US 20240145641A1

(19) United States
(12) Patent Application Publication
Liang et al.
(10) Pub. No.: US 2024/0145641 A1
(43) Pub. Date: May 2, 2024

(54) COLOR CONVERSION PANEL AND DISPLAY DEVICE

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(21) Appl. No.: **18/082,540**

(22) Filed: **Dec. 15, 2022**

(30) **Foreign Application Priority Data**

Oct. 28, 2022 (TW) 111141246

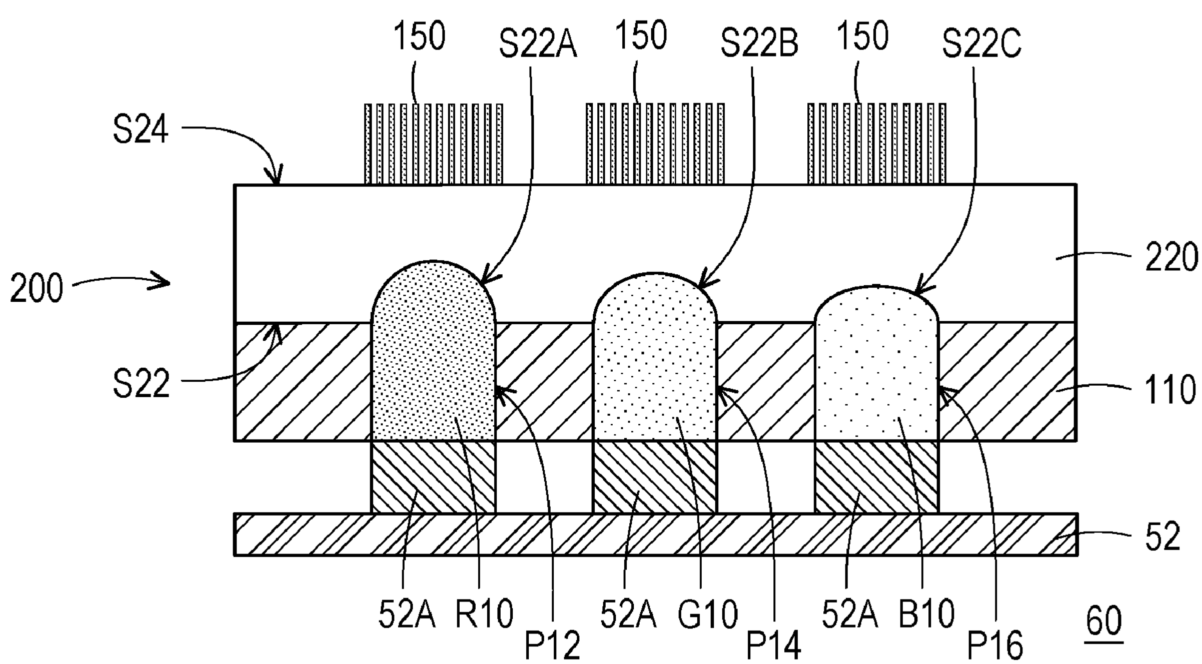
Publication Classification

(51) **Int. Cl.**
H01L 33/50 (2006.01)
H01L 27/146 (2006.01)
H01L 33/40 (2006.01)
H01L 33/46 (2006.01)

(52) **U.S. Cl.**
CPC *H01L 33/504* (2013.01); *H01L 27/14627* (2013.01); *H01L 33/405* (2013.01); *H01L 33/46* (2013.01)

(57) **ABSTRACT**

A color conversion panel and a display device are provided. The color conversion panel includes an opaque substrate and a sapphire substrate. The opaque substrate includes a plurality of first pixel openings, a plurality of second pixel openings and a plurality of third pixel openings. The first pixel openings are filled with red quantum dot material, and the second pixel openings are filled with green quantum dot material. The sapphire substrate is on the opaque substrate. A first surface of the sapphire substrate that faces the opaque substrate has a plurality of first arc surfaces corresponding to the first pixel openings, a plurality of second arc surfaces corresponding to the second pixel openings, and a plurality of third arc surfaces corresponding to the third pixel openings.



