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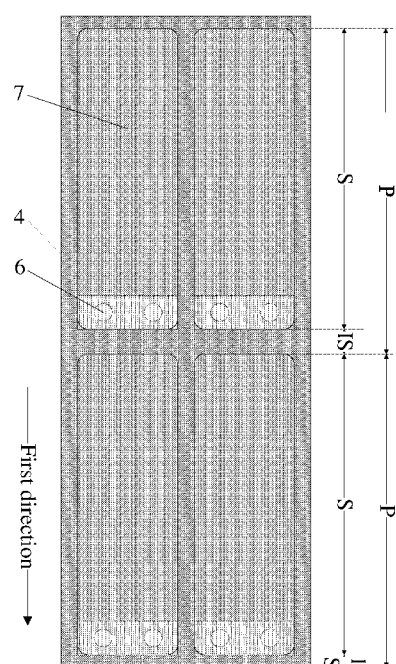
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FIG. 4



(57) Abstract: An array substrate having a subpixel region (S) and an inter-subpixel (IS) region is disclosed. The array substrate includes a base substrate (1); a thin film transistor (5) on the base substrate (1) and including a drain electrode (5a); a passivation layer (2) on a side of the thin film transistor (5) distal to the base substrate (1); a pixel electrode layer (3) on a side of the passivation layer (2) distal to the base substrate (1); a pixel definition layer (4) in the inter-subpixel region (IS) on a side of the pixel electrode layer (3) distal to the passivation layer (2) and defining the subpixel region (S); and an organic light emitting layer (7) in the subpixel region (S) on a side of the pixel electrode layer (3) distal to the passivation layer (2). The array substrate includes a via (6) extending through the passivation layer (2). The pixel electrode layer (3) is electrically connected to the drain electrode (5a) of the thin film transistor (5) through the via (6). The via (6) is in the subpixel region (S).



ARRAY SUBSTRATE, DISPLAY PANEL HAVING THE SAME, AND METHOD OF FABRICATING ARRAY SUBSTRATE

TECHNICAL FIELD

[0001] The present invention relates to display technology, more particularly, to an array substrate, a display panel having the same, and a method of fabricating an array substrate.

BACKGROUND

[0002] Organic light emitting diode (OLED) display apparatuses are self-emissive devices, and do not require backlights. OLED display apparatuses provide more vivid colors and a larger color gamut as compared to the conventional liquid crystal display (LCD) apparatuses. Further, OLED display apparatuses can be made more flexible, thinner, and lighter than a typical LCD apparatus.

[0003] An OLED display apparatus typically includes an anode, an organic layer including a light emitting layer, and a cathode. OLEDs can either be a bottom-emission type OLED or a top-emission type OLED. In bottom-emission type OLEDs, the light is extracted from an anode side. In bottom-emission type OLEDs, the anode is generally transparent, while a cathode is generally reflective. In a top-emission type OLED, light is extracted from a cathode side. The cathode is optically transparent, while the anode is reflective.

SUMMARY

[0004] In one aspect, the present invention provides an array substrate having a subpixel region and an inter-subpixel region, comprising a base substrate; a thin film transistor on the base substrate and comprising a drain electrode; a passivation layer on a side of the thin film transistor distal to the base substrate; a pixel electrode layer on a side of the passivation layer distal to the base substrate; a pixel definition layer in the inter-subpixel region on a side of the pixel electrode layer distal to the passivation layer and defining the subpixel region; and an organic light emitting layer in the subpixel region on a side of the pixel electrode layer distal to the passivation layer; wherein the array substrate comprises a via extending through the passivation layer; the pixel electrode layer is electrically connected to the drain electrode of the thin film transistor through the via; and the via is in the subpixel region.

[0005] Optionally, a projection of the via on the base substrate is substantially non-overlapping with that of any pixel definition layer in the array substrate.

[0006] Optionally, a projection of the organic light emitting layer on the base substrate substantially covers that of the via.

[0007] Optionally, a projection of a light emitting region of the organic light emitting layer on the base substrate substantially covers that of the via.

[0008] Optionally, the drain electrode of the thin film transistor is in the subpixel region.

[0009] Optionally, a projection of the drain electrode on the base substrate is substantially non-overlapping with that of any pixel definition layer in the array substrate.

[0010] Optionally, a projection of the organic light emitting layer on the base substrate substantially covers that of the drain electrode.

[0011] Optionally, a projection of a light emitting region of the organic light emitting layer on the base substrate substantially covers that of the drain electrode.

[0012] Optionally, a projection of a light emitting region of the organic light emitting layer on the base substrate substantially covers that of the thin film transistor.

[0013] Optionally, the array substrate comprises a plurality of subpixel areas each of which having a shape elongated along a first direction; wherein a width of the subpixel region in each of the plurality of subpixel areas along the first direction is greater than a pitch of the plurality of subpixel areas along the first direction minus 30 μm .

[0014] Optionally, the width of the subpixel region in each of the plurality of subpixel areas along the first direction is approximately the pitch minus 17 μm .

[0015] Optionally, the array substrate comprises a plurality of subpixel areas each of which having a shape elongated along a first direction; wherein a width of the pixel definition layer between adjacent two subpixel regions respectively in adjacent two subpixel areas along the first direction is smaller than 30 μm .

[0016] Optionally, the width of the pixel definition layer between adjacent two subpixel regions respectively in adjacent two subpixel areas along the first direction is approximately 17 μm .

[0017] Optionally, the array substrate comprises a plurality of subpixel areas each of which having a shape elongated along a first direction; wherein the plurality of subpixel areas have a pitch along the first direction; and a width of the organic light emitting layer in each of the plurality of subpixel areas along the first direction is greater than the pitch minus $30\ \mu\text{m}$.

[0018] Optionally, the width of the organic light emitting layer in each of the plurality of subpixel areas along the first direction is approximately the pitch minus $17\ \mu\text{m}$.

[0019] Optionally, a first portion of the pixel electrode layer corresponding to the via has a first surface distal to the base substrate; and the first surface is substantially level with a surface of other portions of the pixel electrode layer distal to the base substrate.

[0020] Optionally, the array substrate comprises a solidified silver paste in the via.

[0021] Optionally, a first portion of the pixel electrode layer corresponding to the via has a first surface distal to the base substrate; and the first surface is concave relative to a surface of other portions of the pixel electrode layer distal to the base substrate.

[0022] In one aspect, the present invention provides a display panel comprising an array substrate described herein.

[0023] In one aspect, the present invention provides a method of fabricating an array substrate, comprising forming a thin film transistor on a base substrate, the thin film transistor being formed to comprises a drain electrode; forming a passivation layer on a side of the thin film transistor distal to the base substrate; forming a pixel electrode layer on a side of the passivation layer distal to the base substrate; forming a pixel definition layer on a side of the pixel electrode layer distal to the passivation layer and defining the subpixel region; forming an organic light emitting layer on a side of the pixel electrode layer distal to the passivation layer; and forming a via extending through the passivation layer, the pixel electrode layer being formed to be electrically connected to the drain electrode of the thin film transistor through the via; wherein the pixel definition layer defines a subpixel region of the array substrate; the organic light emitting layer is formed in the subpixel region; and the via is formed in the subpixel region.

BRIEF DESCRIPTION OF THE FIGURES

[0024] The following drawings are merely examples for illustrative purposes according to various disclosed embodiments and are not intended to limit the scope of the present invention.

[0025] FIG. 1 is a cross-sectional view of a conventional array substrate.

[0026] FIG. 2 is a plan view of a conventional array substrate.

[0027] FIG. 3 is a cross-sectional view of an array substrate in some embodiments according to the present disclosure.

[0028] FIG. 4 is a plan view of an array substrate in some embodiments according to the present disclosure.

