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(54) **PIXEL ARRAY SUBSTRATE**

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(71) Applicant: **HannStar Display Corporation**, Taipei City (TW)

(72) Inventors: **Yu-Chi Chiao**, Taipei City (TW);
I-Tung Chen, Taipei City (TW);
Chiung-Chang Wu, Taipei City (TW);
Chun Chieh Wang, Taipei City (TW);
Ming Han Tsai, Taipei City (TW)

(73) Assignee: **HannStar Display Corporation**, Taipei City (TW)

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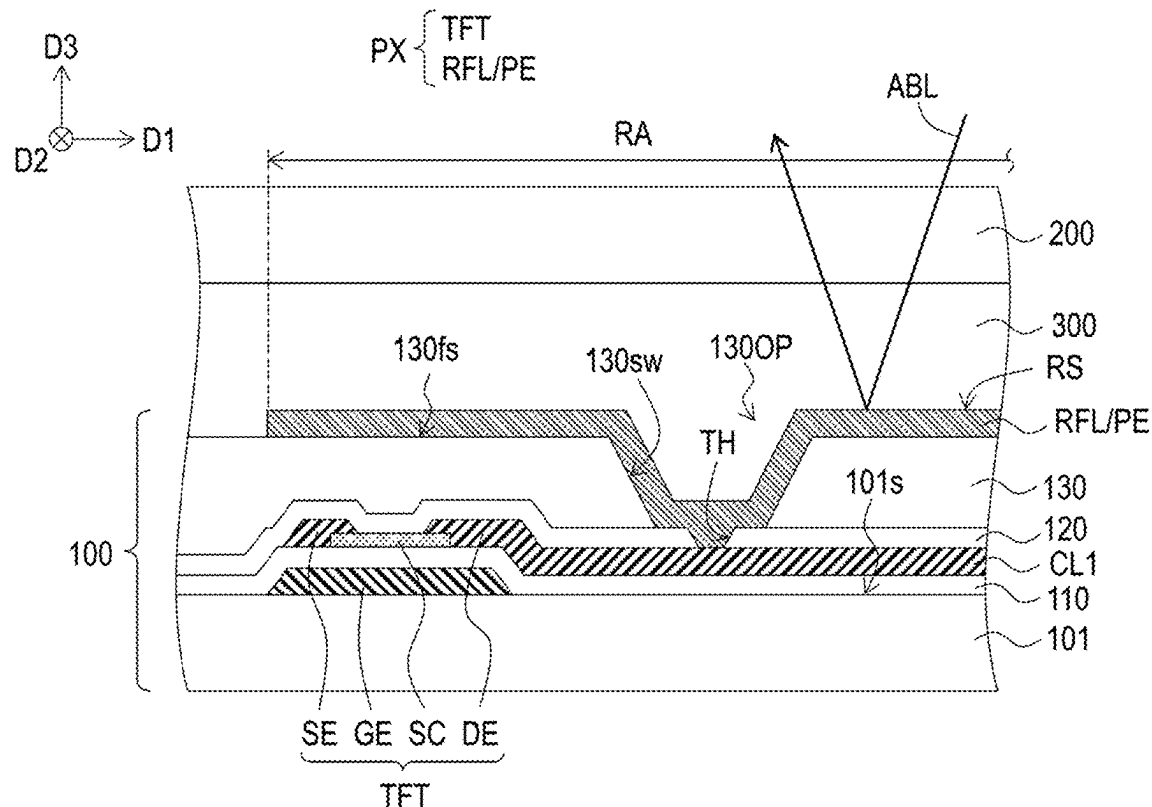
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(57)

ABSTRACT

A pixel array substrate including a substrate, an insulation layer, and multiple pixel structures is provided. The insulation layer is disposed on the substrate. The pixel structures are disposed on the substrate, and each includes an active device and a reflective layer. The active device is disposed between the substrate and the insulation layer. The reflective layer is disposed on the insulation layer, and includes a silver-based reflective layer and a protective layer. The silver-based reflective layer has a reflective surface. The protective layer covers the silver-based reflective layer. A thickness of the protective layer along a normal direction of the reflective surface is greater than or equal to 30 angstroms and less than or equal to 80 angstroms. Another pixel array substrate having a buffer layer is also provided.