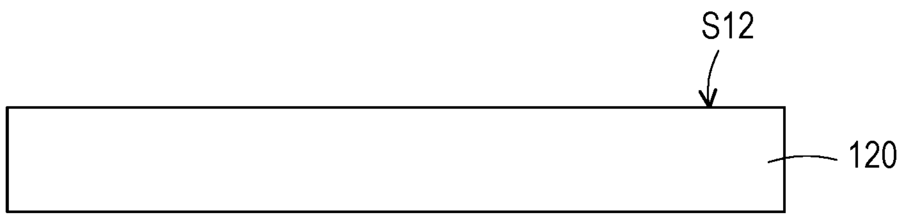


FIG. 1A

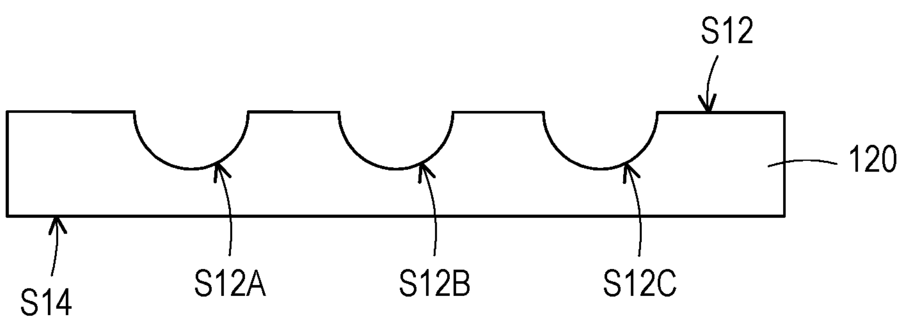


FIG. 1B

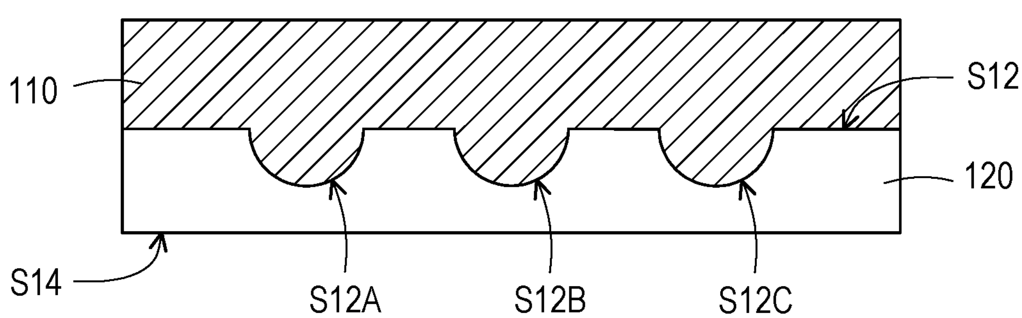


FIG. 1C

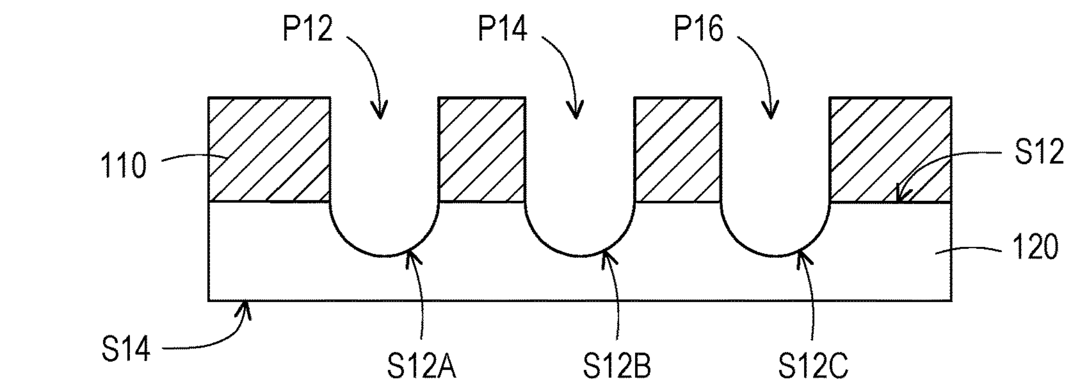


FIG. 1D

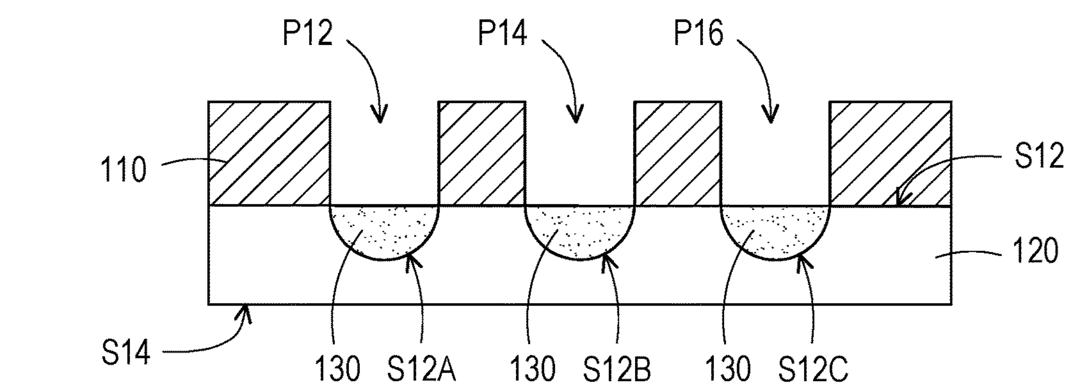


FIG. 1E

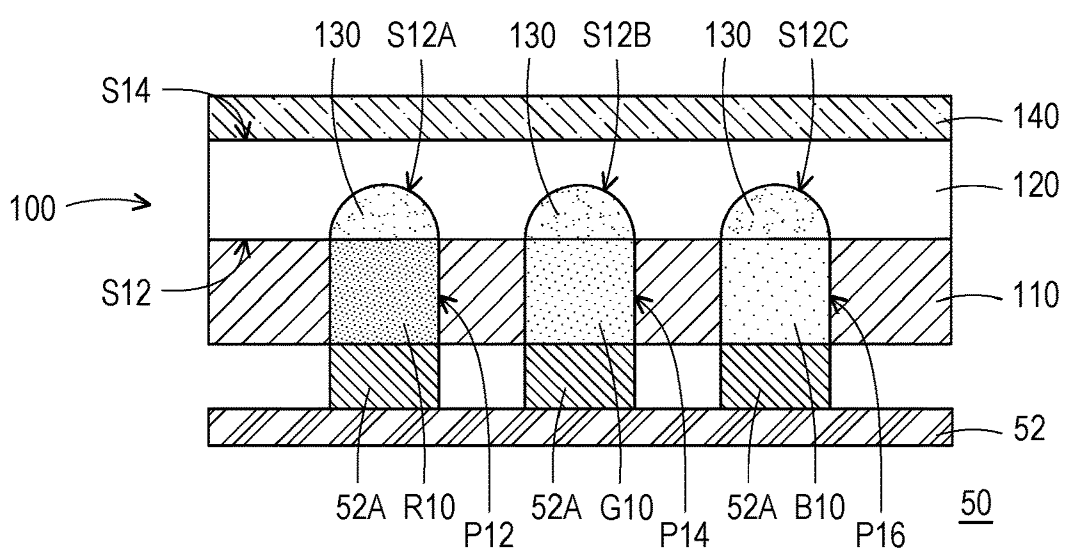


FIG. 1F

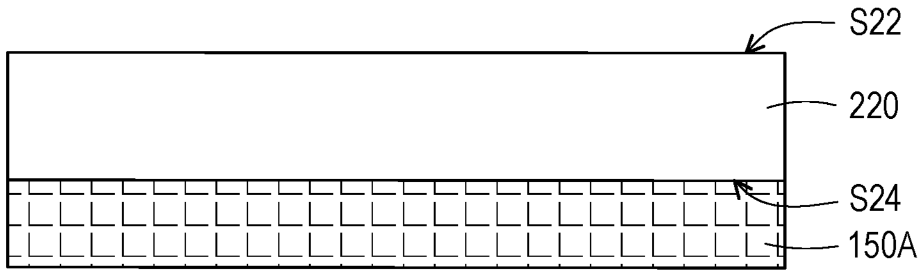


FIG. 2A

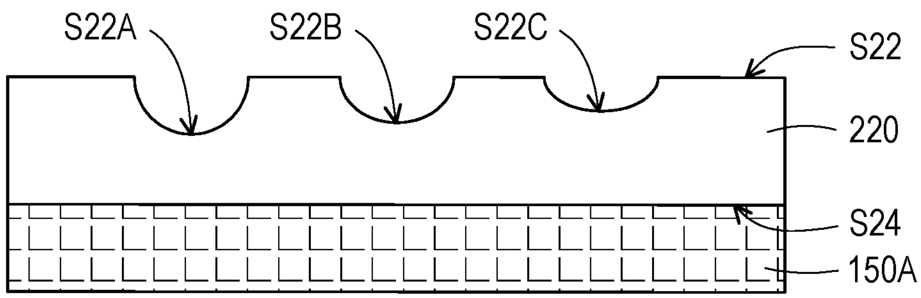


FIG. 2B

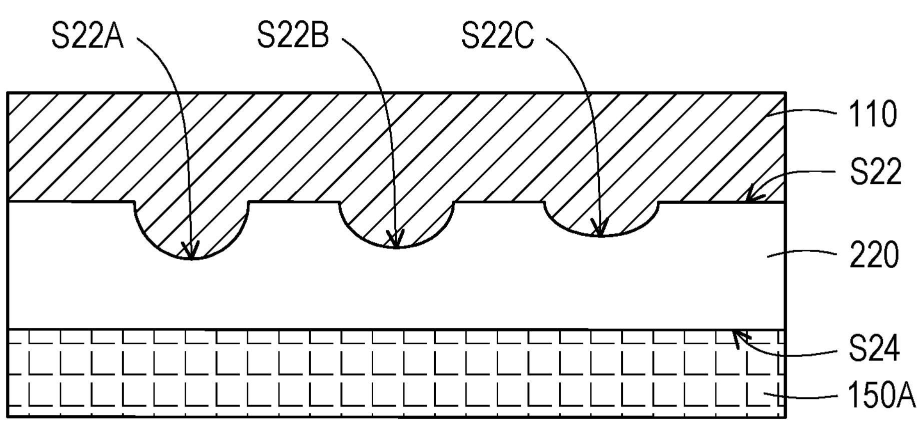


FIG. 2C

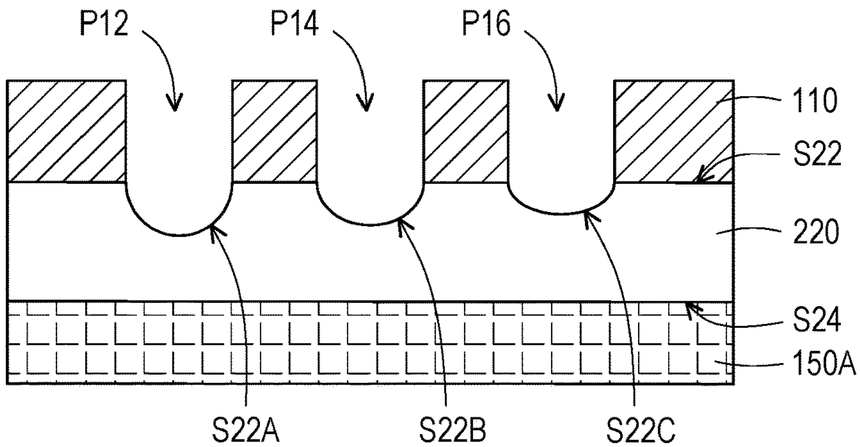


FIG. 2D

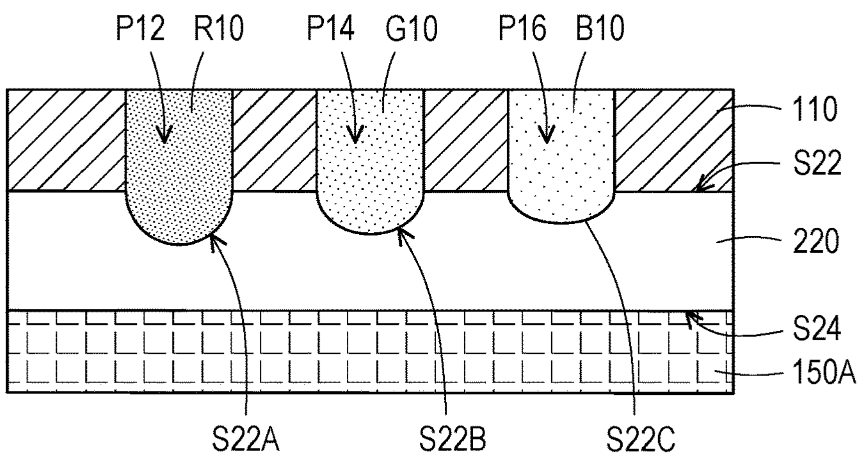


FIG. 2E

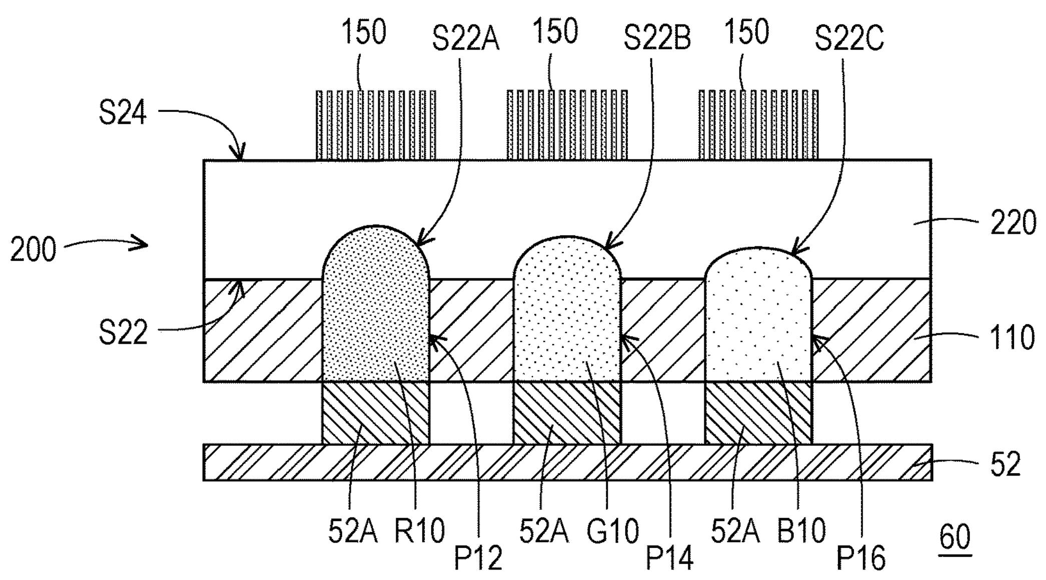


FIG. 2F

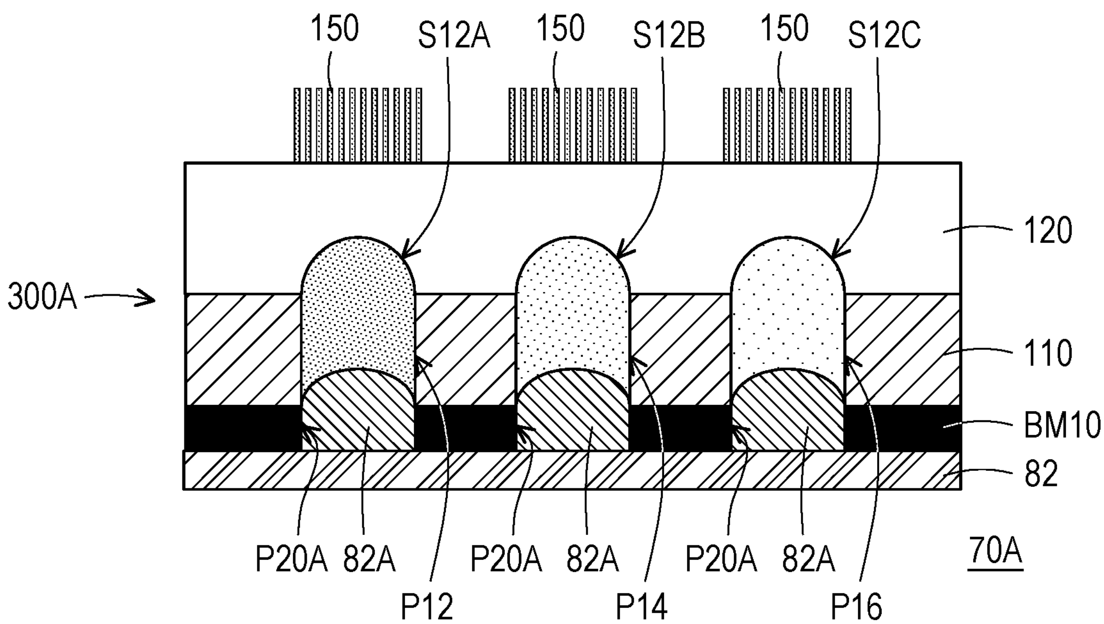

150
S12A
150
S12B
150
S12C
300A
120
110
BM10
82
P20A
82A
P20A
82A
P20A
82A
70A
P12
P14
P16

FIG. 3

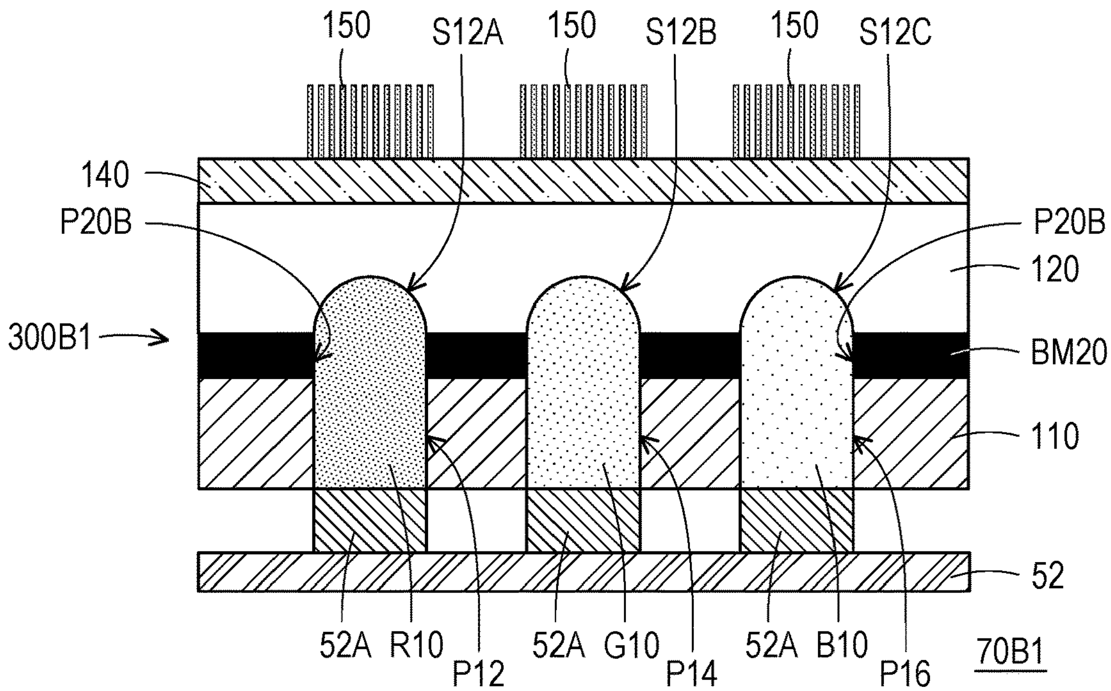

150
S12A
150
S12B
150
S12C
140
P20B
P20B
120
300B1
BM20
110
52
52A
R10
P12
52A
G10
P14
52A
B10
P16
70B1

FIG. 4A

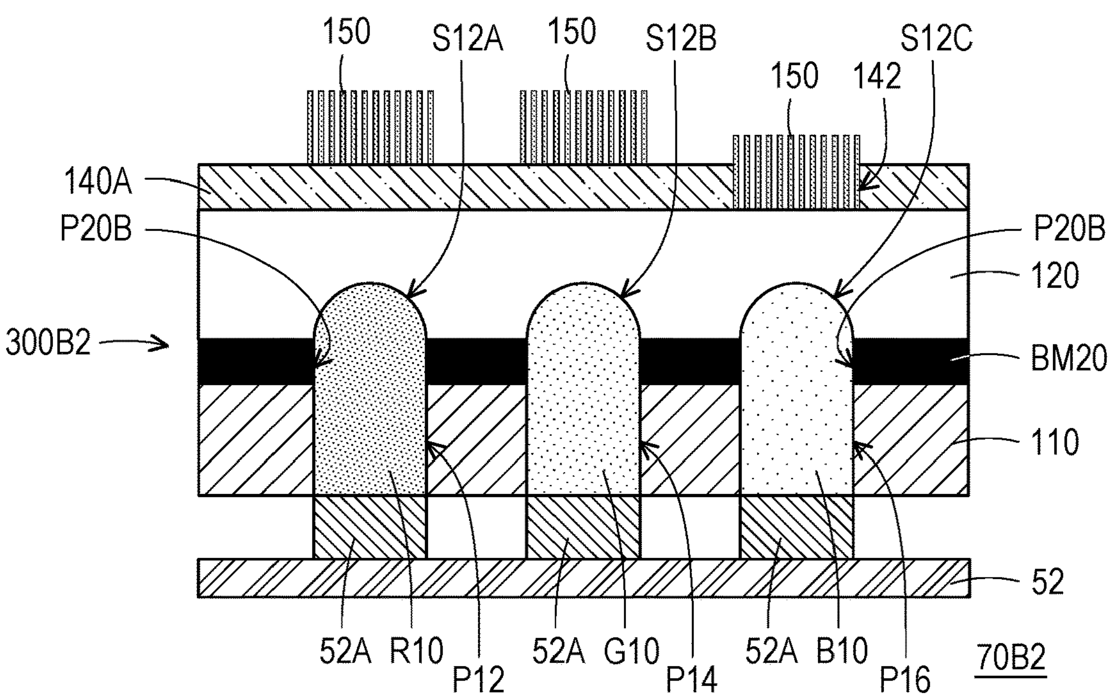

150
S12A
150
S12B
150
142
S12C
140A
P20B
P20B
120
300B2
BM20
110
52
52A
R10
P12
52A
G10
P14
52A
B10
P16
70B2

FIG. 4B

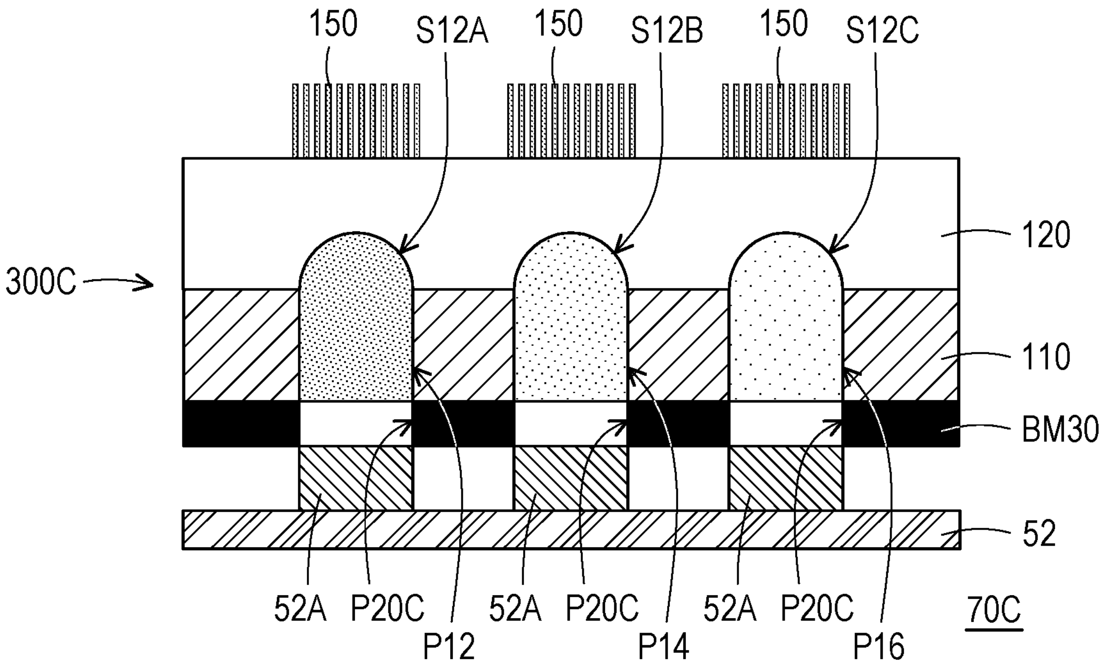

150
S12A
150
S12B
150
S12C
120
300C
110
BM30
52
52A
P20C
52A
P20C
52A
P20C
70C
P12
P14
P16

FIG. 5

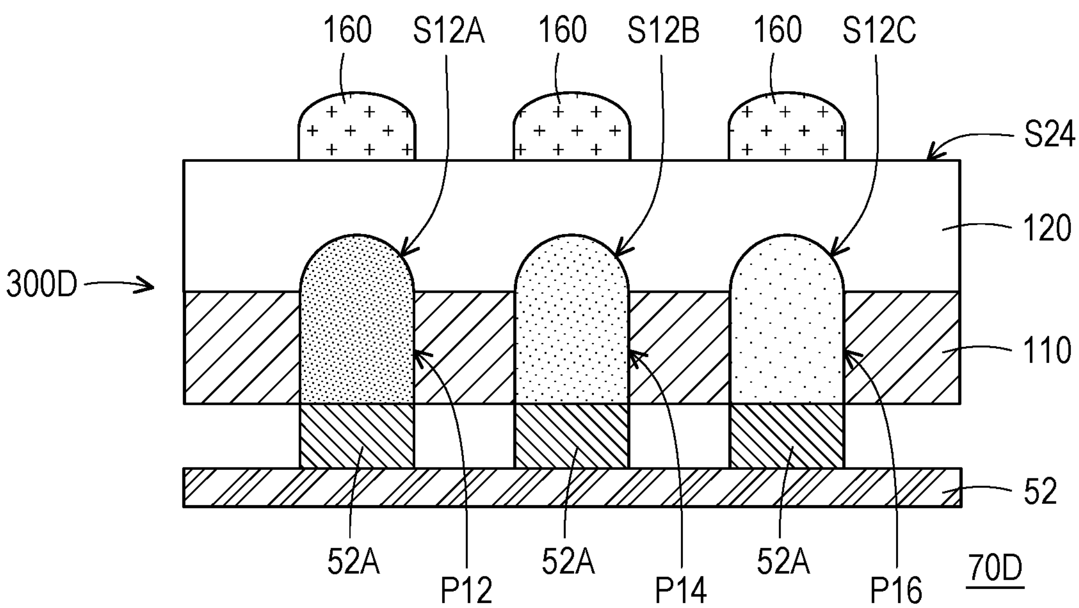

160
S12A
160
S12B
160
S12C
S24
120
300D
110
52
52A
52A
52A
70D
P12
P14
P16

FIG. 6

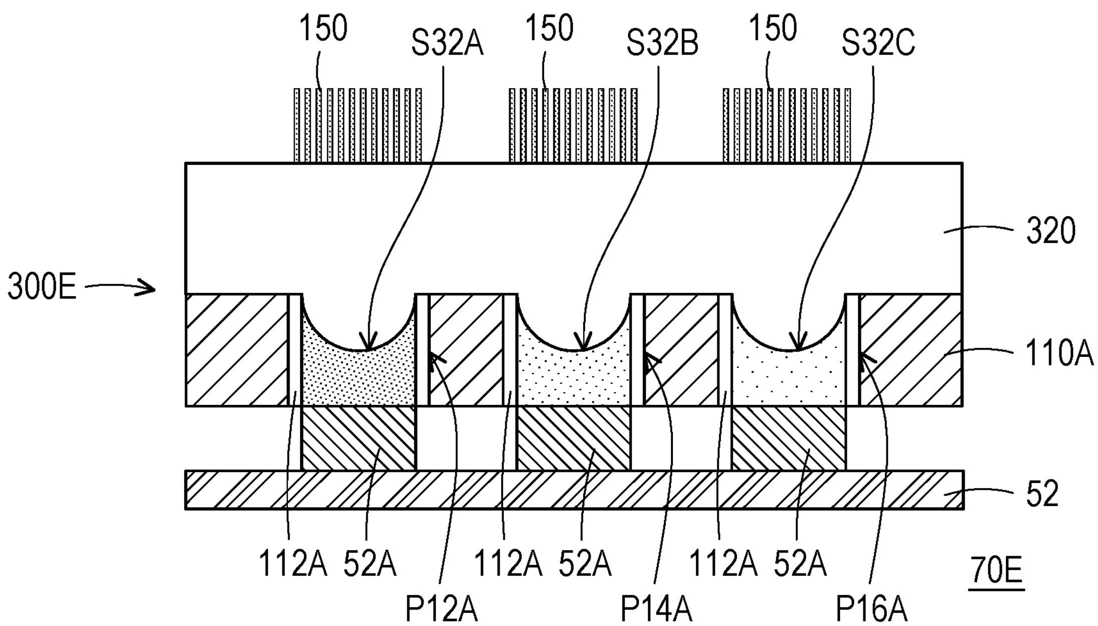

150
S32A
150
S32B
150
S32C
320
300E
110A
52
112A
52A
P12A
112A
52A
P14A
112A
52A
P16A
70E

FIG. 7

COLOR CONVERSION PANEL AND DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of Taiwanese application no. 111141246, filed on Oct. 28, 2022. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

TECHNICAL FIELD