[0029] FIG. 5 is a cross-sectional view of an array substrate in some embodiments according to the present disclosure.

DETAILED DESCRIPTION

[0030] The disclosure will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of some embodiments are presented herein for purpose of illustration and description only. It is not intended to be exhaustive or to be limited to the precise form disclosed.

[0031] FIG. 1 is a cross-sectional view of a conventional array substrate. FIG. 2 is a plan view of a conventional array substrate. Referring to FIG. 1 and FIG. 2, the conventional array substrate in some embodiments includes a subpixel region S and an inter-subpixel region IS. The conventional array substrate includes a base substrate 1, a thin film transistor 5 having a drain electrode 5a on the base substrate 1, a passivation layer 2 on a side of the thin film transistor 5 distal to the base substrate 1, a pixel electrode layer 3 on a side of the passivation layer 2 distal to the base substrate 1, a pixel definition layer 4 in the inter-subpixel region IS on a side of the pixel electrode layer 3 distal to the passivation layer 2 and defining the subpixel region S, and an organic layer 7 in the subpixel region S on a side of the pixel electrode layer 3 distal to the passivation layer 2. The conventional array substrate includes a via 6 extending through the passivation layer 2. The pixel electrode layer 3 is electrically connected to the drain electrode 5a of the thin film transistor 5 through the via 6. In the conventional array substrate, the thin film transistor 5 is entirely covered by the pixel

definition layer 4. For example, the via 6 is in the inter-subpixel region IS. The aperture ratio of the convention array substrate is relatively small.

[0032] In the conventional array substrate, the pixel definition layer 4 generally has an isosceles trapezoidal shape, and is made of a hydrophobic material having a small surface energy to ensure that the ink droplets spread in subpixel areas without overflowing to the pixel definition layer 4 outside the subpixel areas. During the ink-jet printing process, a solvent in the ink droplets close to an edge of the pixel definition layer 4 volatilizes quickly due to a slope angle of the pixel definition layer 4 and a surface energy difference between the ink droplets and the pixel definition layer 4 when they are in contact with each other. After being finally dried, the ink droplets produce an uneven thin film which is relatively thicker at an edge portion and is relatively thinner at the middle portion, a.k.a., "coffee ring effect". Due to this coffee ring effect, the organic layer 7 has a non-uniform thickness. An organic layer 7 having the non-uniform thickness results in an unevenly distributed light emission. Display quality of a display panel having the conventional array substrate is compromised.

[0033] Accordingly, the present disclosure provides, *inter alia*, an array substrate, a display panel having the same, and a method of fabricating an array substrate that substantially obviate one or more of the problems due to limitations and disadvantages of the related art. In one aspect, the present disclosure provides an array substrate having a subpixel region and an inter-subpixel region. In some embodiments, the array substrate includes a base substrate; a thin film transistor on the base substrate and having a drain electrode; a passivation layer on a side of the thin film transistor distal to the base substrate; a pixel electrode layer on a side of the passivation layer distal to the base substrate; a pixel definition layer in the inter-subpixel region on a side of the pixel electrode layer distal to the passivation layer and defining the subpixel region; and an organic light emitting layer in the subpixel region on a side of the pixel electrode layer distal to the passivation layer. The array substrate includes a via extending through the passivation layer. The pixel electrode layer is electrically connected to the drain electrode of the thin film transistor through the via. The via is in the subpixel region.

[0034] As used herein, the term "subpixel region" refers to a light emission region of a subpixel, such as a region corresponding to a light emitting layer in an organic light emitting diode display panel or an organic light emitting diode array substrate. Optionally, a light

emitting layer in an organic light emitting diode display panel or an organic light emitting diode array substrate includes a light emitting portion and a non-emitting portion, in the context of the present disclosure, the subpixel region refers to a region corresponding to the light emitting portion of the light emitting layer of the organic light emitting diode display panel or the organic light emitting diode array substrate. Optionally, a pixel may include a number of separate light emission regions corresponding to a number of subpixels in the pixel. Optionally, the subpixel region is a light emission region of a red color subpixel. Optionally, the subpixel region is a light emission region of a green color subpixel. Optionally, the subpixel region is a light emission region of a blue color subpixel. Optionally, the subpixel region is a light emission region of a white color subpixel.

[0035] As used herein, the term "inter-subpixel region" refers to a region between adjacent subpixel regions, such as a region corresponding a pixel definition layer in an organic light emitting diode display panel or an organic light emitting diode array substrate. Optionally, a light emitting layer in an organic light emitting diode display panel or an organic light emitting diode array substrate includes a light emitting portion and a non-emitting portion, in the context of the present disclosure, the inter-subpixel region includes a region corresponding to the non-emitting portion of the light emitting layer of the organic light emitting diode display panel or the organic light emitting diode array substrate. Optionally, the inter-subpixel region is a region between adjacent subpixel regions in a same pixel. Optionally, the inter-subpixel region is a region between two adjacent subpixel regions from two adjacent pixels. Optionally, the inter-subpixel region is a region between a subpixel region of a red color subpixel and a subpixel region of an adjacent green color subpixel. Optionally, the inter-subpixel region is a region between a subpixel region of a red color subpixel and a subpixel region of an adjacent blue color subpixel. Optionally, the inter-subpixel region is a region between a subpixel region of a green color subpixel and a subpixel region of an adjacent blue color subpixel.

[0036] As used herein, the term "subpixel area" refers to an area in an array substrate corresponding to a subpixel in a display panel having the array substrate. A subpixel area includes a subpixel region and an inter-subpixel region.

[0037] FIG. 3 is a cross-sectional view of an array substrate in some embodiments according to the present disclosure. FIG. 4 is a plan view of an array substrate in some embodiments according to the present disclosure. Referring to FIG. 3 and FIG. 4, the array

substrate in some embodiments includes a subpixel region S and an inter-subpixel region IS. The array substrate includes an array of a plurality of subpixel areas. FIG. 3 shows one subpixel area of the array substrate. The array substrate includes a base substrate 1, a thin film transistor 5 having a drain electrode 5a on the base substrate 1, a passivation layer 2 on a side of the thin film transistor 5 distal to the base substrate 1, a pixel electrode layer 3 on a side of the passivation layer 2 distal to the base substrate 1, a pixel definition layer 4 in the inter-subpixel region IS on a side of the pixel electrode layer 3 distal to the passivation layer 2 and defining the subpixel region S, and an organic layer 7 in the subpixel region S on a side of the pixel electrode layer 3 distal to the passivation layer 2. The array substrate includes a via 6 extending through the passivation layer 2. The pixel electrode layer 3 is electrically connected to the drain electrode 5a of the thin film transistor 5 through the via 6. As shown in FIG. 3 and FIG. 4, the via 6 is in the subpixel region S. The organic layer 7 includes an organic light emitting layer 7b. Optionally, the organic layer 7 further includes one or more organic functional layers.

[0038] In some embodiments, the organic layer 7 further includes one or more organic functional layers between the organic light emitting layer 7b and the pixel electrode layer 3 in the subpixel region. Optionally, the one or more organic functional layer includes a carrier transport layer such as a hole transport layer. Optionally, the one or more organic functional layer includes a carrier injection layer such as a hole injection layer. Optionally, the organic layer 7 includes a hole injection layer on a side of the pixel electrode layer 3 distal to the base substrate 1, a hole transport layer on a side of the hole injection layer distal to the pixel electrode layer 3, and an organic light emitting layer 7b on a side of the hole transport layer distal to the hole injection layer. Referring to FIG. 3, the organic layer 7 includes a hole transport layer 7c on a side of the pixel electrode layer 3 distal to the base substrate 1, and an organic light emitting layer 7b on a side of the hole transport layer 7c distal to base substrate 1.

