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(54) **DISPLAY DEVICE**

(71) Applicant: **PlayNitride Inc.**, Tainan (TW)

(72) Inventors: **Yun-Li Li**, Tainan (TW); **Yu-Hung Lai**, Tainan (TW); **Tzu-Yang Lin**, Tainan (TW)

(73) Assignee: **PlayNitride Inc.**, Tainan (TW)

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H01L 33/46	(2010.01)
G02B 5/08	(2006.01)
H01L 25/075	(2006.01)
H01L 33/62	(2010.01)
H01L 33/38	(2010.01)
H01L 33/10	(2010.01)
H01L 33/08	(2010.01)

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

CPC ***H01L 33/465*** (2013.01); ***G02B 5/085*** (2013.01); ***H01L 25/0753*** (2013.01); ***H01L 33/60*** (2013.01); ***H01L 33/62*** (2013.01); *H01L 33/08* (2013.01); *H01L 33/10* (2013.01); *H01L 33/382* (2013.01); *H01L 2933/0016* (2013.01)

(58) **Field of Classification Search**

CPC . H01L 33/105; H01L 33/465; H01L 25/0753; H01L 33/60; H01L 33/62; H01L 33/382; H01L 33/05; H01L 33/10; H01L 33/08; H01L 2933/0016; H01L 2933/0025; H01L 2923/0058; G02B 5/085

USPC 257/89, 98, 99, E21.108, E33.07; 438/22, 29, 25, 27

See application file for complete search history.

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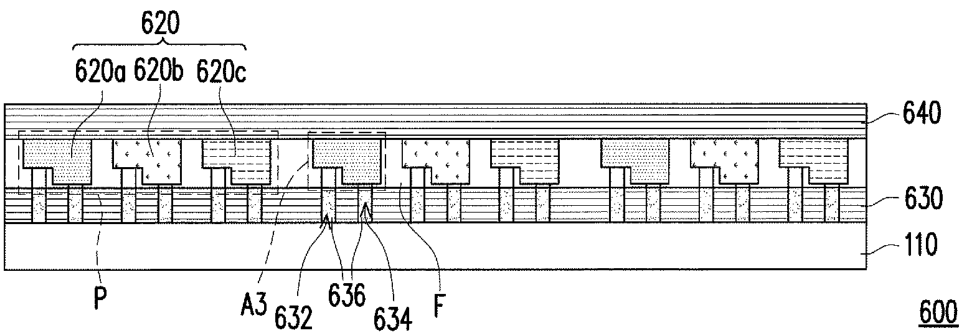
Primary Examiner — Thinh T Nguyen
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A display device including a backplane, a plurality of light-emitting devices, a first distributed Bragg reflector layer and a second distributed Bragg reflector layer is provided. The light-emitting devices are disposed on the backplane. The first distributed Bragg reflector layer is disposed between the backplane and the light-emitting devices. The light-emitting devices are disposed between the first distributed Bragg reflector layer and the second distributed Bragg reflector layer. A projected area of the first distributed Bragg reflector layer on the backplane is larger than a projected area of one of the light-emitting devices on the backplane or a projected area of the second distributed Bragg reflector layer on the backplane is larger than a projected area of one light-emitting device on the backplane.

16 Claims, 7 Drawing Sheets



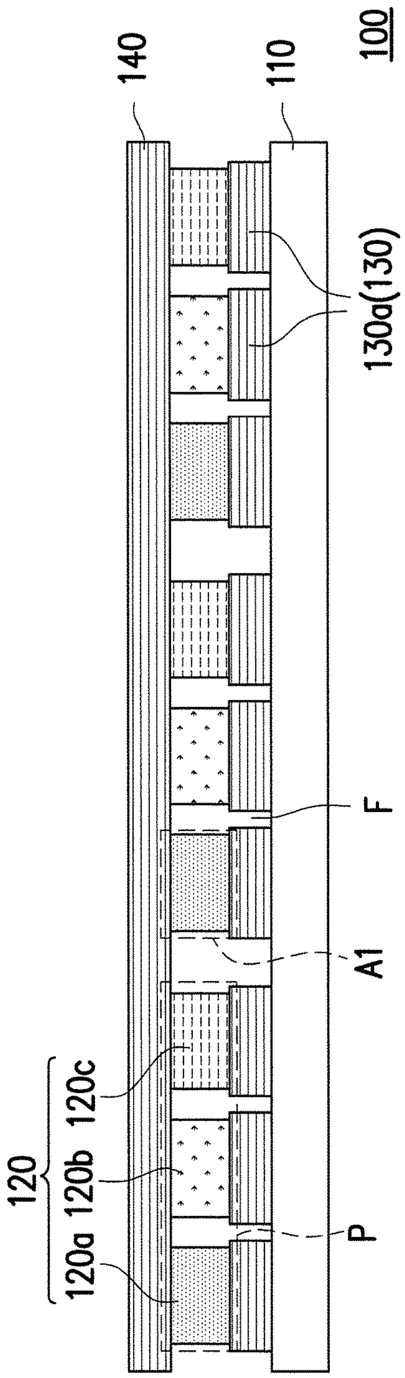

100
140
110
130a(130)
F
A1
P
120
120a
120b
120c

FIG. 1A

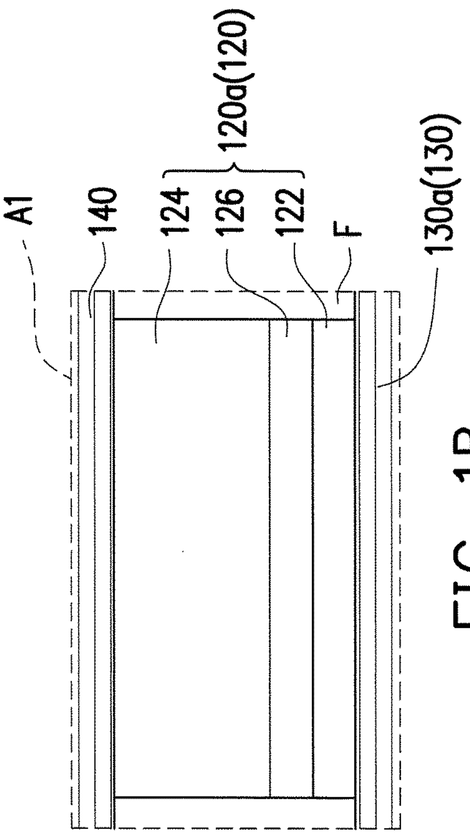

A1
140
124
126
122
F
120a(120)
130a(130)