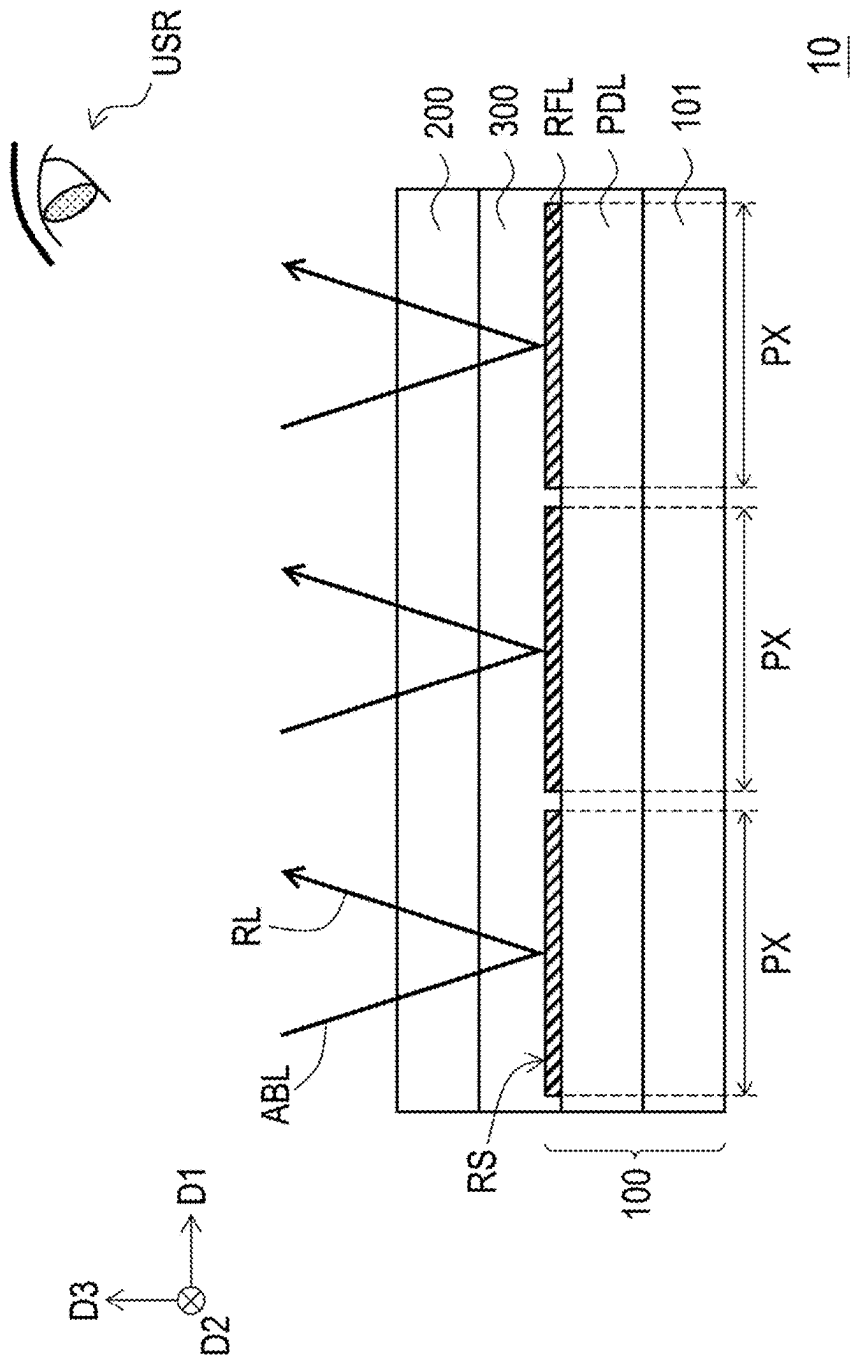


FIG.1

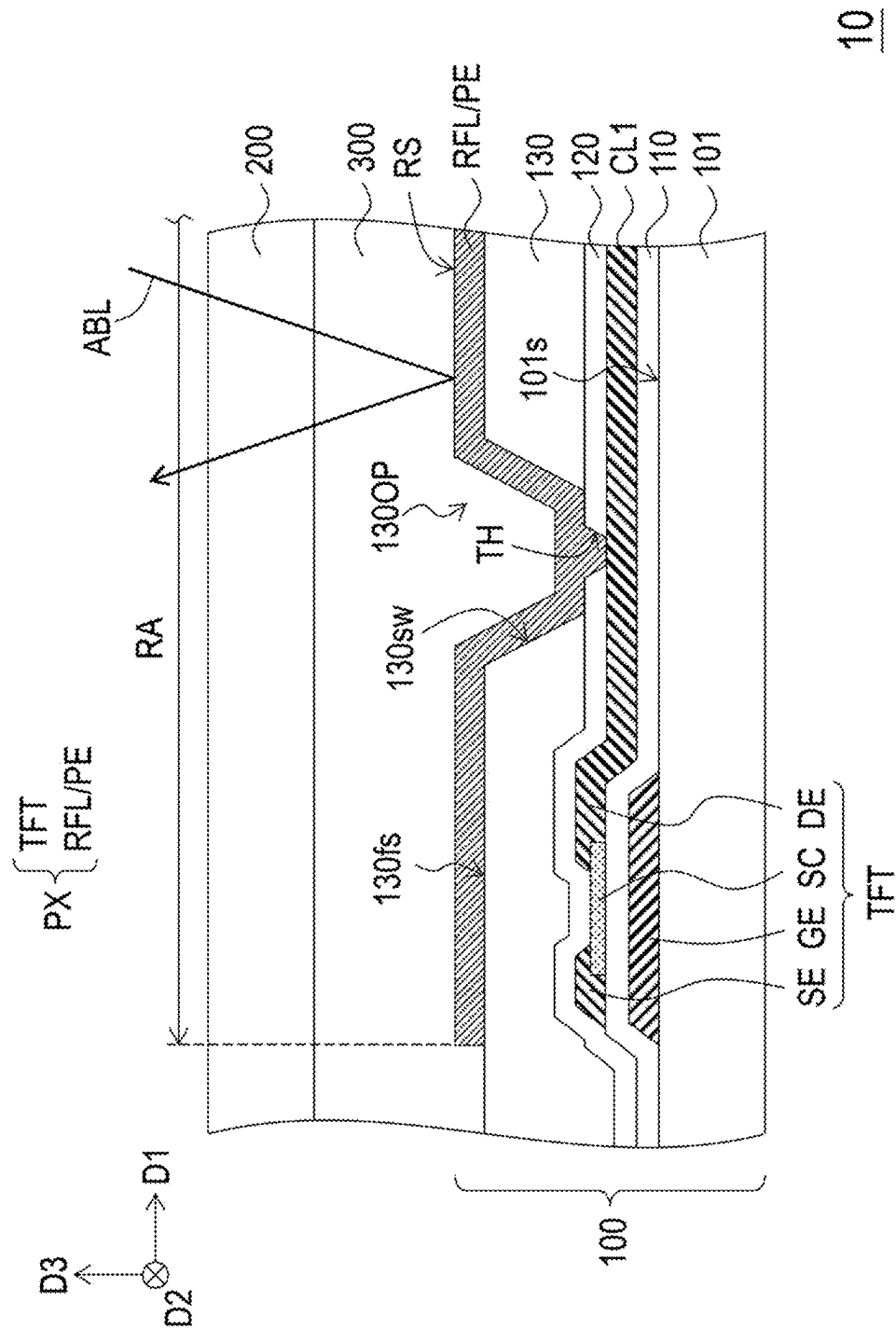