[0002] The present disclosure relates to a panel and a display, and more particularly to a color conversion panel and a display device.

BACKGROUND

[0003] In recent years, as the display technology has been more fully developed, light-emitting elements with low energy consumption that can provide high-contrast images are also adopted in display devices. However, as the pitch between pixels becomes smaller and smaller, the cross-talk phenomenon between adjacent pixels become more serious and thus the performance of color purity and color gamut are affected. When a monochromatic light-emitting diode is combined with a quantum dot material for color conversion to achieve color display, the quantum dot material with isotropic light-emitting characteristic also makes the cross-talk problem even worse.

SUMMARY

[0004] A color conversion panel of the disclosure includes an opaque substrate and a sapphire substrate. The opaque substrate includes a plurality of first pixel openings, a plurality of second pixel openings and a plurality of third pixel openings. The first pixel openings are filled with red quantum dot material, and the second pixel openings are filled with green quantum dot material. The sapphire substrate is on the opaque substrate. A first surface of the sapphire substrate that faces the opaque substrate has a plurality of first arc surfaces corresponding to the first pixel openings, a plurality of second arc surfaces corresponding to the second pixel openings, and a plurality of third arc surfaces corresponding to the third pixel openings.

[0005] The display device of the disclosure includes a light-emitting pixel array panel and a color conversion panel. The light-emitting pixel array panel has a plurality of light-emitting elements. The color conversion panel is configured on the light-emitting pixel array panel. The color conversion panel includes an opaque substrate and a sapphire substrate. The opaque substrate includes a plurality of first pixel openings, a plurality of second pixel openings and a plurality of third pixel openings. The first pixel openings are filled with red quantum dot material, and the second pixel openings are filled with green quantum dot material. The sapphire substrate is on the opaque substrate. A first surface of the sapphire substrate that faces the opaque substrate has a plurality of first arc surfaces corresponding to the first pixel openings, a plurality of second arc surfaces corresponding to the second pixel openings, and a plurality of third arc surfaces corresponding to the third pixel openings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1**A to FIG. **1**F are cross-sectional schematic diagrams illustrating the manufacturing process of a color conversion panel and a display device according to an embodiment of the present disclosure.

[0007] FIG. **2**A to FIG. **2**F are cross-sectional schematic diagrams illustrating the manufacturing process of a color conversion panel and a display device according to another embodiment of the present disclosure.

[0008] FIG. **3** to FIG. **7** are cross-sectional schematic diagrams of a color conversion panel and a display device according to six other embodiments of the present disclosure.

DETAILED DESCRIPTION OF DISCLOSED EMBODIMENTS

[0009] FIG. **1**A to FIG. **1**F are cross-sectional schematic diagrams illustrating the manufacturing process of a color conversion panel and a display device according to an embodiment of the present disclosure. Referring to FIG. **1**A, in the manufacturing process of the color