FIG. 1B

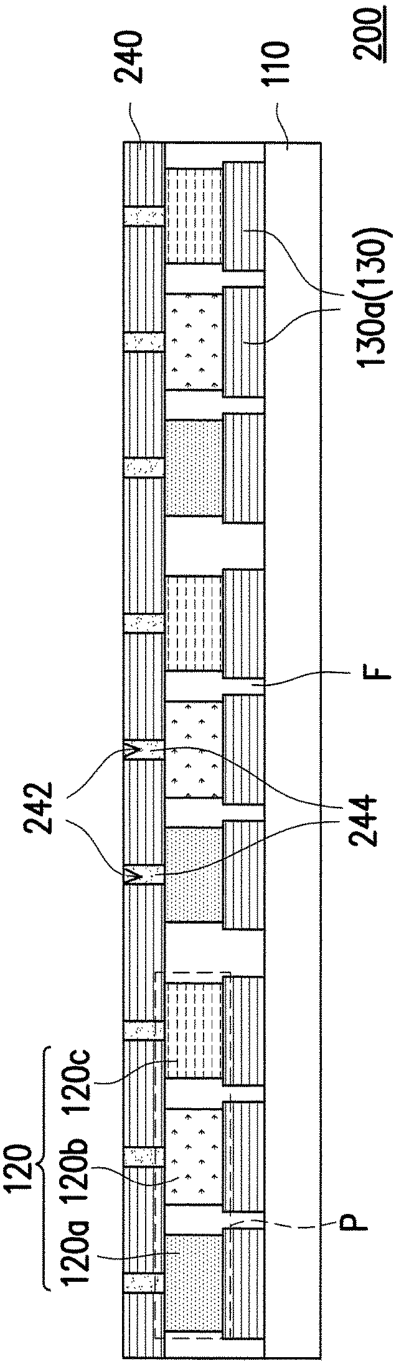

240
110
200
130a(130)
F
242
244
120
120a
120b
120c
P

FIG. 2

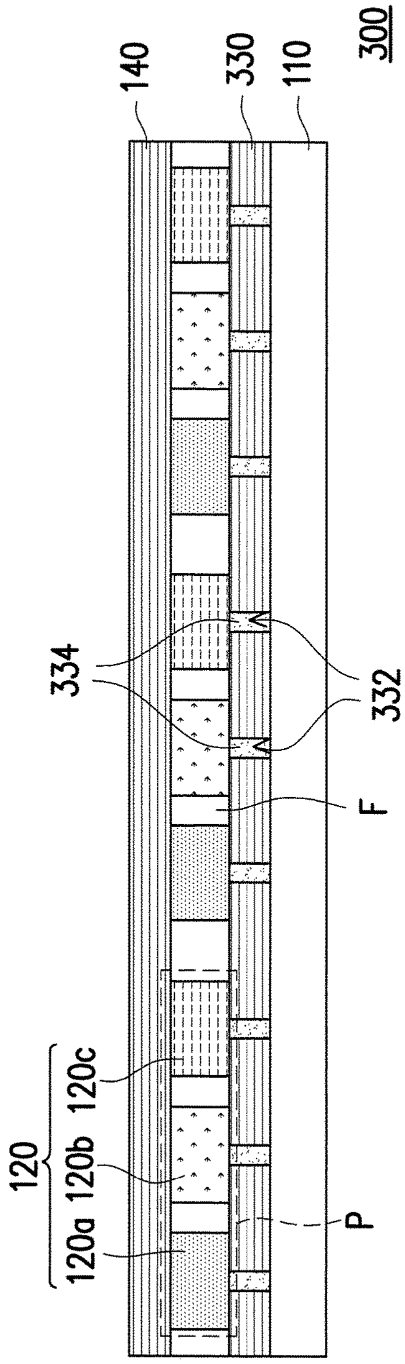

140
330
110
300
334
332
F
120
120a
120b
120c
P

FIG. 3

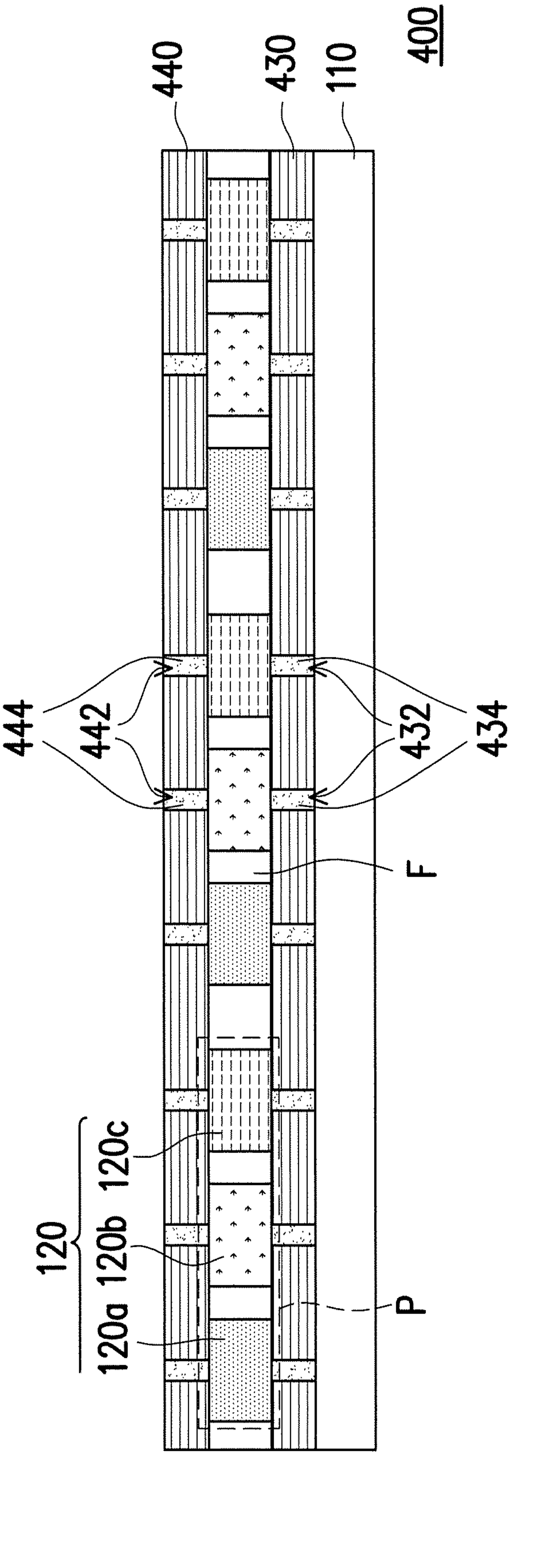


FIG. 4

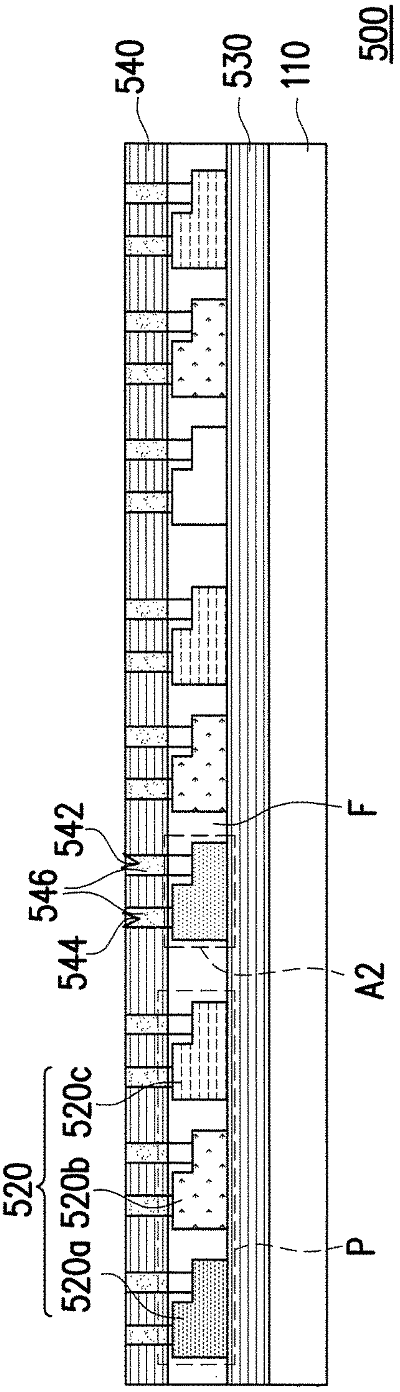

500
540
530
110
542
546
544
520
520a
520b
520c
F
A2
P

FIG. 5A

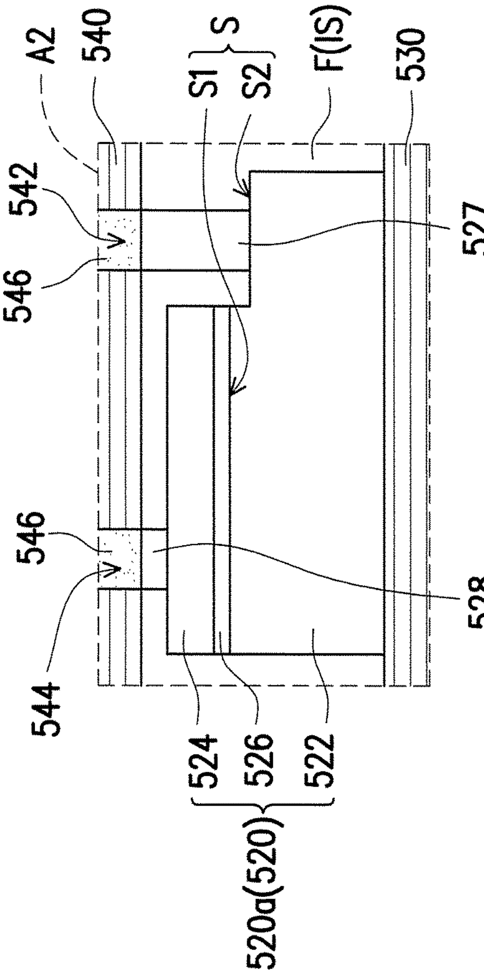

A2
540
S1
S2
S
F(IS)
530
542
546
527
544
528
524
526
522
520a(520)