[0039] In some embodiments, the organic layer 7 further includes one or more organic functional layers on a side of the organic light emitting layer 7b distal to the base substrate 1. Optionally, the one or more organic functional layer includes a carrier transport layer such as an electron transport layer. Optionally, the one or more organic functional layer includes a carrier injection layer such as an electron injection layer. Optionally, the organic layer 7 includes an electron transport layer 7a on a side of the organic light emitting layer 7b distal to the pixel electrode layer 3, and an electron injection layer on a side of the electron transport

layer 7a distal to the organic light emitting layer 7b. Referring to FIG. 3, the organic layer 7 includes a hole transport layer 7c on a side of the pixel electrode layer 3 distal to the base substrate 1, an organic light emitting layer 7b on a side of the hole transport layer 7c distal to base substrate 1, and an electron transport layer 7a on a side of the organic light emitting layer 7b distal to the hole transport layer 7c.

[0040] Optionally, the organic layer 7 includes a hole injection layer on a side of the pixel electrode layer 3 distal to the base substrate 1, a hole transport layer 7c on a side of the hole injection layer distal to the pixel electrode layer 3, an organic light emitting layer 7b on a side of the hole transport layer 7c distal to the hole injection layer, an electron transport layer 7a on a side of the organic light emitting layer 7b distal to the hole transport layer 7c, and an electron injection layer on a side of the electron transport layer 7a distal to the organic light emitting layer 7b.

[0041] Optionally, the pixel electrode layer 3 is a cathode. Optionally, the pixel electrode layer 3 is an anode. Optionally, the array substrate is an organic light emitting diode array substrate. Optionally, the array substrate is an active matrix organic light emitting diode array substrate. Optionally, the array substrate is a passive matrix organic light emitting diode array substrate. Optionally, the thin film transistor 5 is a driving thin film transistor for driving light emission of the organic light emitting layer 7 in the array substrate.

[0042] By having this design, an array substrate having a dramatically increased aperture ratio and an organic layer 7 (e.g., an organic light emitting layer 7b) of a substantially uniform thickness can be achieved. As compared to the conventional array substrate (e.g., the array substrate in FIG. 1 and FIG. 2), the present array substrate has a subpixel region S with an increased width, e.g., along the first direction. Similarly, the organic layer 7 (e.g., the organic light emitting layer 7b) in the present array substrate also has an increased width, e.g., along the first direction. As denoted in FIG. 3, the width of the organic layer 7 (e.g., the organic light emitting layer 7b) along the first direction increases by a value of AW as compared to that in FIG. 1. The organic layer 7 (e.g., the organic light emitting layer 7b) typically has a substantially uniform thickness in a middle portion of the organic layer 7 (e.g., the organic light emitting layer 7b) and has a greater thickness only in an edge portion of the organic layer 7 (e.g., the organic light emitting layer 7b). By increasing the width of the organic layer 7 (e.g., the organic light emitting layer 7b), an area and a width of the middle portion also increase, thereby achieving a substantially more uniform overall thickness and a

substantially more evenly distributed light emission from the organic layer 7. As further detailed in the embodiments below, the aperture ratio of the present array substrate increases by at least 9% as compared to the conventional array substrate.

[0043] The width of the pixel definition layer 4 along the first direction decreases by the value of AW as compared to that in FIG. 1. By having a pixel definition layer 4 with a decreased width (e.g., along the first direction), the via 6 is no longer covered by the pixel definition layer 4. In some embodiments, a projection of the via 6 on the base substrate 1 is substantially non-overlapping with that of any pixel definition layer in the array substrate. For example, and as shown in FIG. 3 and FIG. 4, the projection of the via 6 on the base substrate 1 is substantially non-overlapping with that of the pixel definition layer 4. Optionally, the array substrate may include additional pixel definition layers, and the projection of the via 6 on the base substrate 1 is substantially non-overlapping with those of the additional pixel definition layers.

[0044] In some embodiments, a projection of the organic layer 7 (e.g., the organic light emitting layer 7b) on the base substrate 1 substantially overlaps with that of the via 6. Optionally, a projection of the organic layer 7 (e.g., the organic light emitting layer 7b) on the base substrate 1 substantially covers that of the via 6. In one example, in forming the organic layer 7 (e.g., the organic light emitting layer 7b), some organic light emitting material may be disposed on the pixel definition layer 4. The organic light emitting material on top of the pixel definition layer 4 are not capable of emitting light. Accordingly, in some embodiments, a projection of a light emitting region of the organic layer 7 (e.g., a light emitting region of the organic light emitting layer 7b) on the base substrate 1 substantially overlaps with that of the via 6. Optionally, a projection of a light emitting region of the organic layer 7 (e.g., a light emitting region of the organic light emitting layer 7b) on the base substrate 1 substantially covers that of the via 6.

[0045] In some embodiments, at least a portion of the thin film transistor 5 is in the subpixel region S. In one example, the drain electrode 5a of the thin film transistor 5 is in the subpixel region S. In some embodiments, a projection of the drain electrode 5a on the base substrate 1 is substantially non-overlapping with that of any pixel definition layer in the array substrate. For example, and as shown in FIG. 3 and FIG. 4, the projection of the drain electrode 5a on the base substrate 1 is substantially non-overlapping with that of the pixel definition layer 4. Optionally, the array substrate may include additional pixel definition

layers, and the projection of the drain electrode 5a on the base substrate 1 is substantially non-overlapping with those of the additional pixel definition layers.

[0046] In some embodiments, a projection of the organic layer 7 (e.g., the organic light emitting layer 7b) on the base substrate 1 substantially overlaps with that of the drain electrode 5a. Optionally, a projection of the organic layer 7 (e.g., the organic light emitting layer 7b) on the base substrate 1 substantially covers that of the drain electrode 5a. In some embodiments, a projection of a light emitting region of the organic layer 7 (e.g., a light emitting region of the organic light emitting layer 7b) on the base substrate 1 substantially overlaps with that of the drain electrode 5a. Optionally, a projection of a light emitting region of the organic layer 7 (e.g., a light emitting region of the organic light emitting layer 7b) on the base substrate 1 substantially covers that of the drain electrode 5a.

[0047] In some embodiments, the thin film transistor 5 is entirely in the subpixel region S. In some embodiments, a projection of the thin film transistor 5 on the base substrate 1 is substantially non-overlapping with that of any pixel definition layer in the array substrate. Optionally, the projection of the thin film transistor 5 on the base substrate 1 is substantially non-overlapping with that of the pixel definition layer 4. Optionally, the array substrate may include additional pixel definition layers, and the projection of the thin film transistor 5 on the base substrate 1 is substantially non-overlapping with those of the additional pixel definition layers.

[0048] In some embodiments, a projection of the organic layer 7 (e.g., the organic light emitting layer 7b) on the base substrate 1 substantially overlaps with that of the thin film transistor 5. Optionally, a projection of the organic layer 7 (e.g., the organic light emitting layer 7b) on the base substrate 1 substantially covers that of the thin film transistor 5. In some embodiments, a projection of a light emitting region of the organic layer 7 (e.g., a light emitting region of the organic light emitting layer 7b) on the base substrate 1 substantially overlaps with that of the thin film transistor 5. Optionally, a projection of a light emitting region of the organic layer 7 (e.g., a light emitting region of the organic light emitting layer 7b) on the base substrate 1 substantially covers that of the thin film transistor 5.

[0049] In some embodiments, and referring to FIG. 4, the array substrate includes a plurality of subpixel areas each of which has a shape elongated along the first direction. The plurality of subpixel areas have a pitch p along the first direction. In some embodiments, a width of the subpixel region S in each of the plurality of subpixel areas along the first

direction is equal to $(p - q)$; wherein p is the pitch of the plurality of subpixel areas along the first direction, and q is a value equal to or less than $35 \mu\text{m}$. Optionally, $q = 35 \mu\text{m}$.