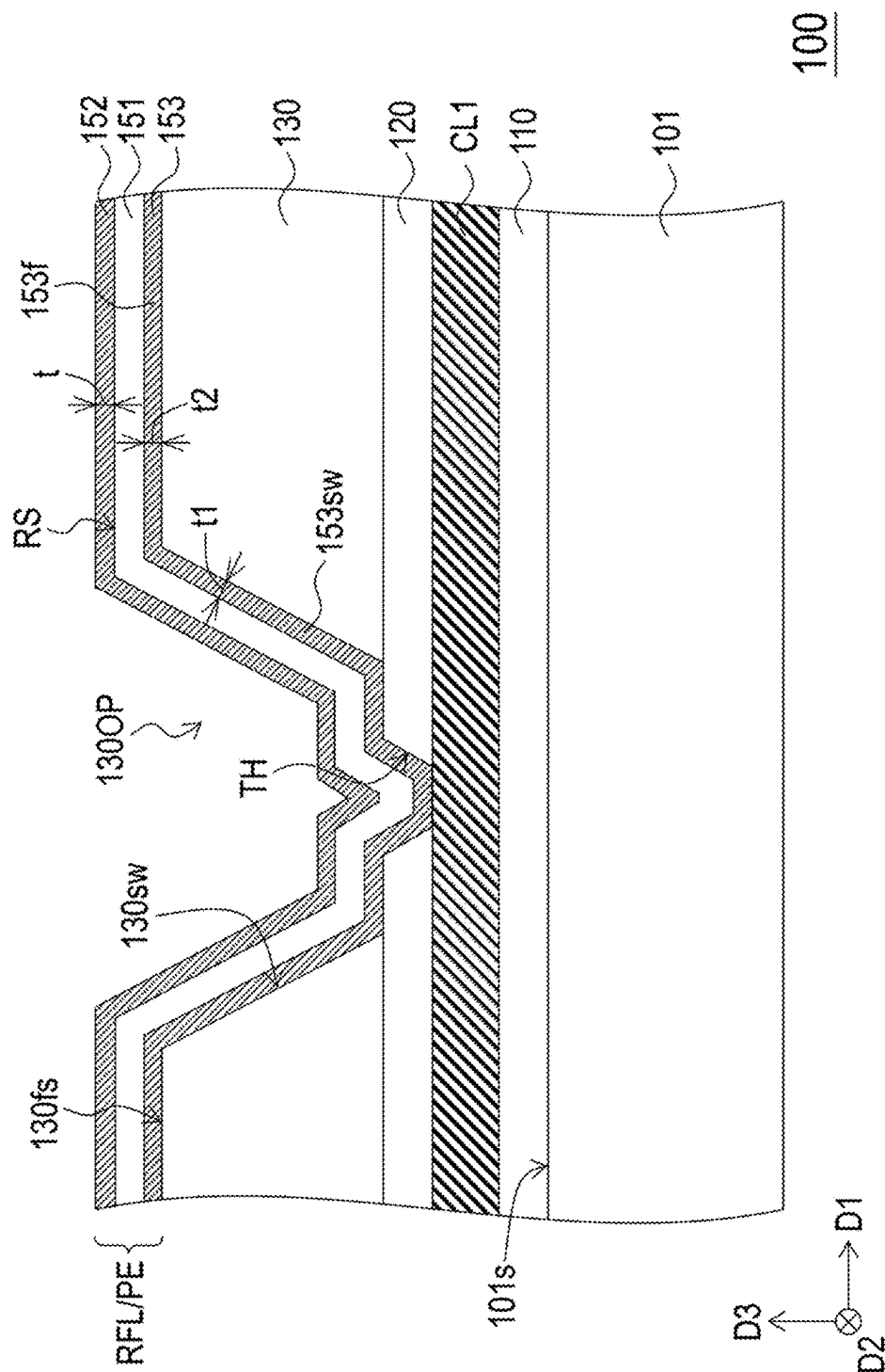