FIG. 5B

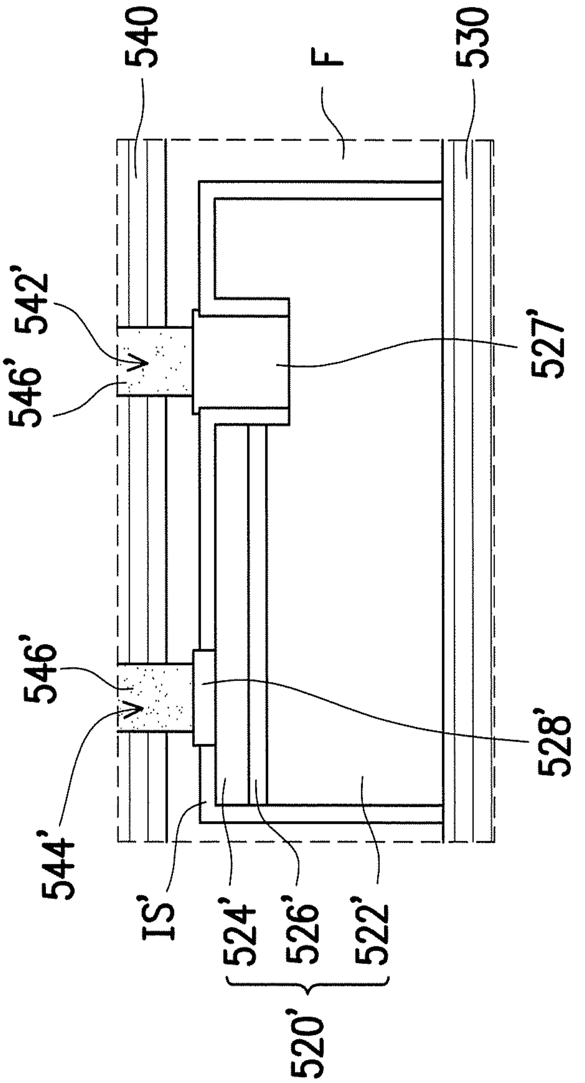


FIG. 5C

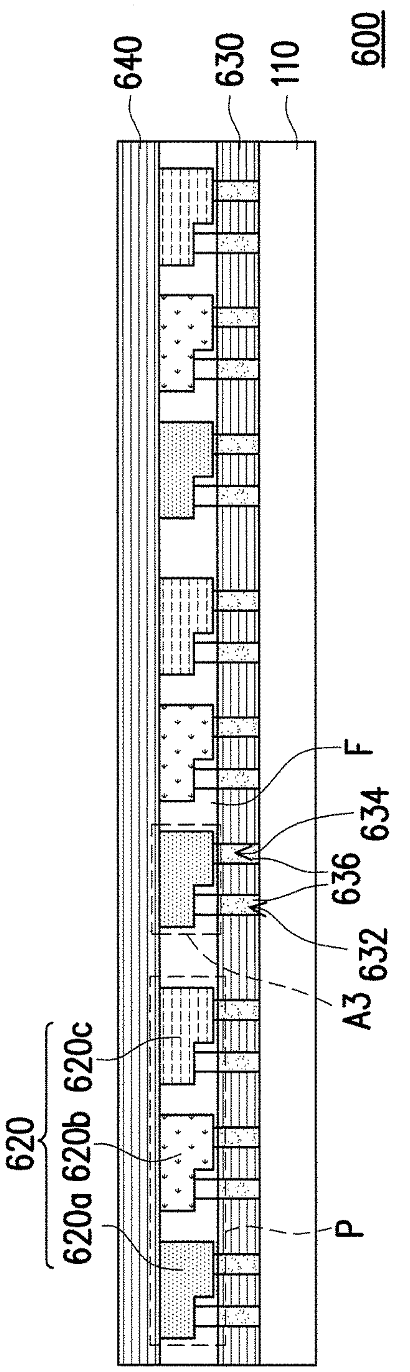
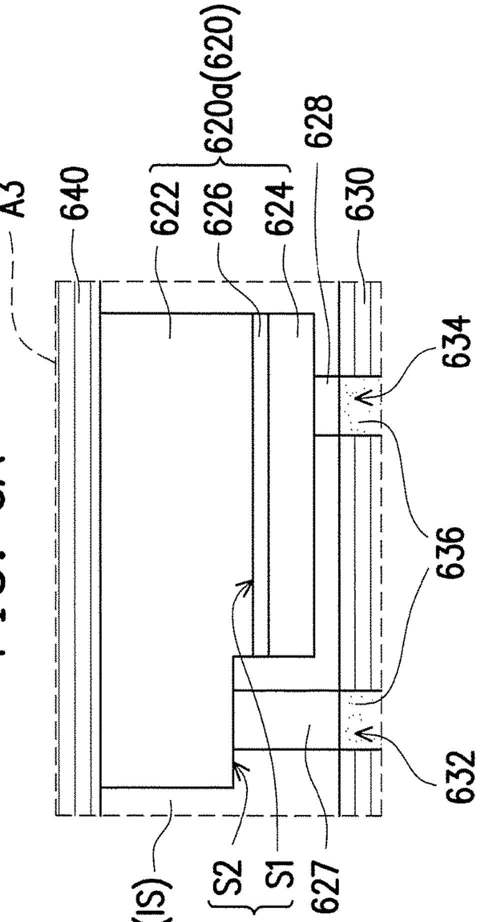

640
630
110
600
F
634
636
A3
632
620
620a
620b
620c
P

FIG. 6A


A3
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622
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624
620a(620)
628
630
634
636
632
627
S1
S2
S
F(IS)

FIG. 6B

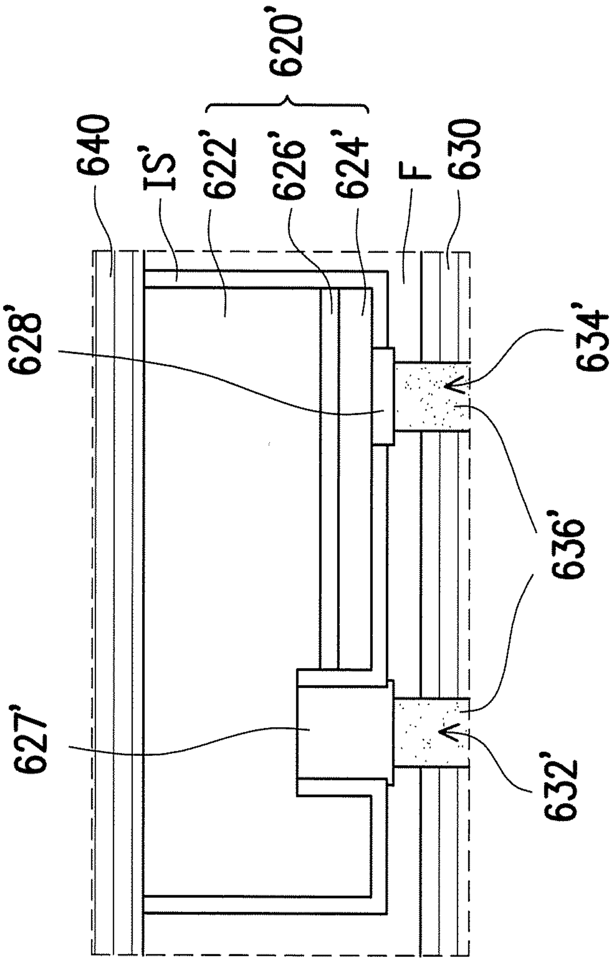

FIG. 6C

DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of Taiwan application serial no. 105144012, filed on Dec. 30, 2016. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a display device.