Optionally, $q = 30 \mu\text{m}$. Optionally, $q = 25 \mu\text{m}$. Optionally, $q = 20 \mu\text{m}$. Optionally, the width of the subpixel region S in each of the plurality of subpixel areas along the first direction is approximately $(p - 17 \mu\text{m})$.

[0050] In one example, the array substrate is a 160 pixel-per-inch (ppi) array substrate. The plurality of subpixel areas in the 160-ppi array substrate have a pitch p_1 of $158.7 \mu\text{m}$ along the first direction (e.g., the longitudinal direction of the subpixel area), and a pitch p_2 of $52.9 \mu\text{m}$ along a second direction (e.g., the lateral direction of the subpixel area). In another example, the width of the subpixel region S in each of the plurality of subpixel areas in the 160-ppi array substrate along the first direction is approximately $(p_1 - 17 \mu\text{m}) = (158.7 \mu\text{m} - 17 \mu\text{m}) = 141.7 \mu\text{m}$. The width of the subpixel region S in each of the plurality of subpixel areas in the 160-ppi array substrate along the second direction is approximately $(p_2 - 17 \mu\text{m}) = (52.9 \mu\text{m} - 17 \mu\text{m}) = 35.9 \mu\text{m}$. The size of the via 6 is typically $14 \mu\text{m} \times 26 \mu\text{m}$. Thus, the aperture ratio in the example is approximately $(141.7 \times 35.9 - 14 \times 26) / (158.7 \times 52.9)$, i.e., approximately 56.3%.

[0051] In the conventional 160-ppi array substrate, the width of the subpixel region S in each of the plurality of subpixel areas in the 160-ppi conventional array substrate along the first direction is approximately $(p_1 - 40.9 \mu\text{m}) = (158.7 \mu\text{m} - 40.9 \mu\text{m}) = 117.8 \mu\text{m}$. The width of the subpixel region S in each of the plurality of subpixel areas in the 160-ppi conventional array substrate along the second direction is approximately $(p_2 - 17 \mu\text{m}) = (52.9 \mu\text{m} - 17 \mu\text{m}) = 35.9 \mu\text{m}$. The aperture ratio in the conventional array substrate is approximately $(117.8 \times 35.9) / (158.7 \times 52.9)$, i.e., approximately 47.1%. Thus, the aperture ratio of the present array substrate increases by 9.2% as compared to the conventional array substrate.

[0052] In some embodiments, the present array substrate includes a plurality of subpixel areas each of which having a shape elongated along the first direction. Optionally, a width of the pixel definition layer between adjacent two subpixel regions S respectively in adjacent two subpixel areas along the first direction is smaller than q , wherein q is a value equal to or less than $35 \mu\text{m}$. Optionally, $q = 35 \mu\text{m}$. Optionally, $q = 30 \mu\text{m}$. Optionally, $q = 25 \mu\text{m}$. Optionally, $q = 20 \mu\text{m}$. In one example, the width of the pixel definition layer between

adjacent two subpixel regions S respectively in adjacent two subpixel areas along the first direction is approximately $17\ \mu\text{m}$.

[0053] In some embodiments, the present array substrate includes a plurality of subpixel areas each of which having a shape elongated along the first direction. The plurality of subpixel areas have a pitch along the first direction. In some embodiments, a width of the organic layer 7 (e.g., the organic light emitting layer 7b) in each of the plurality of subpixel areas along the first direction is equal to $(p - q)$; wherein p is the pitch of the plurality of subpixel areas along the first direction, and q is a value equal to or less than $35\ \mu\text{m}$.

Optionally, $q = 35\ \mu\text{m}$. Optionally, $q = 30\ \mu\text{m}$. Optionally, $q = 25\ \mu\text{m}$. Optionally, $q = 20\ \mu\text{m}$. Optionally, the width of the organic layer 7 (e.g., the organic light emitting layer 7b) in each of the plurality of subpixel areas along the first direction is approximately $(p - 17\ \mu\text{m})$.

[0054] In some embodiments, a width of a light emitting region of the organic layer 7 (e.g., the organic light emitting layer 7b) in each of the plurality of subpixel areas along the first direction is equal to $(p - q)$; wherein p is the pitch of the plurality of subpixel areas along the first direction, and q is a value equal to or less than $35\ \mu\text{m}$. Optionally, $q = 35\ \mu\text{m}$.

Optionally, $q = 30\ \mu\text{m}$. Optionally, $q = 25\ \mu\text{m}$. Optionally, $q = 20\ \mu\text{m}$. Optionally, the width of the light emitting region of the organic layer 7 (e.g., the organic light emitting layer 7b) in each of the plurality of subpixel areas along the first direction is approximately $(p - 17\ \mu\text{m})$.

[0055] In some embodiments, and referring to FIG. 3, a portion of the pixel electrode layer 3 corresponding to the via 6 has a surface distal to the base substrate 1; and the surface of the portion corresponding to the via 6 is substantially level with a surface of other portions of the pixel electrode layer 3 distal to the base substrate 1. Various appropriate methods may be used to make a substantially level surface. In one example, a conductive paste (e.g., a silver paste) can be printed (e.g., by ink-jet printing) in the via 6. The conductive paste is then solidified. Subsequently, the pixel electrode layer 3 is formed on the passivation layer 2 with the via 6 pre-filled with the solidified conductive paste. By having the via 6 pre-filled with the conductive paste, the entire surface of the pixel electrode layer 3 distal to the passivation layer 2 can be made substantially level.

[0056] FIG. 5 is a cross-sectional view of an array substrate in some embodiments according to the present disclosure. Referring to FIG. 5, a portion of the pixel electrode layer 3 corresponding to the via 6 has a surface 8 distal to the base substrate 1. The surface 8

corresponding to the via 6 is concave relative to a surface of other portions of the pixel electrode layer 3 distal to the base substrate 1. In the present array substrate, the via 6 is in a region corresponding to an edge portion of the organic layer 7 (e.g., the organic light emitting layer 7b), which has a larger thickness as compared to the middle portion of the organic layer 7 (e.g., the organic light emitting layer 7b). Thus, the concaved surface 8 corresponding to the via 6 does not present an issue as the excess organic material in the region fills in the concave surface.

[0057] In another aspect, the present disclosure provides a method of fabricating an array substrate. In some embodiments, the method includes forming a thin film transistor on a base substrate, the thin film transistor being formed to comprises a drain electrode; forming a passivation layer on a side of the thin film transistor distal to the base substrate; forming a pixel electrode layer on a side of the passivation layer distal to the base substrate; forming a pixel definition layer on a side of the pixel electrode layer distal to the passivation layer and defining the subpixel region; forming an organic layer on a side of the pixel electrode layer distal to the passivation layer; and forming a via extending through the passivation layer, the pixel electrode layer being formed to be electrically connected to the drain electrode of the thin film transistor through the via. The pixel definition layer defines a subpixel region of the array substrate, and the organic layer is formed in the subpixel region. In the present method, the via is formed in the subpixel region. Optionally, the organic layer is formed by printing, e.g., ink-jet printing. The step of forming the organic layer includes forming an organic light emitting layer. Optionally, the step of forming the organic layer further includes forming one or more organic functional layers. Optionally, the organic light emitting layer is formed by printing, e.g., ink-jet printing. Optionally, the one or more organic functional layers are formed by printing, e.g., ink-jet printing.