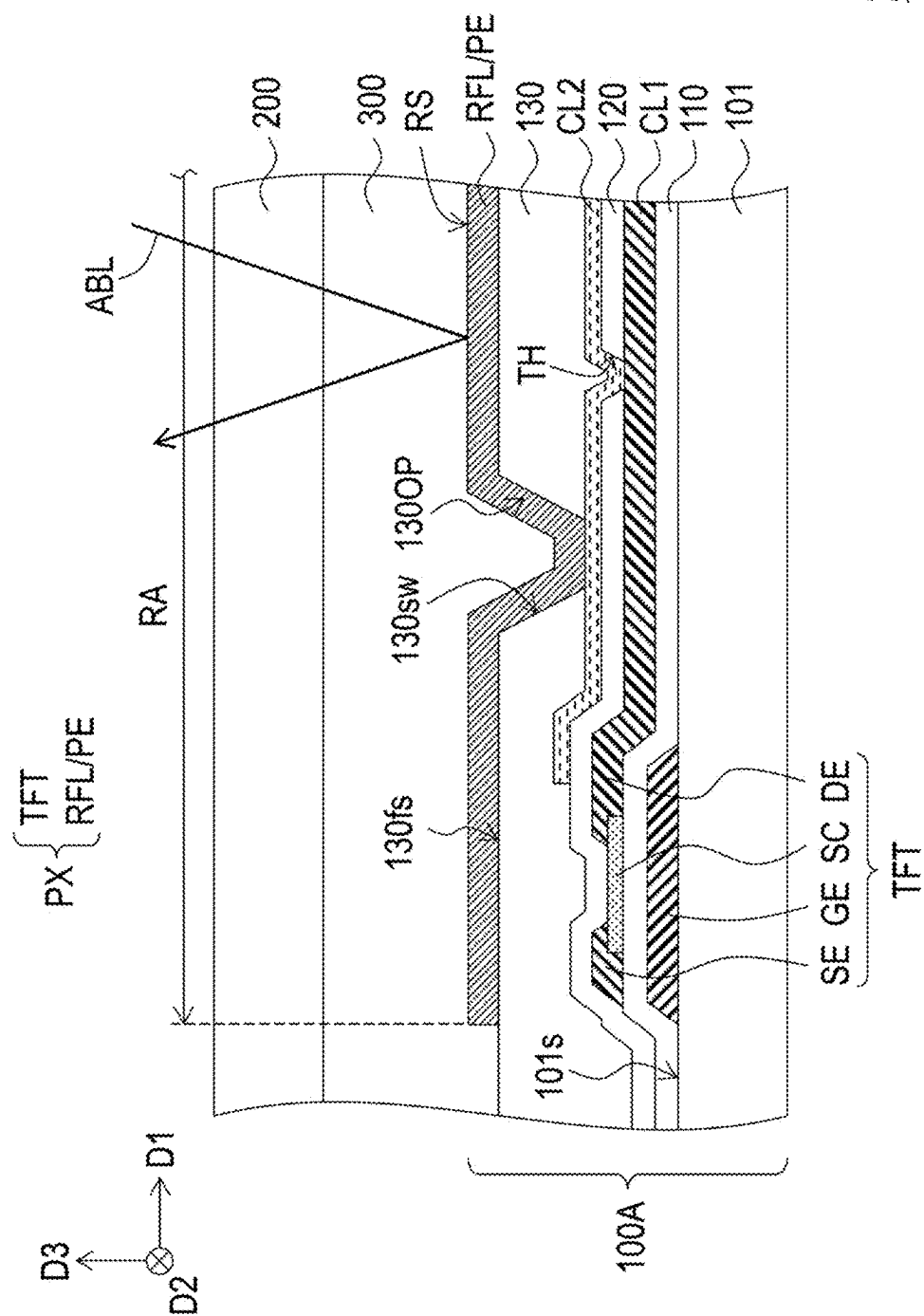
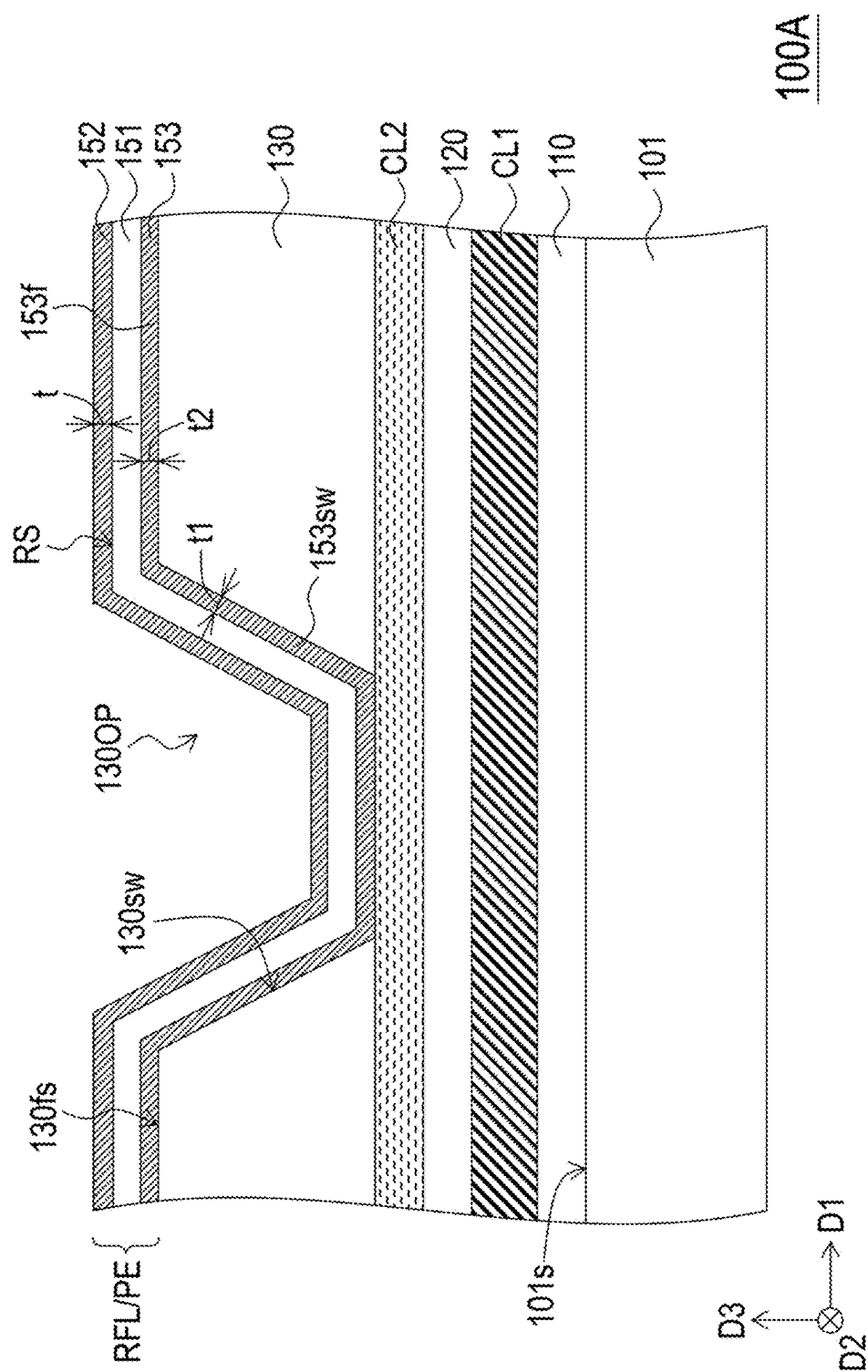