2. Description of Related Art

With progress in optoelectronic technology, many optoelectronic components are developed to be more compact in size. In recent years, thanks to the breakthrough in manufacturing light-emitting diodes (LED), the micro-LED display that is formed by arranging light-emitting diodes in an array has been developed. The micro-LED display has not only better performance in contrast and energy consumption than an organic light-emitting diode (OLED) display but also is visible under the sun. Since the micro-LED display uses an inorganic material, it also has better reliability and longer life time than the OLED display. Now the micro-LED display has proved its value in the market, and the studying of micro-LED are drawing more and more attention, for example, how to lower the manufacturing difficulty and enhance the brightness, color performance, and so on.

SUMMARY OF THE INVENTION

The invention provides a display device which displays images with high color purity. In addition, the display device is easy to manufacture and has favorable cost-effectiveness.

The display device of the invention includes a backplane, a plurality of light-emitting devices, a first distributed Bragg reflector structure, and a second distributed Bragg reflector structure. The light-emitting devices are arranged and disposed on the backplane. The first distributed Bragg reflector structure is disposed between the backplane and the light-emitting devices. The light-emitting devices are disposed between the first distributed Bragg reflector structure and the second distributed Bragg reflector structure. A projected area of the first distributed Bragg reflector structure or the second distributed Bragg reflector structure on the backplane is larger than a projected area of one light-emitting device on the backplane.

In an embodiment of the invention, each of the light-emitting devices includes a first type doped semiconductor layer, a light-emitting layer, and a second type doped semiconductor layer. The light-emitting layer is disposed between the first type doped semiconductor layer and the second type doped semiconductor layer. The first type doped semiconductor layer is disposed between the light-emitting layer and the first distributed Bragg reflector structure, and the second type doped semiconductor layer is disposed between the second distributed Bragg reflector structure and the light-emitting layer. At least one of the first distributed Bragg reflector structure and the second distributed Bragg reflector structure is electrically conductive.

In an embodiment of the invention, the first distributed Bragg reflector structure is electrically conductive. The first distributed Bragg reflector structure includes a plurality of sub Bragg reflector structures that are separated from one another, and the first type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the sub Bragg reflector structures.

In an embodiment of the invention, the second distributed Bragg reflector structure is electrically conductive, and the second type doped semiconductor layers of the light-emitting devices are together electrically connected with the second distributed Bragg reflector structure.

In an embodiment of the invention, the second distributed Bragg reflector structure is not electrically conductive. The second distributed Bragg reflector structure includes a plurality of conductive through holes, and the second type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the conductive through holes.

In an embodiment of the invention, the first distributed Bragg reflector structure is not electrically conductive while the second distributed Bragg reflector structure is electrically conductive. The first distributed Bragg reflector structure includes a plurality of conductive through holes. The first type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the conductive through holes, and the second type doped semiconductor layers of the light-emitting devices are together electrically connected with the second distributed Bragg reflector structure.

In an embodiment of the invention, a material of at least one of the first distributed Bragg reflector structure and the second distributed Bragg reflector structure includes silver.

In an embodiment of the invention, each of the light-emitting devices includes a first type doped semiconductor layer, a light-emitting layer, and a second type doped semiconductor layer. The light-emitting layer is disposed between the first type doped semiconductor layer and the second type doped semiconductor layer. The first type doped semiconductor layer is disposed between the light-emitting layer and the first distributed Bragg reflector structure, and the second type doped semiconductor layer is disposed between the second distributed Bragg reflector structure and the light-emitting layer. At least one of the first distributed Bragg reflector structure and the second distributed Bragg reflector structure is not electrically conductive.

In an embodiment of the invention, the first distributed Bragg reflector structure and the second distributed Bragg reflector structure are not electrically conductive. The first distributed Bragg reflector structure includes a plurality of first conductive through holes and the first type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the first conductive through holes. The second distributed Bragg reflector structure includes a plurality of second conductive through holes, and the second type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the second conductive through holes.

In an embodiment of the invention, the first distributed Bragg reflector structure is not electrically conductive. The first distributed Bragg reflector structure includes a plurality of first conductive through holes and a plurality of second conductive through holes. The first type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the first conductive through holes, and the second type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the second conductive through holes.

In an embodiment of the invention, the second distributed Bragg reflector structure is not electrically conductive. The second distributed Bragg reflector structure includes a plurality of first conductive through holes and a plurality of second conductive through holes. The first type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the first conductive through holes, and the second type doped semiconductor layer of each of the light-emitting devices is electrically connected with one of the second conductive through holes.

In an embodiment of the invention, at least one of the first distributed Bragg reflector structure and the second distributed Bragg reflector structure includes a multilayer film.

In an embodiment of the invention, a reflectivity of the first distributed Bragg reflector structure is different from a reflectivity of the second distributed Bragg reflector structure.

In an embodiment of the invention, each of the light-emitting devices is a micro-LED chip, and a diagonal length of each of the light-emitting devices falls in a range of 2 μm to 150 μm.

In an embodiment of the invention, the light-emitting devices emit lights of different colors.

Based on the above, in the display device of the embodiments of the invention, the first distributed Bragg reflector layer is disposed between the backplane and the light-emitting devices, and the light-emitting devices are disposed between the first distributed Bragg reflector layer and the second distributed Bragg reflector layer. The light emitted by the light-emitting devices is reflected between the first distributed Bragg reflector layer and the second distributed Bragg reflector layer, and the full width at half maximum of the spectrum of the light is reduced. Thus, when the light emitted by the light-emitting devices leaves the display device, the light will have higher color purity to improve the display image. Besides, the projected area of the first distributed Bragg reflector layer or the second distributed Bragg reflector layer on the backplane is larger than the projected area of one light-emitting device on the backplane. Thus, the first distributed Bragg reflector layer or the second distributed Bragg reflector layer may be manufactured whole layer. It is not required to separately manufacture the first distributed Bragg reflector layer or the second distributed Bragg reflector layer on each light-emitting device. Therefore, the display device is easy to manufacture and has favorable cost-effectiveness.

To make the aforementioned and other features and advantages of the invention more comprehensible, several embodiments accompanied with drawings are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. **1**A is a cross-sectional view of a display device according to an embodiment of the invention.

FIG. **1**B is an enlarged view of a region A**1** according to the embodiment of FIG. **1**A.

FIG. **2** is a cross-sectional view of a display device according to another embodiment of the invention.

FIG. **3** is a cross-sectional view of a display device according to yet another embodiment of the invention.

FIG. **4** is a cross-sectional view of a display device according to yet another embodiment of the invention.

FIG. **5**A is a cross-sectional view of a display device according to another embodiment of the invention.

FIG. **5**B is an enlarged view of a region A**2** according to the embodiment of FIG. **5**A.

FIG. **5**C is an enlarged view of a region according to another structural form of the embodiment of FIG. **5**A.

FIG. **6**A is a cross-sectional view of a display device according to yet another embodiment of the invention.

FIG. **6**B is an enlarged view of a region A**3** according to the embodiment of FIG. **6**A.

FIG. **6**C is an enlarged view of a region according to another structural form of the embodiment of FIG. **6**A.

DESCRIPTION OF THE EMBODIMENTS

FIG. **1**A is a cross-sectional view of a display device according to an embodiment of the invention. Please refer to FIG. **1**A. In this embodiment, a display device **100** includes a backplane **110**, a plurality of light-emitting devices **120**, a first distributed Bragg reflector (DBR) layer **130**, and a second distributed Bragg reflector layer **140**. The light-emitting devices **120** are disposed on the backplane **110**. The first distributed Bragg reflector layer **130** is disposed between the backplane **110** and the light-emitting devices **120**, and the light-emitting devices **120** are disposed between the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140**. Specifically, a projected area of the first distributed Bragg reflector layer **130** or a projected area of the second distributed Bragg reflector layer **140** on the backplane **110** is larger than a projected area of one light-emitting device **120** on the backplane **110**. More specifically, in this embodiment, the projected areas of the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140** on the backplane **110** are both larger than the projected area of each light-emitting device **120** on the backplane **110**. In this embodiment, the light-emitting devices **120** are held between the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140**, wherein the second distributed Bragg reflector layer **140** is an entire film layer.