conversion panel and the display device of the present embodiment, a sapphire substrate **120** is provided first. Next, please refer to FIG. **1**B, an etching process or other appropriate methods is performed to form a plurality of first arc surfaces S**12**A, a plurality of second arc surfaces S**12**B and a plurality of third arc surfaces S**12**C on the first surface S**12** of the sapphire substrate **120**. For ease of illustration, only one arc surface is shown here.

[0010] Then please refer to FIG. **1**C, for example, an opaque substrate **110** is formed on the first surface S**12** of the sapphire substrate **120** by an epitaxy process or other appropriate methods. The material of the opaque substrate **110** may be polysilicon, metal or other opaque materials. Opaque refers to the characteristic of having low transmittance to visible light. In this embodiment, the inner concave surface of the first arc surface S**12**A, the inner concave surface of the second arc surface S**12**B, and the inner concave surface of the third arc surface S**12**C face the opaque substrate **110**.

[0011] Referring to FIG. **1**D, for example, a plurality of first pixel openings P**12**, a plurality of second pixel openings P**14**, and a plurality of third pixel openings P**16** are formed on the opaque substrate **110** through an ion reactive etching process or other appropriate methods. For ease of illustration, only one pixel opening is shown here. The position of each first pixel opening P**12** corresponds to a first arc surface S**12**A, the position of each second pixel opening P**14** corresponds to a second arc surface S**12**B, and the position of each third pixel opening P**16** corresponds to a third arc surface S**12**C.