[0058] In some embodiments, the step of forming the organic layer further includes forming one or more organic functional layers between the organic light emitting layer and the pixel electrode layer in the subpixel region.. Optionally, the step of forming the one or more organic functional layer includes forming a carrier transport layer such as a hole transport layer. Optionally, the step of forming the one or more organic functional layer includes forming a carrier injection layer such as a hole injection layer. Optionally, the step of forming the organic layer includes forming a hole injection layer on a side of the pixel electrode layer distal to the base substrate, forming a hole transport layer on a side of the hole injection layer distal to the pixel electrode layer, and forming an organic light emitting layer

on a side of the hole transport layer distal to the hole injection layer. Optionally, the step of forming the organic layer includes forming a hole transport layer on a side of the pixel electrode layer distal to the base substrate, and forming an organic light emitting layer on a side of the hole transport layer distal to base substrate.

[0059] In some embodiments, the step of forming the organic layer further includes forming one or more organic functional layers on a side of the organic light emitting layer distal to the base substrate. Optionally, the step of forming the one or more organic functional layer includes forming a carrier transport layer such as an electron transport layer. Optionally, the step of forming the one or more organic functional layer includes forming a carrier injection layer such as an electron injection layer. Optionally, the step of forming the organic layer includes forming an electron transport layer on a side of the organic light emitting layer distal to the pixel electrode layer, and forming an electron injection layer on a side of the electron transport layer distal to the organic light emitting layer. Optionally, the step of forming the organic layer includes forming a hole transport layer on a side of the pixel electrode layer distal to the base substrate, forming an organic light emitting layer on a side of the hole transport layer distal to base substrate, and forming an electron transport layer on a side of the organic light emitting layer distal to the hole transport layer.

[0060] Optionally, the step of forming the organic layer includes forming a hole injection layer on a side of the pixel electrode layer distal to the base substrate, forming a hole transport layer on a side of the hole injection layer distal to the pixel electrode layer, forming an organic light emitting layer on a side of the hole transport layer distal to the hole injection layer, forming an electron transport layer on a side of the organic light emitting layer distal to the hole transport layer, and forming an electron injection layer on a side of the electron transport layer distal to the organic light emitting layer.

[0061] In some embodiments, the array substrate (e.g., the pixel definition layer) is formed so that a projection of the via on the base substrate is substantially non-overlapping with that of any pixel definition layer in the array substrate.

[0062] In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of the organic layer (e.g., the organic light emitting layer) on the base substrate substantially overlaps with that of the via. Optionally, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of the organic layer (e.g., the organic light emitting layer) on the base substrate

substantially covers that of the via. In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of a light emitting region of the organic layer (e.g., a light emitting region of the organic light emitting layer) on the base substrate substantially overlaps with that of the via. Optionally, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of a light emitting region of the organic layer (e.g., a light emitting region of the organic light emitting layer) on the base substrate substantially covers that of the via.

[0063] In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that at least a portion of the thin film transistor is formed in the subpixel region. In one example, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that the drain electrode of the thin film transistor is formed in the subpixel region. In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of the drain electrode on the base substrate is substantially non-overlapping with that of any pixel definition layer in the array substrate.

[0064] In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of the organic layer (e.g., the organic light emitting layer) on the base substrate substantially overlaps with that of the drain electrode. Optionally, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of the organic layer (e.g., the organic light emitting layer) on the base substrate substantially covers that of the drain electrode. In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of a light emitting region of the organic layer (e.g., a light emitting region of the organic light emitting layer) on the base substrate substantially overlaps with that of the drain electrode. Optionally, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of a light emitting region of the organic layer (e.g., a light emitting region of the organic light emitting layer) on the base substrate substantially covers that of the drain electrode.

[0065] In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that the thin film transistor is entirely formed in the subpixel region. In some embodiments, the array substrate (e.g., the pixel definition layer and the

organic layer) is formed so that a projection of the thin film transistor on the base substrate is substantially non-overlapping with that of any pixel definition layer in the array substrate.

[0066] In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of the organic layer (e.g., the organic light emitting layer) on the base substrate substantially overlaps with that of the thin film transistor. Optionally, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of the organic layer (e.g., the organic light emitting layer) on the base substrate substantially covers that of the thin film transistor. In some embodiments, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of a light emitting region of the organic layer (e.g., a light emitting region of the organic light emitting layer) on the base substrate substantially overlaps with that of the thin film transistor. Optionally, the array substrate (e.g., the pixel definition layer and the organic layer) is formed so that a projection of a light emitting region of the organic layer (e.g., a light emitting region of the organic light emitting layer) on the base substrate substantially covers that of the thin film transistor.

[0067] In some embodiments, the array substrate is formed to include a plurality of subpixel areas each of which is formed to have a shape elongated along a first direction. The plurality of subpixel areas are formed have a pitch p along the first direction. In some embodiments, a width of the subpixel region in each of the plurality of subpixel areas along the first direction is formed to be equal to $(p - q)$; wherein p is the pitch of the plurality of subpixel areas along the first direction, and q is a value equal to or less than $35\ \mu\text{m}$. Optionally, $q = 35\ \mu\text{m}$. Optionally, $q = 30\ \mu\text{m}$. Optionally, $q = 25\ \mu\text{m}$. Optionally, $q = 20\ \mu\text{m}$. Optionally, the width of the subpixel region in each of the plurality of subpixel areas along the first direction is formed to be approximately $(p - 17\ \mu\text{m})$.

[0068] In some embodiments, the array substrate is formed to include a plurality of subpixel areas each of which having a shape elongated along a first direction. Optionally, a width of the pixel definition layer between adjacent two subpixel regions respectively in adjacent two subpixel areas along the first direction is formed to be smaller than q , wherein q is a value equal to or less than $35\ \mu\text{m}$. Optionally, $q = 35\ \mu\text{m}$. Optionally, $q = 30\ \mu\text{m}$. Optionally, $q = 25\ \mu\text{m}$. Optionally, $q = 20\ \mu\text{m}$. In one example, the width of the pixel definition layer between adjacent two subpixel regions respectively in adjacent two subpixel areas along the first direction is formed to be approximately $17\ \mu\text{m}$.

[0069] In some embodiments, the array substrate is formed to include a plurality of subpixel areas each of which having a shape elongated along a first direction. The plurality of subpixel areas have a pitch along the first direction. In some embodiments, a width of the organic layer (e.g., the organic light emitting layer) in each of the plurality of subpixel areas along the first direction is formed to be equal to $(p - q)$; wherein p is the pitch of the plurality of subpixel areas along the first direction, and q is a value equal to or less than $35\ \mu\text{m}$. Optionally, $q = 35\ \mu\text{m}$. Optionally, $q = 30\ \mu\text{m}$. Optionally, $q = 25\ \mu\text{m}$. Optionally, $q = 20\ \mu\text{m}$. Optionally, the width of the organic layer (e.g., the organic light emitting layer) in each of the plurality of subpixel areas along the first direction is formed to be approximately $(p - 17\ \mu\text{m})$.

[0070] In some embodiments, a width of a light emitting region of the organic layer (e.g., the organic light emitting layer) in each of the plurality of subpixel areas along the first direction is formed to be equal to $(p - q)$; wherein p is the pitch of the plurality of subpixel areas along the first direction, and q is a value equal to or less than $35\ \mu\text{m}$. Optionally, $q = 35\ \mu\text{m}$. Optionally, $q = 30\ \mu\text{m}$. Optionally, $q = 25\ \mu\text{m}$. Optionally, $q = 20\ \mu\text{m}$. Optionally, the width of the light emitting region of the organic layer (e.g., the organic light emitting layer) in each of the plurality of subpixel areas along the first direction is formed to be approximately $(p - 17\ \mu\text{m})$.

[0071] In some embodiments, a portion of the pixel electrode layer corresponding to the via has a surface distal to the base substrate; and the surface of the portion corresponding to the via is formed to be substantially level with a surface of other portions of the pixel electrode layer distal to the base substrate. Optionally, the method includes printing (e.g., ink-jet printing) a conductive paste (e.g., a silver paste) in the via. Optionally, the method further includes solidifying the conductive paste. Subsequently, the method further includes forming the pixel electrode layer on the passivation layer with the via pre-filled with the solidified conductive paste.