In this embodiment, the light-emitting devices **120** are arranged on the backplane **110** to form a plurality of pixels P of the display device **100**. The light-emitting devices **120** emit light to display an image. In addition, the light-emitting devices **120** may also be applied to a projection system to project a colorful projection image. Specifically, the light-emitting devices **120** include a plurality of red light-emitting devices **120***a*, green light-emitting devices **120***b*, and blue light-emitting devices **120***c* respectively located in a plurality of sub pixels. Each pixel P includes three sub pixels in the embodiment. One light-emitting device **120***a*, one light-emitting device **120***b*, and one light-emitting device **120***c* are located in one of the pixels. In other embodiments, however, the light-emitting devices **120** in each pixel P may have other colors, such as yellow, or the light-emitting devices **120** with different emitting color may be disposed in other arrangements according to the actual display requirements. Furthermore, in other embodiments, one light-emitting device **120** may emit light of one single color, or one light-emitting device **120** may emit lights of different colors. Nevertheless, the invention is not limited thereto. In addition, the number of the sub pixels included in each pixel P and the number of the light-emitting devices **120** thereof may be changed to achieve multi-color display, single-color display, or other display effects. Nevertheless, the invention is not limited thereto.

In this embodiment, the light-emitting devices **120** (the light-emitting device **120***a*, the light-emitting device **120***b*, and the light-emitting device **120***c*) are light-emitting diode (LED) chips, for example. Specifically, the light-emitting devices **120** are micro-LED (μLED) chips that have been miniaturized, and a diagonal length of each light-emitting device **120** falls in a range of 2 μm to 150 μm, for example. In relevant embodiments, the light-emitting devices **120** may be arranged as different required or have different emitting color, so as to achieve full-color display or projection effect. The invention is not intended to limit the color selection and arrangement of the light-emitting devices **120**. The color selection of the light-emitting devices **120** or the arrangement thereof on the backplane **110** may be adjusted according to different requirements of use, design specifications, and product positioning.

FIG. **1**B is an enlarged view of a region A**1** according to the embodiment of FIG. **1**A. Please refer to FIG. **1**B. In this embodiment, the light-emitting device **120***a*, the light-emitting device **120***b*, and the light-emitting device **120***c* have similar structures, and the light-emitting devices **120** emit lights of different colors depending on material component. Here, the light-emitting device **120***a* is described as an example to illustrate the structure of each light-emitting device **120** in this embodiment. Specifically, each light-emitting device **120** includes a first type semiconductor layer **122**, an active layer **126**, and a second type semiconductor layer **124**, wherein the active layer **126** is disposed between the first type semiconductor layer **122** and the second type semiconductor layer **124**. More specifically, a material of the first type semiconductor layer **122**, the second type semiconductor layer **124**, and the active layer **126** may be a II-VI group material (e.g., ZnSe), a III-V nitride material (e.g., GaN, AlN, InN, InGaN, AlGaN, or AlInGaN), or a semiconductor material suitable for electroluminescence. Nevertheless, the invention is not limited thereto. Moreover, one of the first type semiconductor layer **122** and the second type semiconductor layer **124** is a P type doped semiconductor layer and the other of the first type semiconductor layer **122** and the second type semiconductor layer **124** is an N type doped semiconductor layer. In other words, the first type semiconductor layer **122** and the second type semiconductor layer **124** are semiconductor layers of two different doping types. Due to the different doping types, the first type semiconductor layer **122** and the second type semiconductor layer **124** have different thicknesses. In this embodiment, the thinner layer serves as the first type semiconductor layer **122** while the thicker layer serves as the second type semiconductor layer **124**. Thus, the active layer **126** is close to the backplane **110**, such that the light-emitting devices **120** have better heat dissipation. For example, the first type semiconductor layer **122** is a P type doped semiconductor layer and the second type semiconductor layer **124** is an N type doped semiconductor layer. Besides, the active layer **126** includes a multiple quantum well (MQW) structure or a quantum well (QW) structure, for example. Nevertheless, the invention is not limited thereto.

Please refer to FIG. **1**A and FIG. **1**B. In this embodiment, the first type semiconductor layer **122** is disposed between the active layer **126** and the first distributed Bragg reflector layer **130**, and the second type semiconductor layer **124** is disposed between the second distributed Bragg reflector layer **140** and the light-emitting layer **126**. At least one of the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140** is electrically conductive. Specifically, the first distributed Bragg reflector layer **130** has electrical conductivity and includes a plurality of sub Bragg reflector structures **130***a* that are separated from one another. Each sub Bragg reflector structure **130***a* is corresponding to one of the light-emitting device **120** in this embodiment. A projected area of each sub Bragg reflector structure **130***a* on the backplane **110** is larger than the projected area of one light-emitting device **120** on the backplane **110**. The first type semiconductor layer **122** of each light-emitting device **120** is electrically connected with one sub Bragg reflector structure **130***a*. In other words, the light-emitting device **120** of each sub pixel and the sub Bragg reflector structure **130***a* thereunder are separated from each other on the backplane **110**. Moreover, a gap between the light-emitting devices **120** and a gap between the sub Bragg reflector structures **130***a* are filled with a filler F. The filler F electrically insulates the adjacent two sub Bragg reflector structures **130***a*. The filler F may be a light-transmissive, translucent, or opaque plastic material or a photoresist material. Nevertheless, the invention is not limited thereto.

Furthermore, in this embodiment, the second distributed Bragg reflector layer **140** also has electrical conductivity, and the second type semiconductor layers **124** of the light-emitting devices **120** are all electrically connected with the second distributed Bragg reflector layer **140**. In the embodiment, the second distributed Bragg reflector layer **140** is a common electrode layer to the light-emitting devices **120**. Specifically, the material of at least one of the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140** includes silver. Alternatively, the materials of the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140** may be included other electrically conductive materials. Additionally, in this embodiment, the backplane **110** includes a circuit structure (not shown), and the light-emitting devices **120** are electrically connected to the circuit structure through the sub Bragg reflector structures **130***a* electrically contacted with a plurality of contacts of the circuit structure. Besides, the second distributed Bragg reflector layer **140** may also be electrically connected with the circuit structure on the backplane **110**. Therefore, the light-emitting devices **120** disposed on the backplane **110** may be respectively driven by a current transmitted by the circuit structure to emit light. Specifically, the backplane **110** having different circuit structure designs may be a semiconductor substrate, a submount substrate, a complementary metal-oxide-semiconductor (CMOS) circuit substrate, a liquid crystal on silicon (LCOS) substrate, or other types of substrates. The type of the backplane **110** and the circuit structure corresponding to the backplane **110** may be adjusted according to different requirements of use, design specifications, and product positioning. Thus, the invention is not limited to the above.