[0012] Next, referring to FIG. **1**E, optionally, a plurality of high-refractive material layers **130** are formed in a space defined by the first arc surface S**12**A, the second arc surface S**12**B, and the third arc surface S**12**C. The high-refractive material layer **130** is located between the first arc surface S**12**A and the first pixel opening P**12**, between the second arc surface S**12**B and the second pixel opening P**14**, and between the third arc surface S**12**C and the third pixel opening P**16**.

[0013] Next, referring to FIG. **1**F, the red quantum dot material R**10** is filled in the first pixel opening P**12**, and the green quantum dot material G**10** is filled in the second pixel opening P**14**. In addition, the blue quantum dot material B**10** may also be selectively filled into the third pixel opening P**16**. In other embodiments, the third pixel opening P**16** may not be filled with a solid material, or may be filled with a polymer material or other appropriate material with better light transmission. In other embodiments, a reflecting layer (not shown) may be disposed on the inner walls of the first pixel opening P**12**, the second pixel opening P**14**, and the third pixel opening P**16** of the opaque substrate **110**, and the material of the reflecting layer is metal or other highly reflective materials. In this way, the color conversion panel **100** of this embodiment is basically completed. Moreover, a distributed Bragg reflecting layer **140** may also be selectively disposed on a second surface S**14** of the sapphire substrate **120** away from the opaque substrate **110**.

[0014] Then, the color conversion panel **100** is combined with a light-emitting pixel array panel **52**, and the display device **50** of this embodiment is basically completed.

[0015] The display device **50** of this embodiment includes a light-emitting pixel array panel **52** and a color conversion panel **100**. The light-emitting pixel array panel **52** has a plurality of light-emitting elements **52**A. The light-emitting element may be an inorganic light-emitting diode chip or an organic light-emitting diode chip. The size of the light-emitting element is on the level of microns. The size of the light-emitting element may be on the level below 100 microns. The side length of the light-emitting element may be less than 100 microns. The light-emitting element may be a micro light-emitting diode (micro LED). The color conversion panel **100** is disposed on the light-emitting pixel array panel **52**. The color conversion panel **100** includes an opaque substrate **110** and a sapphire substrate **120**. The opaque substrate **110** includes a plurality of first pixel openings P**12**, a plurality of second pixel openings P**14**, and a plurality of third pixel openings P**16**. The first pixel opening P**12** is filled with red quantum dot material R**10**, and the second pixel opening P**14** is filled with green quantum dot material G**10**. The sapphire substrate **120** is located on the opaque substrate **110**. The first surface S**12** of the sapphire substrate **120** that faces the opaque substrate **110** has a plurality of first arc surfaces S**12**A corresponding to the first pixel opening P**12**, a plurality of second arc surfaces S**12**B corresponding to the second pixel opening P**14**, and a plurality of third arc surfaces S**12**C corresponding to the third pixel opening P**16**.

[0016] In the display device **50** and the color conversion panel **100** of this embodiment, the light emitted by the light-emitting element **52**A is, for example, incident on the red quantum dot material R**10** in the first pixel opening P**12**. Then, the red quantum dot material R**10** converts the light into red light and emits the red light. When the red light passes through the first arc surface S**12**A, the light will be refracted to produce a light-converging effect, thereby reducing the amount of red light incident on adjacent sub-pixels, that is, reducing cross-talk phenomenon. Similarly, the light emitted by the light-emitting element **52**A is, for example, incident on the green quantum dot material G**10** in the second pixel opening P**14**. When the green light emitted by the green quantum dot material G**10** passes through the second arc surface S**12**B, the light is also refracted to produce a light-converging effect, thereby reducing the amount of green light incident on adjacent sub-pixels. The light emitted by the light-emitting element **52**A is, for example, incident on the blue quantum dot material B**10** in the third pixel opening P**16**. When the blue light emitted by the blue quantum dot material B**10** passes through the third arc surface S**12**C, the light will also be refracted to produce a light-converging effect, thereby reducing the amount of blue light incident on adjacent sub-pixels.

[0017] Since the first pixel opening P**12**, the second pixel opening P**14**, and the third pixel opening P**16** formed on the opaque substrate **110** are adopted, it is possible to prevent different color lights from generating cross-talk between the first pixel opening P**12**, the second pixel opening P**14**, and the third pixel opening P**16**. Furthermore, the first arc surface S**12**A, the second arc surface S**12**B, and the third arc surface S**12**C also have the effect of converging light, thereby reducing the possibility for the color lights exiting the first arc surface S**12**A, the second arc surface S**12**B, and the third arc surface S**12**C to generate cross-talk. Moreover, since the processing of the sapphire substrate **120** is relatively easy, the process time and cost of the display device **50** and the color conversion panel **100** of this embodiment are also reduced.

[0018] The refractive index of the high-refractive material layer **130** is, for example, between 1.7 and 2.0. In this embodiment, the refractive index of the high-refractive material layer **130** is, for example, between the refractive index of the quantum dot material and the refractive index of the sapphire substrate **120**. The high-refractive material layer **130** is helpful to enhance the effect of converging light produced by the first arc surface S**12**A, the second arc surface S**12**B, and the third arc surface S**12**C.

[0019] The distributed Bragg reflecting layer **140** is able to prevent ambient light from entering the display device **50** and excite the quantum dot material to emit light that does not meet the requirements, and the distributed Bragg reflecting layer **140** is also able to prevent light not in the desired wavelength band from emitting from the display device **50**.

[0020] The light-emitting element **52**A in this embodiment is exemplified as emitting blue light, but the present disclosure is not limited thereto. When the light-emitting element **52**A emits blue light, even if the third pixel opening P**16** is not filled with the blue quantum dot material B**10** but is kept in vacuum or only filled with gas, or filled with a polymer material with better light transmission or other appropriate materials, etc., the light exiting the third pixel opening P**16** is still blue light. Therefore, the purpose of color display may still be achieved. In other embodiments, the light-emitting element **52**A emits ultraviolet light, and the third pixel opening P**16** is required to be filled with blue quantum dot material B**10** to convert the ultraviolet light into visible light in the blue wavelength band.

[0021] FIG. **2**A to FIG. **2**F are cross-sectional schematic diagrams illustrating the manufacturing process of a color conversion panel and a display device according to another embodiment of the present disclosure. Please refer to FIG. **2**F, a display device **60** and a color conversion panel **200** of this embodiment are similar to the display device **50** and the color conversion panel **100** of FIG. **1**F, and the following description mainly focuses on the difference between the two embodiments. In addition, various additional technical solutions in the embodiment of FIG. **1**F that do not cause conflict when applied to this embodiment may also be applied to this embodiment.

[0022] Referring to FIG. **2**A, in the manufacturing process of the color conversion panel and the display device of the present embodiment, firstly, a sapphire substrate **220** and a gallium nitride layer **150**A that are combined together are provided. Next, please refer to FIG. **2**B, an etching process or other appropriate methods is performed to form a plurality of first arc surfaces S**22**A, a plurality of second arc surfaces S**22**B, and a plurality of third arc surfaces S**22**C on the first surface S**22** of the sapphire substrate **220**. For ease of illustration, only one arc surface is shown here. Then please refer to FIG. **2**C, for example, an opaque substrate **110** is formed on the first surface S**22** of the sapphire substrate **220** through an epitaxy process or other suitable methods. The material of the opaque substrate **110** may be polysilicon, metal or other opaque materials.

[0023] Then please refer to FIG. **2**D, for example, a plurality of first pixel openings P**12**, a plurality of second pixel openings P**14**, and a plurality of third pixel openings P**16** are formed on the opaque substrate **110** through an ion reactive etching process or other appropriate methods. For ease of illustration, only one pixel opening is shown here. The position of each first pixel opening P**12** corresponds to a first arc surface S**22**A, the position of each second pixel opening P**14** corresponds to a second arc surface S**22**B, and the position of each third pixel opening P**16** corresponds to a third arc surface S**22**C.

