid, the third grid, the fourth grid and the fifth grid on the substrate; and an orthogonal projection of a blue pixel opening on the substrate is located in an orthogonal projection of any of the second grid, the third grid, the fourth grid and the fifth grid on the substrate.

15. (canceled)

16. The display panel according to claim **12**, wherein the display panel has a display area, the display area includes a main display region and a photosensitive region, and the first photosensitive openings and the second photosensitive openings are located in the photosensitive region;

in the main display region, the plurality of touch lines are arranged crosswise to constitute a second mesh structure; the second mesh structure includes a plurality of sixth grids, the plurality of sixth grids are arranged in multiple rows and multiple columns, each row includes multiple sixth grids arranged in a second direction, and each column includes multiple sixth grids arranged in a first direction, wherein

sixth grids of two adjacent rows are staggered, and a sixth grid is provided with a first pixel opening therein.

17. The display panel according to claim **16**, wherein the sixth grid is substantially in a rhombic shape.

18. The display panel according to claim **1**, further comprising:

an encapsulation layer disposed between the black matrix and the substrate, wherein the encapsulation layer includes a plurality of encapsulation sub-films that are stacked, and any two adjacent encapsulation sub-films have different refractive indexes; and/or

a color film disposed on a side of the black matrix away from the substrate, wherein the color film includes a plurality of filter patterns; the plurality of filter patterns and the plurality of second photosensitive openings are staggered, and the orthogonal projection of the second pixel opening on the substrate is located within an orthographic projection of a filter pattern on the substrate.

19. (canceled)

20. The display panel according to claim **1**, wherein an orthogonal projection of a first pixel opening on the substrate is located within the orthogonal projection of the second pixel opening on the substrate.

21. A method for manufacturing a display panel, comprising:

forming a pixel defining layer on a substrate, wherein the pixel defining layer is provided therein with a plurality of first pixel openings and a plurality of first photosensitive openings;

forming a first electrode layer on a side of the pixel defining layer away from the substrate; and

forming a black matrix on a side of the first electrode layer away from the substrate, wherein the black matrix is provided therein with a plurality of second pixel openings and a plurality of second photosensitive openings; an orthogonal projection of at least one first pixel opening on the substrate is located within an orthogonal projection of a second pixel opening on the substrate; and an orthogonal projection of at least one second photosensitive opening on the substrate is located within an orthogonal projection of a first photosensitive opening on the substrate.

22. A display apparatus, comprising:

the display panel according to claim **1**, the display panel including a light-exit side and a non-light-exit side that are opposite; and

a photosensitive device disposed on the non-light-exit side of the display panel.

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