In this embodiment, the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140** are respectively formed by stacking two materials that have different refractive indexes, and the reflectivity of the first distributed Bragg reflector layer **130** is different from the reflectivity of the second distributed Bragg reflector layer **140**. Specifically, the reflectivity of the first distributed Bragg reflector layer **130** is greater than the reflectivity of the second distributed Bragg reflector layer **140**. The reflectivity of the first distributed Bragg reflector layer **130** is 99% and the reflectivity of the second distributed Bragg reflector layer **140** is 40%, for example. The light emitted by the light-emitting devices **120** is reflected between the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140** and leaves the display device **100** from the second distributed Bragg reflector layer **140**. With different design of the refractive indexes and thicknesses of the stacking materials of the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140**, a wavelength of the light emitted by the light-emitting devices **120** is adjusted after the light is reflected between the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140**. Specifically, a full width at half maximum of a spectrum of the light is gradually reduced after one or more reflections. Thus, the wavelength distribution of the spectrum of the light becomes narrower when the light leaves the display device **100**, and the display image will have higher color purity. Specifically, the full width at half maximum of the spectrum of the light emitted by the light-emitting devices **120** falls in a range of 30 nm to 40 nm, for example. The light emitted by the light-emitting devices **120** will resonate by reflecting between the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140**, after the light leaves the display device **100**, the full width at half maximum of the spectrum of the light measured outside the display device **100** is reduced to a range of 10 nm to 25 nm, for example. In other words, the full width at half maximum of the spectrum of the light-emitting devices **120** is able to reduce 16% to 75%, so as to increase straight light intensity and color purity of the light-emitting devices **120**. In other embodiments, however, the full width at half maximum of the spectrum of the light emitted by the light-emitting devices **120** may be other values. Preferably, the design of the first distributed Bragg reflector layer **130** and the second distributed Bragg reflector layer **140** improves the full width at half maximum of the spectrum of the light-emitting devices **120** at least 40% to 90%. Moreover, in these embodiments, the light-emitting performance of the display device **100** may be adjusted through other proper structural designs. Thus, the invention is not limited to the above.

Specifically, in the embodiment of the invention, the first distributed Bragg reflector layer **130** or the second distributed Bragg reflector layer **140** has a projected area on the backplane **110**, which is larger than the projected area of one light-emitting device **120** on the backplane **110**. In other words, the first distributed Bragg reflector layer **130** or the second distributed Bragg reflector layer **140** is manufactured on the backplane **110** or on those light-emitting devices **120** by entire film formation. Thus, it is not required to individually manufacture the first distributed Bragg reflector layer **130** or the second distributed Bragg reflector layer **140** on each light-emitting device **120** in advance. Therefore, the display device **100** is easy to manufacture and has lower cost. In this embodiment, the second distributed Bragg reflector layer **140** is manufactured as a whole film layer on the light-emitting devices **120** and the filler F. In addition, a projected area of each sub Bragg reflector structure **130*a*** on the backplane **110** is different from the projected area of the light-emitting device **120**, which is disposed on the sub Bragg reflector structure **130*a***, on the backplane **110**. Specifically, the projected area of the sub Bragg reflector structure **130*a*** on the backplane **110** is larger than the projected area of the light-emitting device **120** on the backplane **110**.

FIG. **2** is a cross-sectional view of a display device according to another embodiment of the invention. A display device **200** of the embodiment of FIG. **2** is similar to the display device **100** of the embodiment of FIG. **1**A to FIG. **1**B. Please refer to the display device **100** described in the embodiment of FIG. **1**A to FIG. **1**B for details of the components of the display device **200**. Thus, descriptions thereof are not repeated hereinafter. A main difference between the display device **200** and the display device **100** is as follows. In this embodiment, a second distributed Bragg reflector layer **240** of the display device **200** is an insulator, it means that the second distributed Bragg reflector layer **240** is not electrically conductive. The second distributed Bragg reflector layer **240** includes a plurality of conductive through holes **242** filled with an electrically conductive material **244**, and the second type semiconductor layer **124** of each light-emitting device **120** is electrically connected with the electrically conductive material **244** in one conductive through hole **242**. In addition, the electrically conductive materials **244** in the conductive through holes **242** may be electrically connected with the circuit structure (not shown) in common on the backplane **110** or other external circuits, for example.

Specifically, the first type semiconductor layers **122** of the light-emitting devices **120** of the display device **200** are electrically connected with the circuit structure of the backplane **110** through the sub Bragg reflector structures **130*a*** having conductivity, and the second type semiconductor layers **124** of the light-emitting devices **120** are electrically connected with the circuit structure of the backplane **110** through the conductive through holes **242** and the electrically conductive materials **244**. Therefore, the light-emitting layers **126** of the light-emitting devices **120** disposed on the backplane **110** may be respectively driven by the backplane **110**. In this embodiment, the projected area of the first distributed Bragg reflector layer **130** or the second distributed Bragg reflector layer **240** on the backplane **110** is larger than the projected area of one light-emitting device **120** on the backplane **110**. Specifically, the projected area of one sub Bragg reflector structure **130*a*** on the backplane **110** is larger than the projected area of the corresponding light-emitting device **120** on the backplane **110**. Therefore, the display image of the display device **200** has higher color purity, and the display device **200** is easy to manufacture and has favorable cost-effectiveness.

FIG. **3** is a cross-sectional view of a display device according to another embodiment of the invention. A display device **300** of the embodiment of FIG. **3** is similar to the display device **100** of the embodiment of FIG. **1**A to FIG. **1**B. Please refer to the display device **100** for details of the components of the display device **300**. Thus, descriptions thereof are not repeated hereinafter. A main difference between the display device **300** and the display device **100** is as follows. In this embodiment, a first distributed Bragg reflector layer **330** of the display device **300** is an insulator, not electrically conductive, and the second distributed Bragg reflector layer **140** is electrically conductive. Moreover, the first distributed Bragg reflector layer **330** includes a plurality of conductive through holes **332** that are disposed separately and respectively correspond to the light-emitting devices **120**, and the first type semiconductor layer **122** of each light-emitting device **120** is electrically connected with an electrically conductive material **334** in one conductive through hole **332**. Furthermore, the electrically conductive materials **334** in the conductive through holes **332** are electrically connected with the circuit structure (not shown) on the backplane **110** respectively, for example.

Specifically, the light-emitting devices **120** are electrically connected with the circuit structure of the backplane **110** through the electrically conductive materials **334** of the conductive through holes **332**, and through the second distributed Bragg reflector layer **140**. Therefore, the active layers **126** of the light-emitting devices **120** disposed on the backplane **110** may be respectively driven by the backplane **110**. In this embodiment, the projected area of the first distributed Bragg reflector layer **330** or the projected area of the second distributed Bragg reflector layer **140** on the backplane **110** is larger than the projected area of one light-emitting device **120** on the backplane **110**. Therefore, the display image of the display device **300** has higher color purity, and the display device **300** is easy to manufacture and has favorable cost-effectiveness.

FIG. **4** is a cross-sectional view of a display device according to yet another embodiment of the invention. A display device **400** of the embodiment of FIG. **4** is similar to the display device **300** of the embodiment of FIG. **3**. Please refer to the display device **300** described in the embodiment of FIG. **3** for details of the components of the display device **400**. Thus, descriptions thereof are not repeated hereinafter. A main difference between the display device **400** and the display device **300** is as follows. In this embodiment, a first distributed Bragg reflector layer **430** and a second distributed Bragg reflector layer **440** of the display device **400** are insulated layer. In addition, at least one of the first distributed Bragg reflector layer **430** and the second distributed Bragg reflector layer **440** includes a multilayer film. In some embodiments, the first distributed Bragg reflector layer **430** and the second distributed Bragg reflector layer **440** may include other insulating materials or non-conductive structures. Nevertheless, the invention is not limited thereto. Moreover, in this embodiment, the first distributed Bragg reflector layer **430** includes a plurality of first conductive through holes **432**, and the first type semiconductor layer **122** of each light-emitting device **120** is electrically connected with an electrically conductive material **434** of one first conductive through hole **432**. The second distributed Bragg reflector layer **440** includes a plurality of second conductive through holes **442**, and the second type semiconductor layer **124** of each light-emitting device **120** is electrically connected with an electrically conductive material **444** of one second conductive through hole **442**. In addition, the electrically conductive materials **434**、**444** are electrically connected with the circuit structure (not shown) on the backplane **110** respectively.

Specifically, the light-emitting devices **120** are electrically connected with the backplane **110** through the first conductive through holes **432** and the second conductive through holes **442**. Therefore, the active layers **126** of the light-emitting devices **120** disposed on the backplane **110** may be respectively driven by the backplane **110**. In this embodiment, both the first distributed Bragg reflector layer **430** and the second distributed Bragg reflector layer **440** are formed with entire film layer and the holes are formed afterwards. Therefore, it is not required other subsequent processes (process of cutting or bonding the backplane **110**, for example) after respectively forming the first distributed Bragg reflector layer **430** and the second distributed Bragg reflector layer **440** on the light-emitting devices **120**. The display image of the display device **400** has higher color purity, and the display device **400** is easy to manufacture and has favorable cost-effectiveness.