FIG. 2







PIXEL ARRAY SUBSTRATE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of U.S. provisional application Ser. No. 63/555,105, filed on Feb. 19, 2024 and Taiwan application serial no. 113113609, filed on Apr. 11, 2024. The entirety of each of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND

Technical Field

[0002] The disclosure relates to a pixel array substrate, and more particularly, to a pixel array substrate provided with a reflective layer.

Description of Related Art

[0003] Natural light or ambient light are mainly used for a reflective display panel as a light source for display, making the reflective display panel have good energy-saving characteristics. Therefore, it is often used outdoors or in areas with sufficient light, such as outdoor billboards, electronic tags, sports watches, etc. Considering high reflectivity and low resistivity, silver is the first choice among all metallic elements as a reflective layer.

[0004] Since silver has poor chemical resistance, heat resistance, and weather resistance, and has high electrochemical mobility, silver has many problems and limitations in manufacturing a reflective electrode of a reflective or transreflective display panel. For example, etching and heating steps are often involved in other processes after a silver process, resulting in changes in optical properties of a silver reflective layer (such as a decrease in reflectivity or color shift of the reflective light) and deterioration in reliability (such as a phenomenon of the silver reflective layer being peeled off from an underlying film layer).

SUMMARY

[0005] The disclosure provides a pixel array substrate, which has a higher process yield and better optical performance.

[0006] A pixel array substrate in the disclosure includes a substrate, an insulation layer, and multiple pixel structures. The insulation layer is disposed on the substrate. The pixel structures are disposed on the substrate, and each includes an active device and a reflective layer. The active device is disposed between the substrate and the insulation layer. The reflective layer is disposed on the insulation layer, and includes a silver-based reflective layer and a protective layer. The silver-based reflective layer has a reflective surface. The protective layer covers the silver-based reflective layer. A thickness of the protective layer along a normal direction of the reflective surface is greater than or equal to 30 angstroms and less than or equal to 80 angstroms.

[0007] A pixel array substrate in the disclosure includes a substrate, an insulation layer, and multiple pixel structures. The insulation layer is disposed on the substrate. The pixel structures are disposed on the substrate, and each includes an active device and a reflective layer. The active device is disposed between the substrate and the insulation layer. The

reflective layer is disposed on the insulation layer, and includes a silver-based reflective layer and a buffer layer. The silver-based reflective layer has a reflective surface. The buffer layer is disposed between the insulation layer and the silver-based reflective layer. A material of the buffer layer includes a conductive material. The insulation layer has an opening and a side wall surface defining the opening. The silver-based reflective layer and the buffer layer extend to cover the side wall surface of the insulation layer. A first thickness of a side wall portion of the buffer layer covering the side wall surface along a normal direction of the side wall surface is greater than or equal to 30 angstroms and less than or equal to 80 angstroms.

[0008] Based on the above, in the pixel array substrate according to an embodiment of the disclosure, in order to increase the chemical resistance and the weather resistance of the silver-based reflective layer during the manufacturing process, it is covered with the protective layer, and the thickness of the protective layer ranges from 30 angstroms to 80 angstroms. In addition to better uniformity of the film thickness, the protective layer may also prevent the reflectivity of the reflective layer from decreasing or causing color shift due to the configuration of the protective layer. In the pixel array substrate according to another embodiment of the disclosure, the buffer layer is provided between the silver-based reflective layer and the insulation layer, and the thickness of the side wall portion of the buffer layer in the opening of the insulation layer ranges from 30 angstroms to 80 angstroms. In addition to increasing the adhesion between the silver-based reflective layer and the insulation layer, it may also prevent the issue of unclear etching of the reflective layer during the patterning process since the buffer layer is too thick.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic cross-sectional view of a display panel according to an embodiment of the disclosure.

[0010] FIG. 2 is a schematic enlarged view of a partial area of the display panel in FIG. 1.

[0011] FIG. 3 is a schematic enlarged view of a pixel array substrate in FIG. 2.

[0012] FIG. 4 is a schematic cross-sectional view of a display panel according to another embodiment of the disclosure.

[0013] FIG. 5 is a schematic enlarged view of a pixel array substrate in FIG. 4.

DETAILED DESCRIPTION OF DISCLOSED EMBODIMENTS

[0014] Reference will now be made in detail to the exemplary embodiments of the disclosure, and examples of the exemplary embodiments are illustrated in the accompanying drawings. Whenever possible, the same reference numerals are used in the drawings and descriptions to indicate the same or similar parts.

[0015] FIG. 1 is a schematic cross-sectional view of a display panel according to an embodiment of the disclosure. FIG. 2 is a schematic enlarged view of a partial area of the display panel in FIG. 1. FIG. 3 is a schematic enlarged view of a pixel array substrate in FIG. 2.

[0016] Referring to FIGS. 1 and 2, a display panel 10 may include a pixel array substrate 100, a color filter substrate 200, and a liquid crystal layer 300. The pixel array substrate

100 and the color filter substrate **200** are disposed to overlap each other, and the liquid crystal layer **300** is disposed between the pixel array substrate **100** and the color filter substrate **200**. That is, the display panel **10** is, for example, a liquid crystal display panel, but the disclosure is not limited thereto. In other embodiments, the liquid crystal layer **300** may be replaced with other types of display medium layers.

[0017] It should be noted first that an overlapping relationship between the pixel array substrate **100** and the color filter substrate **200** means, for example, that the two overlap each other along a direction **D3**. Unless otherwise mentioned below, the overlapping relationship between the two components is defined in the same way, and an overlapping direction thereof will not be repeated again.

[0018] The pixel array substrate **100** includes a substrate **101** and multiple pixel structures **PX** disposed on the substrate **101**. A material of the substrate **101** may include glass, quartz, high molecular polymers (e.g., polyimide, polycarbonate, polymethyl methacrylate, or other suitable flexible plate materials), or other suitable plate materials.