[0072] In some embodiments, a portion of the pixel electrode layer corresponding to the via has a surface distal to the base substrate; and the surface of the portion corresponding to the via is formed to be concave relative to a surface of other portions of the pixel electrode layer distal to the base substrate.

[0073] In another aspect, the present disclosure provides a display panel having an array substrate described herein or fabricated by a method described herein. The present display

panel has a dramatically increased aperture ratio and an organic light emitting layer of substantially uniform thickness. Optionally, the aperture ratio of the present display panel increases at least by 9% as compared to the conventional array substrate.

[0074] In another aspect, the present disclosure provides a display apparatus having a display panel described herein. Examples of appropriate display apparatuses includes, but are not limited to, an electronic paper, a mobile phone, a tablet computer, a television, a monitor, a notebook computer, a digital album, a GPS, etc.

[0075] The foregoing description of the embodiments of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form or to exemplary embodiments disclosed. Accordingly, the foregoing description should be regarded as illustrative rather than restrictive. Obviously, many modifications and variations will be apparent to practitioners skilled in this art. The embodiments are chosen and described in order to explain the principles of the invention and its best mode practical application, thereby to enable persons skilled in the art to understand the invention for various embodiments and with various modifications as are suited to the particular use or implementation contemplated. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents in which all terms are meant in their broadest reasonable sense unless otherwise indicated. Therefore, the term "the invention", "the present invention" or the like does not necessarily limit the claim scope to a specific embodiment, and the reference to exemplary embodiments of the invention does not imply a limitation on the invention, and no such limitation is to be inferred. The invention is limited only by the spirit and scope of the appended claims. Moreover, these claims may refer to use "first", "second", etc. following with noun or element. Such terms should be understood as a nomenclature and should not be construed as giving the limitation on the number of the elements modified by such nomenclature unless specific number has been given. Any advantages and benefits described may not apply to all embodiments of the invention. It should be appreciated that variations may be made in the embodiments described by persons skilled in the art without departing from the scope of the present invention as defined by the following claims. Moreover, no element and component in the present disclosure is intended to be dedicated to the public regardless of whether the element or component is explicitly recited in the following claims.

WHAT IS CLAIMED IS:

1. An array substrate having a subpixel region and an inter-subpixel region, comprising:
 - a base substrate;
 - a thin film transistor on the base substrate and comprising a drain electrode;
 - a passivation layer on a side of the thin film transistor distal to the base substrate;
 - a pixel electrode layer on a side of the passivation layer distal to the base substrate;
 - a pixel definition layer in the inter-subpixel region on a side of the pixel electrode layer distal to the passivation layer and defining the subpixel region; and
 - an organic light emitting layer in the subpixel region on a side of the pixel electrode layer distal to the passivation layer;wherein the array substrate comprises a via extending through the passivation layer;
 - the pixel electrode layer is electrically connected to the drain electrode of the thin film transistor through the via; and
 - the via is in the subpixel region.
2. The array substrate of claim 1, wherein a projection of the via on the base substrate is substantially non-overlapping with that of any pixel definition layer in the array substrate.
3. The array substrate of claim 1, wherein a projection of the organic light emitting layer on the base substrate substantially covers that of the via.
4. The array substrate of claim 1, wherein a projection of a light emitting region of the organic light emitting layer on the base substrate substantially covers that of the via.
5. The array substrate of claim 1, wherein the drain electrode of the thin film transistor is in the subpixel region.

6. The array substrate of claim 5, wherein a projection of the drain electrode on the base substrate is substantially non-overlapping with that of any pixel definition layer in the array substrate.

7. The array substrate of claim 5, wherein a projection of the organic light emitting layer on the base substrate substantially covers that of the drain electrode.

8. The array substrate of claim 5, wherein a projection of a light emitting region of the organic light emitting layer on the base substrate substantially covers that of the drain electrode.

9. The array substrate of claim 5, wherein a projection of a light emitting region of the organic light emitting layer on the base substrate substantially covers that of the thin film transistor.

10. The array substrate of claim 1, comprising a plurality of subpixel areas each of which having a shape elongated along a first direction;

wherein a width of the subpixel region in each of the plurality of subpixel areas along the first direction is greater than a pitch of the plurality of subpixel areas along the first direction minus $30\ \mu\text{m}$.

11. The array substrate of claim 10, wherein the width of the subpixel region in each of the plurality of subpixel areas along the first direction is approximately the pitch minus $17\ \mu\text{m}$.

12. The array substrate of claim 1, comprising a plurality of subpixel areas each of which having a shape elongated along a first direction;

wherein a width of the pixel definition layer between adjacent two subpixel regions respectively in adjacent two subpixel areas along the first direction is smaller than $30\ \mu\text{m}$.

13. The array substrate of claim 12, wherein the width of the pixel definition layer between adjacent two subpixel regions respectively in adjacent two subpixel areas along the first direction is approximately $17\ \mu\text{m}$.

14. The array substrate of claim 1, comprising a plurality of subpixel areas each of which having a shape elongated along a first direction;

wherein the plurality of subpixel areas have a pitch along the first direction;
and

a width of the organic light emitting layer in each of the plurality of subpixel areas along the first direction is greater than the pitch minus $30\ \mu\text{m}$.

15. The array substrate of claim 14, wherein the width of the organic light emitting layer in each of the plurality of subpixel areas along the first direction is approximately the pitch minus $17\ \mu\text{m}$.

16. The array substrate of claim 1, wherein a first portion of the pixel electrode layer corresponding to the via has a first surface distal to the base substrate; and
the first surface is substantially level with a surface of other portions of the pixel electrode layer distal to the base substrate.

17. The array substrate of claim 16, comprising a solidified silver paste in the via.

18. The array substrate of claim 1, wherein a first portion of the pixel electrode layer corresponding to the via has a first surface distal to the base substrate; and
the first surface is concave relative to a surface of other portions of the pixel electrode layer distal to the base substrate.

19. A display panel, comprising the array substrate of any one of claims 1 to 18.

20. A method of fabricating an array substrate, comprising:
forming a thin film transistor on a base substrate, the thin film transistor being formed to comprises a drain electrode;
forming a passivation layer on a side of the thin film transistor distal to the base substrate;
forming a pixel electrode layer on a side of the passivation layer distal to the base substrate;
forming a pixel definition layer on a side of the pixel electrode layer distal to the passivation layer and defining a subpixel region;
forming an organic light emitting layer on a side of the pixel electrode layer distal to the passivation layer; and

forming a via extending through the passivation layer, the pixel electrode layer being formed to be electrically connected to the drain electrode of the thin film transistor through the via;

wherein the pixel definition layer defines a subpixel region of the array substrate;

the organic light emitting layer is formed in the subpixel region; and
the via is formed in the subpixel region.