FIG. **5**A is a cross-sectional view of a display device according to another embodiment of the invention. FIG. **5**B is an enlarged view of a region A**2** according to the embodiment of FIG. **5**A. A display device **500** of the embodiment of FIG. **5**A to FIG. **5**B is like the display device **100** of the embodiment of FIG. **1**A to FIG. **1**B. Please refer to the display device **100** for details of the components of the display device **500**. Thus, descriptions thereof are not repeated hereinafter. A main difference between the display device **500** and the display device **100** is as follows. In this embodiment, the light-emitting devices **520** (including a red light-emitting device **520***a*, a green light-emitting device **520***b*, and a blue light-emitting device **520***c*) of the display device **500** include a first type semiconductor layer **522**, an active layer **526**, and a second type semiconductor layer **524**, wherein the active layer **526** is disposed between the first type semiconductor layer **522** and the second type semiconductor layer **524**. In addition, the light-emitting device **520** further includes a first electrode **527**, a second electrode **528**, and an insulation layer IS. The first electrode **527** contacts electrically with the first type semiconductor layer **522**, and the second electrode **528** contacts electrically with the second type semiconductor layer **524**. Moreover, the insulation layer IS is formed on the surfaces of the first type semiconductor layer **522**, the active layer **526**, and the second type semiconductor layer **524** to electrically insulate the first electrode **527** from the second type semiconductor layer **524** and the active layer **526**. The insulation layer IS may be formed together with the filler F with use of the same material or be formed individually. Specifically, the first type semiconductor layer **522** of each light-emitting device **520** has a surface S that faces the active layer **526**. The surface S has a first portion surface S**1** and a second portion surface S**2**. Moreover, the active layer **526** covers the first portion surface S**1** and exposes the second portion surface S**2**. In this embodiment, the light-emitting devices **520** are horizontal structured micro-LED (μLED) chips, for example, which are different from the vertical structured light-emitting devices **120** (micro-LED (μLED) chips) of the embodiment of FIG. **1**A to FIG. **1**B.

In this embodiment, the second distributed Bragg reflector layer **540** is an insulator and includes a plurality of first conductive through holes **542** filled with an electrically conductive material **546** and a plurality of second conductive through holes **544** filled with the electrically conductive material **546**. The first type semiconductor layer **522** of each light-emitting device **520** is electrically connected with the electrically conductive material **546** of one of the first conductive through holes **542** through the first electrode **527**, and the second type semiconductor layer **524** of each light-emitting device **520** is electrically connected with the electrically conductive material **546** of one of the second conductive through holes **544** through the second electrode **528**. The first conductive through holes **542** and the second conductive through holes **544** electrically connect with the circuit structure (not shown) on the backplane **110** respectively, the light-emitting devices **520** electrically connect to the circuit structure on the backplane **110** respectively. Furthermore, the first conductive through holes **542** and the second conductive through holes **544** are located on the same side of the light-emitting devices **520**. In this embodiment, the first distributed Bragg reflector layer **530** located on the other side of the light-emitting devices **520** is electrically insulating to the light-emitting devices **520**. For example, the first distributed Bragg reflector layer **530** includes a non-conductive multilayer film. Nevertheless, the invention is not limited thereto.

In this embodiment, the projected area of the first distributed Bragg reflector layer **530** or the projected area of the second distributed Bragg reflector layer **540** on the backplane **110** is larger than the projected area of one light-emitting device **520** on the backplane **110**.

FIG. **5**C is an enlarged view of a region according to another light-emitting device structure of the embodiment of

FIG. **5**A. Please refer to FIG. **5**C. A light-emitting device **520'** is like the light-emitting device **520** shown in FIG. **5**B. A main difference between the light-emitting device **520'** and the light-emitting device **520** is as follows. The light-emitting device **520'** includes a first type semiconductor layer **522'**, an active layer **526'**, a second type semiconductor layer **524'**, a first electrode **527'**, a second electrode **528'**, and an insulation layer IS'. The insulation layer IS' electrically insulates the first electrode **527'** from the second type semiconductor layer **524'** and the active layer **526'**. Specifically, the first electrode **527'** is electrically connected with the first type semiconductor layer **522'** through a via hole, such that the first type semiconductor layer **522'** is electrically connected with the electrically conductive material **546'** of the first conductive through hole **542'** through the first electrode **527'**. In addition, the second type semiconductor layer **524'** is electrically connected with the electrically conductive material **546'** of the second conductive through hole **544'** through the second electrode **528'**.

FIG. **6**A is a cross-sectional view of a display device **600** according to yet another embodiment of the invention. FIG. **6**B is an enlarged view of a region A**3** according to the embodiment of FIG. **6**A. The display device **600** is like the display device **500** of the embodiment of FIG. **5**A to FIG. **5**B. Please refer to the display device **500** for details of the components of the display device **600**. Thus, descriptions thereof are not repeated hereinafter. A main difference between the display device **600** and the display device **500** is as follows. In this embodiment, the light-emitting devices **620** (including a red light-emitting device **620***a*, a green light-emitting device **620***b*, and a blue light-emitting device **620***c*) include a first type semiconductor layer **622**, an active layer **626**, and a second type semiconductor layer **624**, wherein the active layer **626** is disposed between the first type semiconductor layer **622** and the second type semiconductor layer **624**. In addition, the light-emitting device **620** further includes a first electrode **627**, a second electrode **628**, and an insulation layer IS. The first electrode **627** is in contact electrically with the first type semiconductor layer **622**, and the second electrode **628** is in contact electrically with the second type semiconductor layer **624**. The insulation layer IS is formed on the surfaces of the first type semiconductor layer **622**, the active layer **626**, and the second type semiconductor layer **624**, so as to electrically insulate the first electrode **627** from the second type semiconductor layer **624** and the active layer **626**. Specifically, the first type semiconductor layer **622** has a surface S facing the light-emitting layer **626**. The surface S has a first portion surface S**1** and a second portion surface S**2**. Moreover, the light-emitting layer **626** covers the first portion surface S**1** and exposes the second portion surface S**2**. In this embodiment, the first distributed Bragg reflector structure **630** is electrically insulated and includes a plurality of first conductive through holes **632** filled with an electrically conductive material **636** and a plurality of second conductive through holes **634** filled with the electrically conductive material **636**. The first type semiconductor layer **622** of each light-emitting device **620** is electrically connected with the first conductive through hole **632** through the first electrode **627**, and the second type semiconductor layer **624** of each light-emitting device **620** is electrically connected with the second conductive through hole **634** through the second electrode **628**. The light-emitting devices **620** electrically connect to the circuit structure (not shown) of the backplane **110** by the first conductive through holes **632** and the second conductive through holes **634** respectively, for example. Furthermore, the first conductive through holes **632** and the second conductive through holes **634** are located on the same side of the light-emitting devices **620**. In this embodiment, the second distributed Bragg reflector layer **640** includes a multilayer film that is formed with insulating material. Nevertheless, the invention is not limited thereto.

Specifically, the light-emitting layers **626** of the light-emitting devices **620** disposed on the backplane **110** may be respectively driven by the circuit structure of the backplane **110**. In this embodiment, the first distributed Bragg reflector layer **630** or the second distributed Bragg reflector layer **640** is manufactured by the entire layer on two opposite sides of the light-emitting devices **620** respectively. Thus, the projected area of the first distributed Bragg reflector layer **630** or the second distributed Bragg reflector layer **640** on the backplane **110** is larger than the projected area of one light-emitting device **620** on the backplane **110**. Therefore, the display device **600** has higher color purity, and the display device **600** is easy to manufacture and has favorable cost-effectiveness.