[0019] In this embodiment, the pixel structures **PX** are arranged in an array on the substrate **101**. For example, the pixel structures **PX** may be arranged into multiple pixel columns and multiple pixel rows along a direction **D1** and a direction **D2** perpendicular to each other. The pixel array substrate **100** may be provided with a pixel driving layer **PDL**. Each of the pixel structures **PX** may include an active device **TFT** disposed in the pixel driving layer **PDL** and a reflective layer **RFL** disposed on the pixel driving layer **PDL**. For example, the pixel driving layer **PDL** may further be provided with multiple scan lines (not shown) and multiple data lines (not shown). The active device **TFT** may be electrically connected to a scan line and a data line, but the disclosure is not limited thereto. In particular, the reflective layer **RFL** in this embodiment may be conductive and serve as a pixel electrode **PE** of the pixel structure **PX** at the same time, but the disclosure is not limited thereto. An area of the reflective layer **RFL** may be defined as a reflective area **RA** of the display panel **10**. In this embodiment, the display panel **10** may be a reflective display panel, but the disclosure is not limited thereto. In other embodiments, the display panel **10** may further be a transmissive display panel. For example, each of the pixel structures **PX** of the display panel **10** may further include a transmission area (not shown), the reflective layer **RFL** is disposed in the reflective area **RA** but not in the transmission area, and light from a backlight module (not shown) may pass through the transmission area.

[0020] On the other hand, the color filter substrate **200** may be provided with a color filter layer (not shown) and a common electrode layer (not shown), but the disclosure is not limited thereto. An electric field generated between the common electrode layer and the reflective layer **RFL** (i.e., the pixel electrode **PE**) is adapted to drive multiple liquid crystal molecules (not shown) of the liquid crystal layer **300** to rotate to form an arrangement state corresponding to a direction and intensity of the electric field. It is noted that ambient light or light of a front light module in each of FIGS. 1 and 2 is labelled as “**ABL**”. By changing the arrangement state of the liquid crystal molecules, a polarization state of the ambient light **ABL** or the light **ABL** of the

front light module passing through the liquid crystal layer **300** is changed to form a light intensity corresponding to the arrangement state.

[0021] In this embodiment, the ambient light **ABL** or the light **ABL** of the front light module is used as an illumination source for the display panel **10** during display, and the ambient light **ABL** or the light **ABL** of the front light module passing through the liquid crystal layer **300** is reflected by the reflective layer **RFL** to pass through the liquid crystal layer **300** again to form reflective light **RL** with a specific light intensity. By controlling the intensity of the electric field between each of the pixel electrodes **PE** of the pixel structures **PX** and the common electrode layer, the multiple reflective light **RL** reflected by the reflective layers **RFL** of the pixel structures **PX** to be transmitted to a user **USR** may have different light intensities to achieve an effect of displaying images.

[0022] Furthermore, a step of forming the active device **TFT** includes, for example, sequentially forming a gate **GE**, a gate insulation layer **110**, a semiconductor pattern **SC**, a source **SE**, and a drain **DE** on the substrate **101**. The semiconductor pattern **SC** is disposed to overlap the gate **GE**. The source **SE** and the drain **DE** overlap the semiconductor pattern **SC**, and are in electrical contact with two different areas of the semiconductor pattern **SC**. In this embodiment, the gate **GE** of the active device **TFT** may be selectively disposed below the semiconductor pattern **SC** to form a bottom-gate thin film transistor (bottom-gate **TFT**), but the disclosure is not limited thereto. In other embodiments, the gate of the active device may be selectively disposed above the semiconductor pattern to form a top-gate thin film transistor (top-gate **TFT**).

[0023] Furthermore, the active device **TFT** may be covered with an insulation layer **120** and an insulation layer **130** sequentially. In this embodiment, the insulation layer **120** is, for example, a passivation layer, and the insulation layer **130** is, for example, a planarization layer. In some embodiments, the pixel array substrate **100** may not include the insulation layer **120**. In this embodiment, the insulation layer **120** has a contact hole **TH**, and the contact hole **TH** passes through the insulation layer **120**. The insulation layer **130** has an opening **130OP** overlapping the contact hole **TH**, a side wall surface **130_{sw}** defining the opening **130OP**, and a surface **130_s** connected to the side wall surface **130_{sw}**, and the opening **130OP** passes through the insulation layer **130**. The surface **130_s** is a surface of the insulation layer **130** facing away from the substrate **101**, and an extension direction of the side wall surface **130_{sw}** intersects with a substrate surface **101_s**.

[0024] The reflective layer **RFL** of the pixel structure **PX** is disposed on the surface **130_s** of the insulation layer **130**, and is electrically connected to the drain **DE** of the active device **TFT** through the opening **130OP** of the insulation layer **130** and the contact hole **TH** of the insulation layer **120**. For example, in this embodiment, the pixel driving layer **PDL** may further be provided with a conductive layer **CL1** extending from the drain **DE** of the active device **TFT**, and the opening **130OP** and the contact hole **TH** expose a portion of a surface of the conductive layer **CL1**. The reflective layer **RFL** disposed on the surface **130_s** further extends to cover the side wall surface **130_{sw}** of the insulation layer **130** and the contact hole **TH** of the insulation layer **120** to be electrically connected to the conductive layer **CL1**.

[0025] It should be noted that the gate GE, the source SE, the drain DE, the semiconductor pattern SC, the gate insulation layer 110, the passivation layer (i.e. the insulation layer 120), and the planarization layer (i.e. the insulation layer 130) may be respectively implemented by any gate, any source, any drain, any semiconductor pattern, any gate insulation layer, any passivation layer, and any planarization layer for the reflective display panel that are well known to those skilled in the art, and the gate GE, the source SE, the drain DE, the semiconductor pattern SC, the gate insulation layer 110, the passivation layer, and the planarization layer may be respectively formed by any method well known to those skilled in the art. Therefore, the same details will not be repeated in the following.