FIG. 1

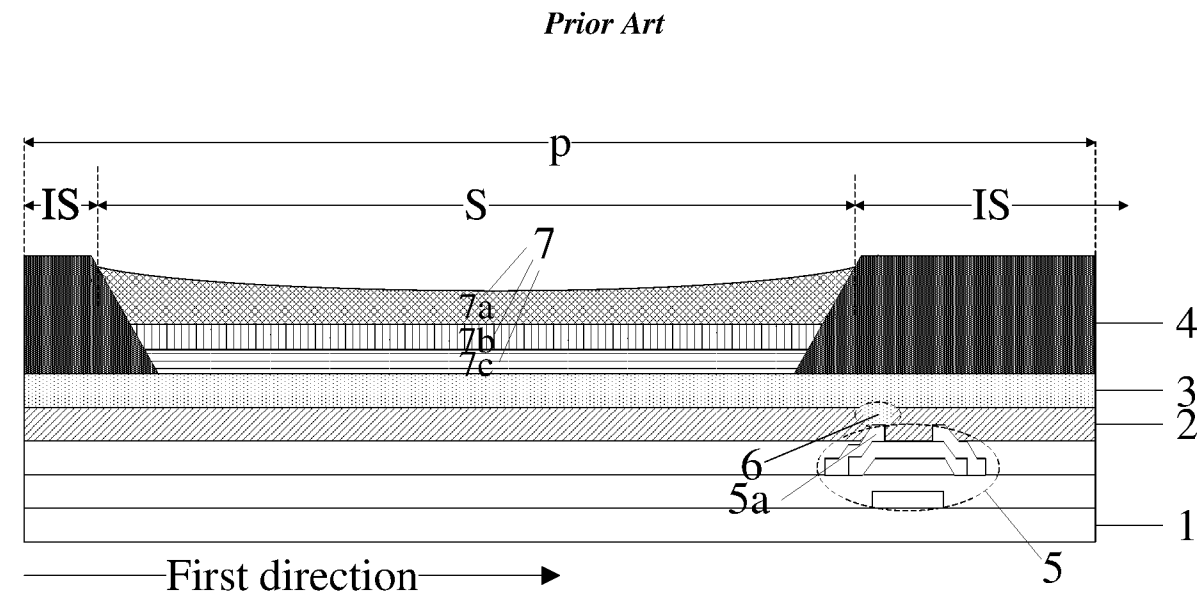


FIG. 2

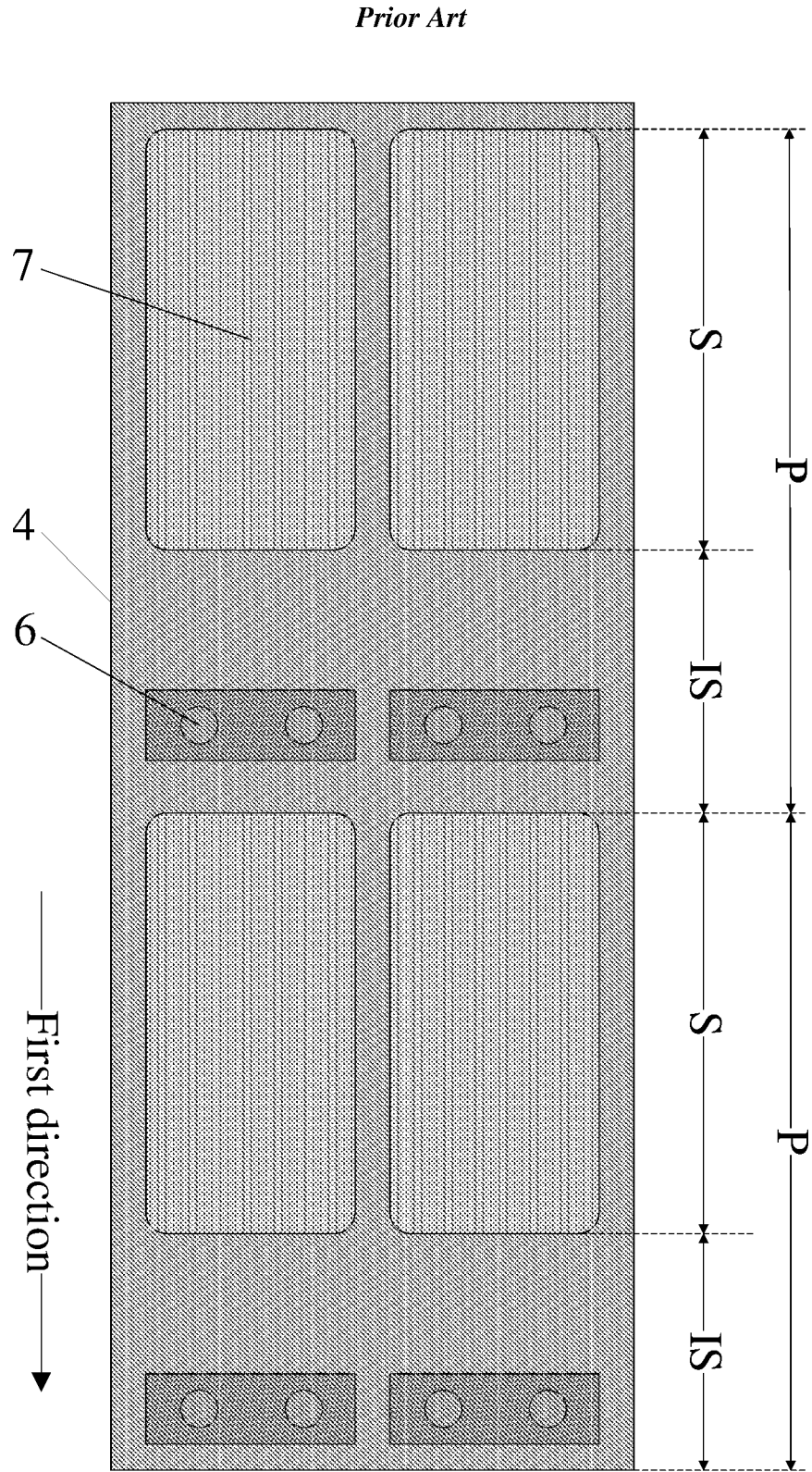


FIG. 3

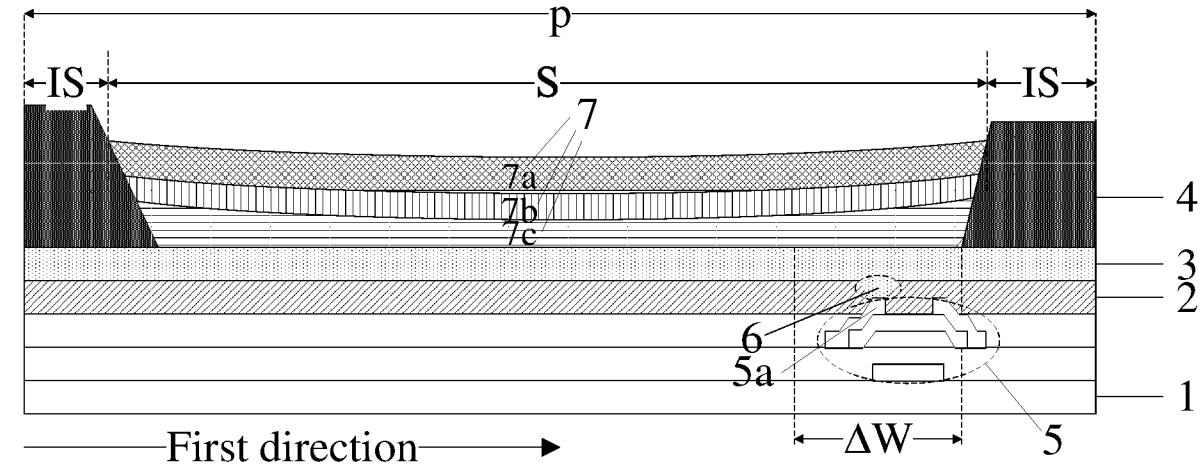


FIG. 4

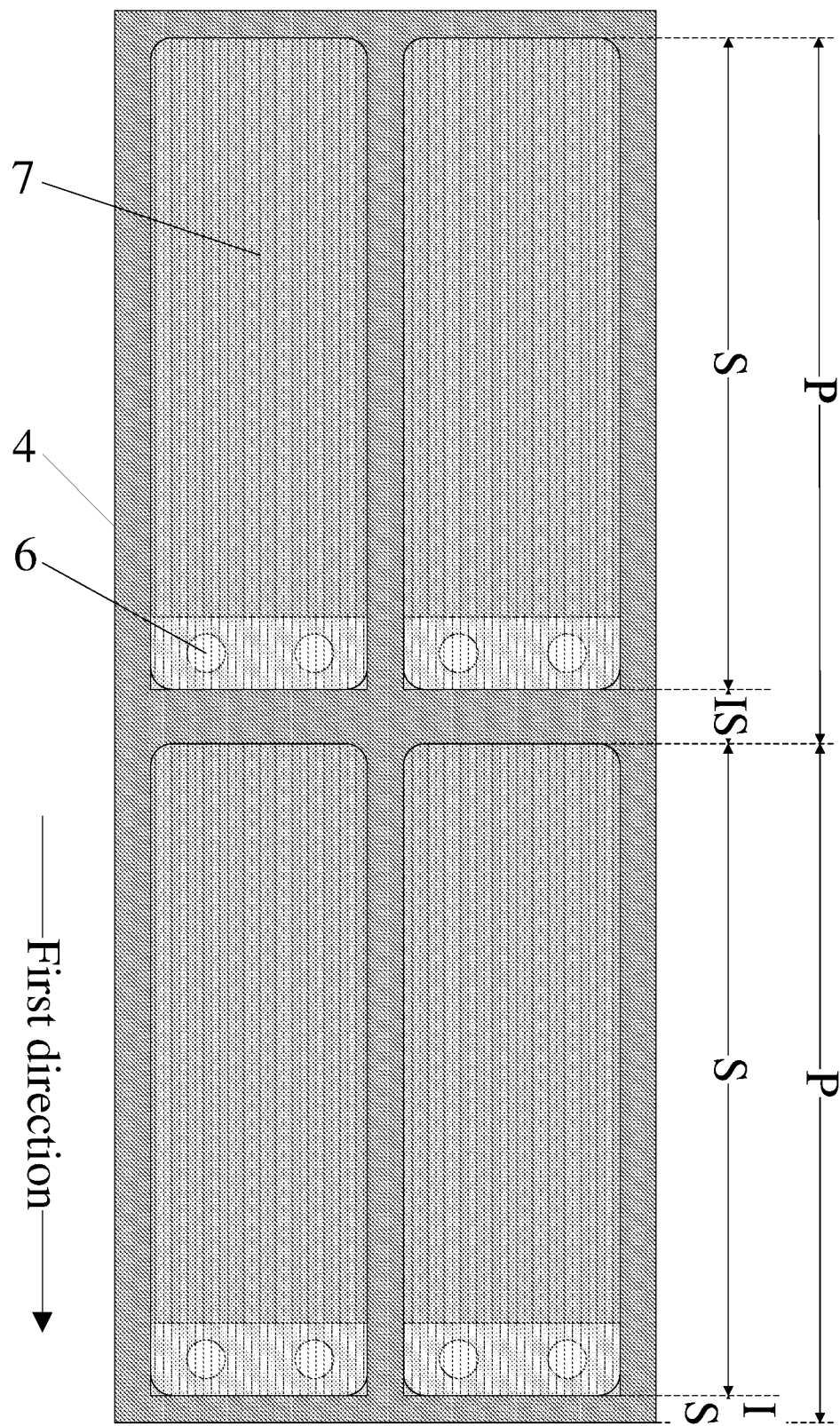
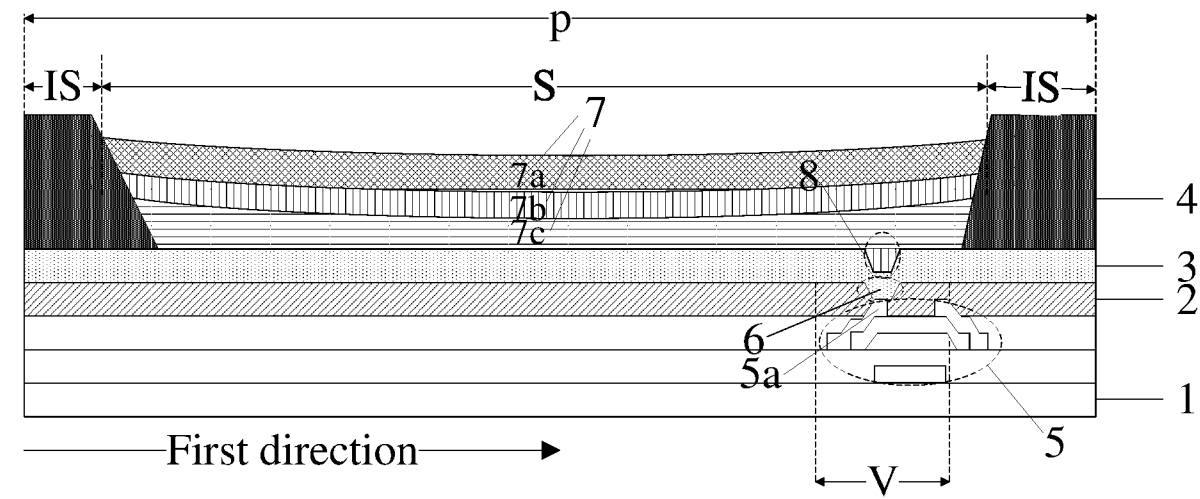


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/086844

A. CLASSIFICATION OF SUBJECT MATTER

H01L 27/32(2006.01)i; H01L 51/52(2006.01)i; H01L 51/56(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI;EPODOC;CNPAT;CNKI: OLED, organic, pixel, subpixel, defin+, region, area, TFT, drain, via, hole

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 101640215 A (SAMSUNG MOBILE DISPLAY CO., LTD.) 03 February 2010 (2010-02-03) description page 5, paragraph 2 to page 7, paragraph 4 and figures 1-2	1-20
X	CN 101656265 A (SAMSUNG MOBILE DISPLAY CO., LTD.) 24 February 2010 (2010-02-24) description page 5, paragraph 3 to page 7, paragraph 3 and figure 2	1-20
X	CN 101645455 A (SAMSUNG MOBILE DISPLAY CO., LTD.) 10 February 2010 (2010-02-10) description page 6, paragraph 6 to page 8, paragraph 9 and figures 1-6	1-20
X	US 2017018602 A1 (SAMSUNG DISPLAY CO., LTD.) 19 January 2017 (2017-01-19) description paragraphs [0035]-[0099], figures 1-9D	1-20
X	CN 101330004 A (SAMSUNG SDI CO., LTD.) 24 December 2008 (2008-12-24) description page 8, paragraph 2 to page 10, paragraph 6, figures 3A-5	1-8, 10-20
X	US 2009315034 A1 (LEE, JAE-SEOB ET AL.) 24 December 2009 (2009-12-24) description paragraphs [0025]-[0044], figures 1A-3	1-8, 10-20
X	US 2007035239 A1 (SAMSUNG SDI CO., LTD.) 15 February 2007 (2007-02-15) description paragraphs [0036]-[0070], figures 1-9E	1-8, 10-20

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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“A” document defining the general state of the art which is not considered to be of particular relevance

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“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

01 February 2018

Date of mailing of the international search report

24 February 2018

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/086844**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013330868 A1 (SAMSUNG DISPLAY CO., LTD.) 12 December 2013 (2013-12-12) description paragraphs [0018]-[0040], figures 1A-1E	1-8, 10-20

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2017/086844

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				US	7825476	B2	02 November 2010
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				EP	1753030	A2	14 February 2007
				US	7495716	B2	24 February 2009
				KR	100709255	B1	19 April 2007
US	2013330868	A1	12 December 2013	KR	100971751	B1	21 July 2010
				US	9437843	B2	06 September 2016
				KR	20100045305	A	03 May 2010
				US	2010102715	A1	29 April 2010