FIG. **6**C is an enlarged view of a region according to another light-emitting device structure of the embodiment of FIG. **6**A. A light-emitting device **620'** is like the light-emitting device **620** shown in FIG. **6**B. A main difference between the light-emitting device **620'** and the light-emitting device **620** is as follows. The light-emitting device **620'** includes a first type semiconductor layer **622'**, an active layer **626'**, a second type semiconductor layer **624'**, a first electrode **627'**, a second electrode **628'**, and an insulation layer IS'. The insulation layer IS' electrically insulates the first electrode **627'** from the second type semiconductor layer **624'** and the active layer **626'**. Specifically, the first electrode **627'** is electrically connected with the first type semiconductor layer **622'** through a via hole, such that the first type semiconductor layer **622'** is electrically connected with the electrically conductive material **636'** of the first conductive through hole **632'** through the first electrode **627'**. In addition, the second type semiconductor layer **624'** is electrically connected with the electrically conductive material **636'** of the second conductive through hole **634'** through the second electrode **628'**.

Based on the above, in the display device of the embodiments of the invention, the first distributed Bragg reflector layer is disposed between the backplane and the active devices, and the light-emitting devices are disposed between the first distributed Bragg reflector layer and the second distributed Bragg reflector layer. The light emitted by the light-emitting devices is reflected between the first distributed Bragg reflector layer and the second distributed Bragg reflector layer, and the full width at half maximum of the spectrum of the light will reduced when leave the second distributed Bragg reflector layer. Besides, the projected area of the first distributed Bragg reflector layer or the second distributed Bragg reflector layer on the backplane is larger than the projected area of one light-emitting device on the backplane. Thus, the first distributed Bragg reflector layer or the second distributed Bragg reflector layer may be manufactured with entire film on all the light-emitting devices to manufacture easily, and the process has favorable cost-effectiveness.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed embodiments without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the invention covers modifications and variations of this disclosure provided that they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A display device, comprising:

a backplane;

a plurality of light-emitting devices disposed on the backplane;

a first distributed Bragg reflector layer disposed between the backplane and the light-emitting devices; and

a second distributed Bragg reflector layer, wherein the light-emitting devices are disposed between the first distributed Bragg reflector layer and the second distributed Bragg reflector layer, and a projected area of the first distributed Bragg reflector layer on the backplane is larger than a projected area of one of the light-emitting devices on the backplane or a projected area of the second distributed Bragg reflector layer on the backplane is larger than a projected area of one of the light-emitting devices on the backplane.

2. The display device according to claim 1, wherein each of the light-emitting devices comprises a first type semiconductor layer, an active layer, and a second type semiconductor layer, wherein the active layer is disposed between the first type semiconductor layer and the second type semiconductor layer, the first type semiconductor layer is disposed between the active layer and the first distributed Bragg reflector layer, and the second type semiconductor layer is disposed between the second distributed Bragg reflector layer and the active layer, wherein at least one of the first distributed Bragg reflector layer and the second distributed Bragg reflector layer is conductive.

3. The display device according to claim 2, wherein the first distributed Bragg reflector layer is conductive and comprises a plurality of sub Bragg reflector structures that are separated from one another, and the first type semiconductor layer of each of the light-emitting devices is electrically connected with one of the sub Bragg reflector structures.

4. The display device according to claim 3, wherein the second distributed Bragg reflector layer is conductive, and the second type semiconductor layers of the light-emitting devices are electrically connected with the second distributed Bragg reflector layer.

5. The display device according to claim 3, wherein the second distributed Bragg reflector layer is an insulator and comprises a plurality of conductive through holes, and the second type semiconductor layer of each of the light-emitting devices is connected with one of the conductive through holes.

6. The display device according to claim 2, wherein the first distributed Bragg reflector layer is electrically insulated while the second distributed Bragg reflector layer is conductive, and the first distributed Bragg reflector layer comprises a plurality of conductive through holes, wherein the first type semiconductor layer of each of the light-emitting devices is connected with one of the conductive through holes of the first distributed Bragg reflector layer, and the second type semiconductor layers of the light-emitting devices are electrically connected with the second distributed Bragg reflector layer.

7. The display device according to claim 2, wherein a material of at least one of the first distributed Bragg reflector layer and the second distributed Bragg reflector layer comprises silver.

8. The display device according to claim 1, wherein each of the light-emitting devices comprises a first type semiconductor layer, an active layer, and a second type semiconductor layer, wherein the active layer is disposed between the first type semiconductor layer and the second type semiconductor layer, the first type semiconductor layer is disposed between the active layer and the first distributed Bragg reflector layer, and the second type semiconductor layer is disposed between the second distributed Bragg reflector layer and the active layer, wherein at least one of the first distributed Bragg reflector layer and the second distributed Bragg reflector layer is electrically insulated.

9. The display device according to claim 8, wherein the first distributed Bragg reflector layer and the second distributed Bragg reflector layer are electrically insulated, and the first distributed Bragg reflector layer comprises a plurality of first conductive through holes, and the first type semiconductor layer of each of the light-emitting devices is connected with one of the first conductive through holes, wherein the second distributed Bragg reflector layer comprises a plurality of second conductive through holes, and the second type semiconductor layer of each of the light-emitting devices is connected with one of the second conductive through holes.

10. The display device according to claim 8, wherein the first distributed Bragg reflector layer is electrically insulated, and the first distributed Bragg reflector layer comprises a plurality of first conductive through holes and a plurality of second conductive through holes, wherein the first type semiconductor layer of each of the light-emitting devices is connected with one of the first conductive through holes, and the second type semiconductor layer of each of the light-emitting devices is connected with one of the second conductive through holes.

11. The display device according to claim 8, wherein the second distributed Bragg reflector layer is electrically insulated, and the second distributed Bragg reflector layer comprises a plurality of first conductive through holes and a plurality of second conductive through holes, wherein the first type semiconductor layer of each of the light-emitting devices is connected with one of the first conductive through holes, and the second type semiconductor layer of each of the light-emitting devices is connected with one of the second conductive through holes.

12. The display device according to claim 1, wherein at least one of the first distributed Bragg reflector layer and the second distributed Bragg reflector layer comprises a multilayer film.

13. The display device according to claim 1, wherein a reflectivity of the first distributed Bragg reflector layer is different from a reflectivity of the second distributed Bragg reflector layer.

14. The display device according to claim 1, wherein each of the light-emitting devices is a micro-LED, and a diagonal length of each of the light-emitting devices falls in a range of 2 μm to 150 μm.

15. The display device according to claim 1, wherein the light-emitting devices emit lights include different colors.

16. The display device according to claim 1, wherein the projected area of the second distributed Bragg reflector layer on the backplane is larger than the projected area of one of the light-emitting devices on the backplane.

* * * * *

专利名称(译)	显示设备		
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申请号	US15/841290	申请日	2017-12-14
[标]申请(专利权)人(译)	錼创科技股份有限公司		
申请(专利权)人(译)	PLAYNITRIDE INC.		
当前申请(专利权)人(译)	PLAYNITRIDE INC.		
[标]发明人	LI YUN LI LAI YU HUNG LIN TZU YANG		
发明人	LI, YUN-LI LAI, YU-HUNG LIN, TZU-YANG		
IPC分类号	H01L33/60 H01L33/46 G02B5/08 H01L25/075 H01L33/62 H01L29/20 H01L33/10 H01L33/38 H01L33/08		
CPC分类号	H01L33/465 G02B5/085 H01L25/0753 H01L33/60 H01L33/62 H01L2933/0016 H01L33/08 H01L33/10 H01L33/382 G02B5/288		
审查员(译)	NGUYEN，THINHŤ		
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摘要(译)

提供一种显示装置，包括背板，多个发光装置，第一分布布拉格反射层和第二分布布拉格反射层。发光器件设置在背板上。第一分布式布拉格反射器层设置在背板和发光器件之间。发光器件设置在第一分布布拉格反射器层和第二分布布拉格反射器层之间。背板上的第一分布式布拉格反射器层的投影面积大于背板上的一个发光器件的投影面积或者背板上的第二分布式布拉格反射器层的投影面积大于投影面积背板上的一个发光装置。