[0026] Referring to FIGS. 2 and 3, the reflective layer RFL is a stacked structure of multiple film layers. In this embodiment, the reflective layer RFL includes, for example, a silver-based reflective layer 151, a protective layer 152, and a buffer layer 153. However, the disclosure is not limited thereto. In other embodiments, in addition to the silver-based reflective layer 151, the reflective layer may also be provided with only one of the protective layer 152 and the buffer layer 153. In this embodiment, a material of the silver-based reflective layer 151 is, for example, a silver element or a metal alloy material containing the silver element.

[0027] The silver-based reflective layer 151 has a reflective surface RS, and the protective layer 152 covers the reflective surface RS of the silver-based reflective layer 151. A material of the protective layer 152 includes a light-transmitting conductive material. In this embodiment, the protective layer 152 may include indium-containing oxide, such as indium tin oxide (ITO) or indium zinc oxide (IZO).

[0028] In particular, the configuration of the protective layer 152 may prevent the silver-based reflective layer 151 from being exposed to the air for a long time during a manufacturing process, causing material deterioration and affecting optical properties (such as color change and/or a decrease in reflectivity of the reflective layer RFL). When a thickness of the protective layer 152 is too thick, the reflectivity of the reflective layer RFL decreases, and the image becomes yellowish. When the thickness of the protective layer 152 is too thin, the protective layer 152 is easily broken. Therefore, in this embodiment, a thickness t of the protective layer 152 along a normal direction of the reflective surface RS is greater than or equal to 30 angstroms and less than or equal to 80 angstroms. Preferably, the thickness t may be greater than or equal to 50 angstroms and less than or equal to 60 angstroms. Considering uniformity of a film thickness of the protective layer 152 during fabrication, when the thickness t of the protective layer 152 is 30 angstroms, the film thickness thereof may still be uniform to prevent the protective layer 152 from being broken, thereby ensuring chemical resistance and weather resistance of the reflective layer RFL during the manufacturing process. In addition, it may also reduce an impact of the protective layer 152 on the optical properties of the silver-based reflective layer 151 (that is, reducing the decrease in the reflectivity of the reflective layer RFL). On the other hand, even if the thickness t of the protective layer 152 is 80 angstroms, it will also not cause an issue of underetching of the reflective layer RFL during a patterning process.

[0029] In this embodiment, the buffer layer 153 is disposed between the insulation layer 130 and the silver-based

reflective layer 151. A material of the buffer layer 153 may be similar to the material of the protective layer 152, and may include, for example, indium-containing oxide. However, the disclosure is not limited thereto. In this embodiment, the material of the buffer layer 153 may include a light-transmitting or opaque conductive material. For example, the material of the buffer layer 153 includes metal oxide (such as ITO, IZO, MoTaO_x or MoO_x), Mo, MoTa, AlNd, Ti, or Cr. It is particularly noted that the buffer layer 153 covers the surface 130_f of the insulation layer 130 and further extends to cover the side wall surface 130_{sw} of the insulation layer 130 and is electrically connected to the conductive layer CL1. More specifically, the silver-based reflective layer 151 is connected to the insulation layer 130 through the buffer layer 153.

[0030] The configuration of the buffer layer 153 may increase adhesion between the silver-based reflective layer 151 and the insulation layer 130 to prevent the silver-based reflective layer 151 from being peeled off from the insulation layer 130. In this embodiment, the buffer layer 153 has a side wall portion 153_{sw} covering the side wall surface 130_{sw} and a horizontal portion 153_f covering the surface 130_f. The side wall portion 153_{sw} of the buffer layer 153 extends along the side wall surface 130_{sw} of the insulation layer 130, and the horizontal portion 153_f of the buffer layer 153 extends along the surface 130_f of the insulation layer 130. Due to a shadow effect, a film thickness of the side wall portion 153_{sw} will be thinner than a film thickness of the horizontal portion 153_f.

[0031] When a thickness of the buffer layer 153 is too thick, the reflective layer RFL is not etched cleanly during the patterning process. When the thickness of the buffer layer 153 is too thin, the side wall portion 153_{sw} of the buffer layer 153 is prone to be too thin, resulting in discontinuity in film deposition, causing the silver-based reflective layer 151 to be peeled off.

[0032] Therefore, in this embodiment, a first thickness t_1 of the side wall portion 153_{sw} of the buffer layer 153 along a normal direction of the side wall surface 130_{sw} is greater than or equal to 30 angstroms and less than or equal to 80 angstroms. A second thickness t_2 of the horizontal portion 153_f of the buffer layer 153 along a normal direction of the surface 130_f is greater than or equal to 40 angstroms and less than or equal to 100 angstroms. Preferably, the first thickness t_1 may be greater than or equal to 50 angstroms and less than or equal to 60 angstroms, and the second thickness t_2 may be greater than or equal to 70 angstroms and less than or equal to 80 angstroms.

[0033] In particular, when the first thickness t_1 of the side wall portion 153_{sw} of the buffer layer 153 is 30 angstroms, the film thickness thereof is uniform to prevent the side wall portion 153_{sw} of the buffer layer 153 from being broken, thereby ensuring an adhesion relationship between the silver-based reflective layer 151 and the insulation layer 130. On the other hand, even if the first thickness t_1 of the side wall portion 153_{sw} of the buffer layer 153 is 80 angstroms, or the second thickness t_2 of the horizontal portion 153_f of the buffer layer 153 is 100 angstroms, it will also not cause the issue of underetching of the reflective layer RFL during the patterning process.

[0034] Some other embodiments are provided below to describe the invention in detail, where the same reference numerals denote the same or like components, and descriptions of the same technical contents are omitted. The afore-

mentioned embodiment may be referred for descriptions of the omitted parts, and detailed descriptions thereof are not repeated in the following embodiment.