[0024] Next, referring to FIG. **2**E, optionally, red quantum dot material R**10** is filled in a space defined by the first pixel opening P**12** and the first arc surface S**22**A, and green quantum dot material G**10** is filled in a space defined by the second pixel opening P**14** and the second arc surface S**22**B. Moreover, the blue quantum dot material B**10** may also be selectively filled in a space defined by the third pixel opening P**16** and the third arc surface S**22**C. In other embodiments, the space defined by the third pixel opening P**16** and the third arc surface S**22**C may not be filled with a solid material, or may be filled with a polymer material or other appropriate materials with better light transmittance. In this way, the color conversion panel **200** of this embodiment is basically completed, which is shown in FIG. **2**F.

[0025] Next, please refer to FIG. **2**F, thereafter, the color conversion panel **200** is combined with the light-emitting pixel array panel **52**, and the display device **60** of this embodiment is basically completed. Furthermore, the gallium nitride layer **150**A is further patterned to form a plurality of metalenses **150** on a surface of the sapphire substrate **220** away from the opaque substrate **110** and corresponding to the first pixel openings P**12**, the second pixel openings P**14**, and the third pixel openings P**16**. The metalens **150** utilizes a combination of microstructures to produce the effect of an optical element. Here, the metalens **150** is configured to produce a light converging effect on the light that passes through, so as to further alleviate cross-talk phenomenon. The metalens **150** is made of gallium nitride.

[0026] Since the first pixel opening P**12**, the second pixel opening P**14**, and the third pixel opening P**16** formed on the opaque substrate **110** are adopted, it is possible to prevent different color lights from generating cross-talk between the first pixel opening P**12**, the second pixel opening P**12**, and the third pixel opening P**16**. Furthermore, the first arc surface S**22**A, the second arc surface S**22**B, and the third arc surface S**22**C also have the effect of converging light, thereby reducing the possibility for the color lights exiting the first arc surface S**22**A, the second arc surface S**22**B, and the third arc surface S**22**C to generate cross-talk. Moreover, since the processing of the sapphire substrate **120** is relatively easy, the process time and cost of the display device **60** and the color conversion panel **200** of this embodiment are also reduced.

[0027] In this embodiment, the radian of the first arc surface S**22**A, the radian of the second arc surface S**22**B, and the radian of the third arc surface S**22**C are different from each other. Since the wavelength bands of the color lights passing through the first arc surface S**22**A, the second arc surface S**22**B, and the third arc surface S**22**C are different, the radians may be adjusted for different color lights to obtain the optimal refractive angles respectively, thus alleviating cross-talk phenomenon.

[0028] FIG. **3** to FIG. **7** are cross-sectional schematic diagrams of a color conversion panel and a display device according to six other embodiments of the present disclosure.

[0029] Referring to FIG. **3**, a display device **70**A and a color conversion panel **300**A of this embodiment are similar to the display device **50** and the color conversion panel **100** of FIG. **1**F, and the following description mainly focuses on the differences between the two embodiments. In addition, various additional technical solutions in the foregoing embodiments that do not cause conflict when applied to this embodiment may also be applied to this embodiment. A light-emitting pixel array panel **82** of this embodiment further has a light-blocking matrix BM**10**, and the light-blocking matrix BM**10** has a plurality of light-transmitting openings P**20**A corresponding to the light-emitting elements **82**A. That is, each light-emitting element **82**A is located in one light-transmitting opening P**20**A. Therefore, it is possible to further alleviate the cross-talk phenomenon between adjacent light-emitting elements **82**A. Moreover, in this embodiment, one surface of the light-emitting element **82**A facing the color conversion panel **300**A is an arc surface, so that the light emitted by the light-emitting element **82**A is less divergent, and the cross-talk phenomenon between adjacent light-emitting elements **82**A may be further alleviated.

[0030] Referring to FIG. **4**A, a display device **70**B**1** and a color conversion panel **300**B**1** of this embodiment are similar to the display device **50** and the color conversion panel **100** of FIG. **1**F, and the following description mainly focuses on the differences between the two embodiments. In addition, various additional technical solutions in the foregoing embodiments that do not cause conflict when applied to this embodiment may also be applied to this embodiment. The color conversion panel **300**B**1** of this embodiment further includes a light-blocking matrix BM**20** disposed between the opaque substrate **110** and the sapphire substrate **120**. The light-blocking matrix BM**20** has a plurality of light-transmitting openings P**20**B corresponding to the first pixel openings P**12**, the second pixel openings P**14**, and the third pixel openings P**16**. That is, the red quantum dot material R**10** is filled into a space defined by the first pixel opening P**12**, the light-transmitting opening P**20**B, and the first arc surface S**12**A; the green quantum dot material G**10** is filled into a space defined by the second pixel opening P**14**, the light-transmitting opening P**20**B, and the second arc surface S**12**B; and the blue quantum dot material B**10** is filled into a space defined by the third pixel opening P**16**, the light-transmitting opening P**20**B, and the third arc surface S**12**C. The light-blocking matrix BM**20** is able to further alleviate cross-talk phenomenon between the first pixel opening P**12**, the second pixel opening P**14**, and the third pixel opening

P16. The distributed Bragg reflecting layer **140** is located on the surface of the sapphire substrate **120** away from the opaque substrate **110**, and the distributed Bragg reflecting layer **140** is located between the sapphire substrate **120** and the metalens **150**.

[0031] Referring to FIG. **4**B, a display device **70**B**2** and a color conversion panel **300**B**2** of this embodiment are similar to the display device **70**B**1** and the color conversion panel **300**B**1** of FIG. **4**A, and the following description mainly focuses on the differences between the two embodiments. In addition, various additional technical solutions in the foregoing embodiments that do not conflict when applied to this embodiment may also be applied to this embodiment. The distributed Bragg reflecting layer **140**A of the color conversion panel **300**B**2** in this embodiment may have an opening **142** corresponding to the third pixel opening P**16**, so that the blue light passing through the third arc surface S**12**C may not pass through the distributed Bragg reflecting layer **140**A.

[0032] In an embodiment that is not shown, the distributed Bragg reflecting layer **140**A does not have the opening **142**, but a portion of the distributed Bragg reflecting layer **140**A corresponding to the third pixel opening P**16** may have a thin design, so that the thickness of the distributed Bragg reflecting layer **140**A that allows the blue light passing through the third arc surface S**12**C to pass through is relatively thin. In another embodiment that is not shown, the distributed Bragg reflecting layer **140**A may be patterned and only correspond to the first pixel opening P**12** and the second pixel opening P**14**, and positions that do not correspond to the first pixel opening P**12** and the second pixel opening P**14** are not provided with the distributed Bragg reflecting layer **140**A. In another embodiment that is not shown, the distributed Bragg reflecting layer **140**A may be patterned, so that the distributed Bragg reflecting layer **140**A covers the first pixel opening P**12** and the second pixel opening P**14**, but does not cover the third pixel opening P**16**.

[0033] Referring to FIG. **5**, a display device **70**C and a color conversion panel **300**C of this embodiment are similar to the display device **50** and the color conversion panel **100** of FIG. **1**F, and the following description mainly focuses on the differences between the two embodiments. In addition, various additional technical solutions in the foregoing embodiments that do not cause conflict when applied to this embodiment may also be applied to this embodiment. The display device **70**C of this embodiment further includes a light-blocking matrix BM**30** disposed between the light-emitting pixel array panel **52** and the color conversion panel **300**C. The light-blocking matrix BM**30** has a plurality of light-transmitting openings P**20**C corresponding to the first pixel opening P**12**, the second pixel opening P**14**, and the third pixel opening P**16**. That is, the light generated by each light-emitting element **52**A first passes through the corresponding light-transmitting opening P**20**C before entering the corresponding first pixel opening P**12**, the second pixel opening P**14**, and the third pixel opening P**16**. The light-blocking matrix BM**30** is able to further alleviate the cross-talk phenomenon between adjacent light-emitting elements **52**A.