[0035] FIG. 4 is a schematic cross-sectional view of a display panel according to another embodiment of the disclosure. FIG. 5 is a schematic enlarged view of a pixel array substrate in FIG. 4. Referring to FIGS. 4 and 5, a difference between a display panel 20 in this embodiment and the display panel 10 in FIG. 2 is that an electrical connection method between the reflective layer and the drain of the active device is different.

[0036] For example, in this embodiment, a pixel array substrate 100A may further selectively include another conductive layer CL2. The conductive layer CL2 is disposed between the insulation layer 120 and the insulation layer 130, and is electrically connected to the conductive layer CL1 extending from the drain DE of the active device TFT through the contact hole TH of the insulation layer 120. The opening 130OP of the insulation layer 130 exposes a portion of a surface of the conductive layer CL2, and the reflective layer RFL extends to cover the portion of the surface of the conductive layer CL2 to be electrically connected to the conductive layer CL2.

[0037] More specifically, in this embodiment, the reflective layer RFL (i.e., the pixel electrode PE) is electrically connected to the drain DE of the active device TFT through a bridge structure formed by the conductive layer CL2 and the conductive layer CL1. A material of the conductive layer CL2 includes, for example, light-transmitting conductive materials, such as indium tin oxide (ITO) or indium zinc oxide (IZO), but the disclosure is not limited thereto. In other embodiments, the material of the conductive layer CL2 may include metal or alloy.

[0038] Since the components not mentioned in this embodiment are similar to those of the display panel 10 in FIG. 2, and ranges of the thickness t of the protective layer 152 and the first thickness t_1 and the second thickness t_2 of the buffer layer 153 are the same as those in the previous embodiment, relevant paragraphs of the foregoing embodiments may be referred for detailed description. Therefore, the same details will not be repeated in the following.

[0039] Based on the above, in the pixel array substrate according to an embodiment of the disclosure, in order to increase the chemical resistance and the weather resistance of the silver-based reflective layer during the manufacturing process, it is covered with the protective layer, and the thickness of the protective layer ranges from 30 angstroms to 80 angstroms. In addition to better uniformity of the film thickness, the thickness range of the protective layer may also prevent the reflectivity of the reflective layer from decreasing or causing color shift due to the configuration of the protective layer. In the pixel array substrate according to another embodiment of the disclosure, the buffer layer is provided between the silver-based reflective layer and the insulation layer. The thickness of the horizontal portion of the buffer layer ranges from 40 angstroms to 100 angstroms, and the thickness of the side wall portion of the buffer layer in the opening of the insulation layer ranges from 30 angstroms to 80 angstroms. In addition to increasing the adhesion between the silver-based reflective layer and the insulation layer, it may also prevent the issue of underetching of the reflective layer during the patterning process.

What is claimed is:

1. A pixel array substrate, comprising:

- a substrate;
- an insulation layer disposed on the substrate; and
- a plurality of pixel structures disposed on the substrate, and each comprising:
 - an active device disposed between the substrate and the insulation layer; and
 - a reflective layer disposed on the insulation layer, and comprising:
 - a silver-based reflective layer having a reflective surface; and
 - a protective layer covering the silver-based reflective layer,

wherein a thickness of the protective layer along a normal direction of the reflective surface is greater than or equal to 30 angstroms and less than or equal to 80 angstroms.

2. The pixel array substrate according to claim 1, wherein a material of the protective layer comprises a light-transmitting conductive material.

3. The pixel array substrate according to claim 1, wherein the thickness of the protective layer is greater than or equal to 50 angstroms and less than or equal to 60 angstroms.

4. The pixel array substrate according to claim 1, wherein the reflective layer further comprises a buffer layer disposed between the insulation layer and the silver-based reflective layer, and a material of the buffer layer comprises a conductive material.

5. The pixel array substrate according to claim 4, wherein the insulation layer has an opening and a side wall surface defining the opening, the silver-based reflective layer and the buffer layer extend to cover the side wall surface of the insulation layer, and a first thickness of a side wall portion of the buffer layer covering the side wall surface along a normal direction of the side wall surface is greater than or equal to 30 angstroms and less than or equal to 80 angstroms.

6. The pixel array substrate according to claim 5, wherein the insulation layer further has a surface connected to the side wall surface, the surface faces away from the substrate, and a second thickness of a horizontal portion of the buffer layer covering the surface of the insulation layer along a normal direction of the surface is greater than or equal to 40 angstroms and less than or equal to 100 angstroms.

7. The pixel array substrate according to claim 6, wherein the first thickness is greater than or equal to 50 angstroms and less than or equal to 60 angstroms, and the second thickness is greater than or equal to 70 angstroms and less than or equal to 80 angstroms.

8. A pixel array substrate, comprising:

- a substrate;
- an insulation layer disposed on the substrate; and
- a plurality of pixel structures disposed on the substrate, and each comprising:
 - an active device disposed between the substrate and the insulation layer; and
 - a reflective layer disposed on the insulation layer, and comprising:
 - a silver-based reflective layer having a reflective surface; and
 - a buffer layer disposed between the insulation layer and the silver-based reflective layer, wherein a material of the buffer layer comprises a conductive material,

wherein the insulation layer has an opening and a side wall surface defining the opening, the silver-based reflective layer and the buffer layer extend to cover the side wall surface of the insulation layer, and a first thickness of a side wall portion of the buffer layer covering the side wall surface along a normal direction of the side wall surface is greater than or equal to 30 angstroms and less than or equal to 80 angstroms.

9. The pixel array substrate according to claim 8, wherein the reflective layer further comprises:

a protective layer covering the silver-based reflective layer, wherein a thickness of the protective layer along a normal direction of the reflective surface is greater than or equal to 30 angstroms and less than or equal to 80 angstroms.

10. The pixel array substrate according to claim 8, wherein the insulation layer further has a surface connected to the side wall surface, the surface faces away from the substrate, and a second thickness of a horizontal portion of the buffer layer covering the surface of the insulation layer along a normal direction of the surface is greater than or equal to 40 angstroms and less than or equal to 100 angstroms.

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