[0034] Referring to FIG. **6**, a display device **70**D and a color conversion panel **300**D of this embodiment are similar to the display device **50** and the color conversion panel **100** of FIG. **1**F, and the following description mainly focuses on the differences between the two embodiments. In addition, various additional technical solutions in the foregoing embodiments that do not cause conflict when applied to this embodiment may also be applied to this embodiment. The color conversion panel **300**D of this embodiment further includes a plurality of micro lenses **160** located on the second surface S**24** of the sapphire substrate **120** away from the opaque substrate **110** and corresponding to the first pixel opening P**12**, the second pixel opening P**14**, and the third pixel opening P**16**. The micro lens **160** is configured to converge the light that passes through, so as to further alleviate cross-talk phenomenon. The plurality of micro lenses **160** may be formed by patterning the gallium nitride layer **150**A of FIG. **2**E. The material of the micro lens **160** is gallium nitride. In other embodiments, there may be a distributed Bragg reflecting layer on a surface of the sapphire substrate **120** away from the opaque substrate **110**, and the distributed Bragg reflecting layer **140** is located between the sapphire substrate **120** and the micro lens **160**.

[0035] Referring to FIG. **7**, a display device **70**E and a color conversion panel **300**E of this embodiment are similar to the display device **50** and the color conversion panel **100** of FIG. **1**F, and the following description mainly focuses on the differences between the two embodiments. In addition, various additional technical solutions in the foregoing embodiments that do not cause conflict when applied to this embodiment may also be applied to this embodiment. In this embodiment, the inner concave surface of the first arc surface S**32**A, the inner concave surface of the second arc surface S**32**B, and the inner concave surface of the third arc surface S**32**C of the sapphire substrate **320** face away from the opaque substrate **110**A. In addition, a reflecting layer **112**A may be disposed on the inner walls of the first pixel opening P**12**A, the second pixel opening P**14**A, and the third pixel opening P**16**A of the opaque substrate **110**A, and the material of the reflecting layer is metal or other highly reflective materials, so as to further reduce light divergence caused by color conversion when light passes through the quantum dot material. In other embodiments, the reflecting layer **112** may also be disposed only on the inner walls of the first pixel opening P**12**A and the second pixel opening P**14**A.

[0036] To sum up, in the color conversion panel and the display device of the present disclosure, the pixel openings of the opaque substrate are able to avoid cross-talk phenomenon, and the arc surfaces of the sapphire substrate are able to produce light-converging effect, thereby improving the display quality.

What is claimed is:

1. A color conversion panel, comprising:

an opaque substrate, which comprises a plurality of first pixel openings, a plurality of second pixel openings, and a plurality of third pixel openings, wherein the first pixel openings are filled with a red quantum dot material, and the second pixel openings are filled with a green quantum dot material; and

a sapphire substrate, which is disposed on the opaque substrate, wherein a first surface of the sapphire substrate that faces the opaque substrate has a plurality of first arc surfaces corresponding to the first pixel openings, a plurality of second arc surfaces corresponding to the second pixel openings, and a plurality of third arc surfaces corresponding to the third pixel openings.

2. The color conversion panel according to claim **1**, further comprising a plurality of metalenses located on a second surface of the sapphire substrate away from the opaque substrate and corresponding to the first pixel openings, the second pixel openings and the third pixel openings.

3. The color conversion panel according to claim **1**, further comprising a plurality of micro lenses located on a second surface of the sapphire substrate away from the opaque substrate and corresponding to the first pixel openings, the second pixel openings and the third pixel openings.

4. The color conversion panel according to claim **1**, further comprising a distributed Bragg reflecting layer disposed on a second surface of the sapphire substrate away from the opaque substrate.

5. The color conversion panel according to claim **1**, wherein radians of the first arc surfaces are different from radians of the second arc surfaces.

6. The color conversion panel according to claim **1**, further comprising a plurality of high-refractive material layers located between the first arc surfaces and the first pixel openings, between the second arc surfaces and the second pixel openings, and between the third arc surfaces and the third pixel openings, and refractive indices of the high-refractive material layers are between 1.7 and 2.0.

7. The color conversion panel according to claim **1**, wherein inner concave surfaces of the first arc surfaces, inner concave surfaces of the second arc surfaces, and inner concave surfaces of the third arc surfaces face the opaque substrate.

8. The color conversion panel according to claim **1**, wherein inner concave surfaces of the first arc surfaces, inner concave surfaces of the second arc surfaces, and inner concave surfaces of the third arc surfaces face away from the opaque substrate.

9. The color conversion panel according to claim **1**, further comprising a light-blocking matrix disposed between the opaque substrate and the sapphire substrate, wherein the light-blocking matrix has a plurality of light-transmitting openings corresponding to the first pixel openings, the second pixel openings and the third pixel openings.

10. A display device, comprising:

a light-emitting pixel array panel, which has a plurality of light-emitting elements;

a color conversion panel, which is disposed on the light-emitting pixel array panel, and comprises:

an opaque substrate, which comprises a plurality of first pixel openings, a plurality of second pixel openings and a plurality of third pixel openings, wherein the first pixel openings are filled with a red quantum dot material, the second pixel openings are filled with a green quantum dot material; and

a sapphire substrate, which is disposed on the opaque substrate, wherein a first surface of the sapphire substrate that faces the opaque substrate has a plurality of first arc surfaces corresponding to the first pixel openings, a plurality of second arc surfaces corresponding to the second pixel openings, and a plurality of third arc surfaces corresponding to the third pixel openings.

11. The display device according to claim **10**, wherein the color conversion panel further comprises a plurality of metalenses located on a second surface of the sapphire substrate away from the opaque substrate and corresponding to the first pixel openings, the second pixel openings and the third pixel openings.

12. The display device according to claim **10**, wherein the color conversion panel further comprises a plurality of micro lenses located on a second surface of the sapphire substrate away from the opaque substrate and corresponding to the first pixel openings, the second pixel openings and the third pixel openings.

13. The display device according to claim **10**, wherein the color conversion panel further comprises a distributed Bragg reflecting layer disposed on a second surface of the sapphire substrate away from the opaque substrate.

14. The display device according to claim **10**, wherein the color conversion panel further comprises a plurality of high-refractive material layers located between the first arc surfaces and the first pixel openings, between the second arc surfaces and the second pixel openings, and between the third arc surfaces and the third pixel openings, and refractive indices of the high-refractive material layers are between 1.7 and 2.0.

15. The display device according to claim **10**, wherein inner concave surfaces of the first arc surfaces, inner concave surfaces of the second arc surfaces, and inner concave surfaces of the third arc surfaces face the opaque substrate.

16. The display device according to claim **10**, wherein inner concave surfaces of the first arc surfaces, inner concave surfaces of the second arc surfaces, and inner concave surfaces of the third arc surfaces face away from the opaque substrate.

17. The display device according to claim **10**, wherein the color conversion panel further comprises a light-blocking matrix disposed between the opaque substrate and the sapphire substrate, wherein the light-blocking matrix has a plurality of light-transmitting openings corresponding to the first pixel openings, the second pixel openings and the third pixel openings.

18. The display device according to claim **10**, further comprising a light-blocking matrix disposed between the light-emitting pixel array panel and the color conversion panel, wherein the light-blocking matrix has a plurality of light-transmitting openings corresponding to the first pixel openings, the second pixel openings and the third pixel openings.

19. The display device according to claim **10**, wherein the light-emitting pixel array panel further has a light-blocking matrix, and the light-blocking matrix has a plurality of light-transmitting openings corresponding to the light-emitting elements, and the light-emitting elements are located in the light-transmitting openings.

20. The display device according to claim **10**, wherein a surface of the light-emitting elements facing the color conversion panel is an arc surface.

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