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Min et al.

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(45) **Date of Patent: Aug. 19, 2025**

(54) **LIGHT EMITTING MODULE HAVING MOLDING LAYER INCLUDING LIGHT DIFFUSION LAYER AND BLACK MOLDING LAYER AND DISPLAY DEVICE HAVING THE SAME**

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(73) Assignee: **SEOUL VIOSYS CO., LTD.**, Ansan-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 677 days.

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(22) Filed: **Mar. 11, 2022**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**

H10H 20/855 (2025.01)
B29D 11/00 (2006.01)

(Continued)

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

CPC ***H10H 20/855*** (2025.01); ***B29D 11/00788*** (2013.01); ***B29D 11/00798*** (2013.01); ***H01L 25/0753*** (2013.01); *H10H 20/0363* (2025.01)

(58) **Field of Classification Search**

CPC H10H 20/855; B29D 11/00788; B29D 11/00798; H01L 25/0753

See application file for complete search history.

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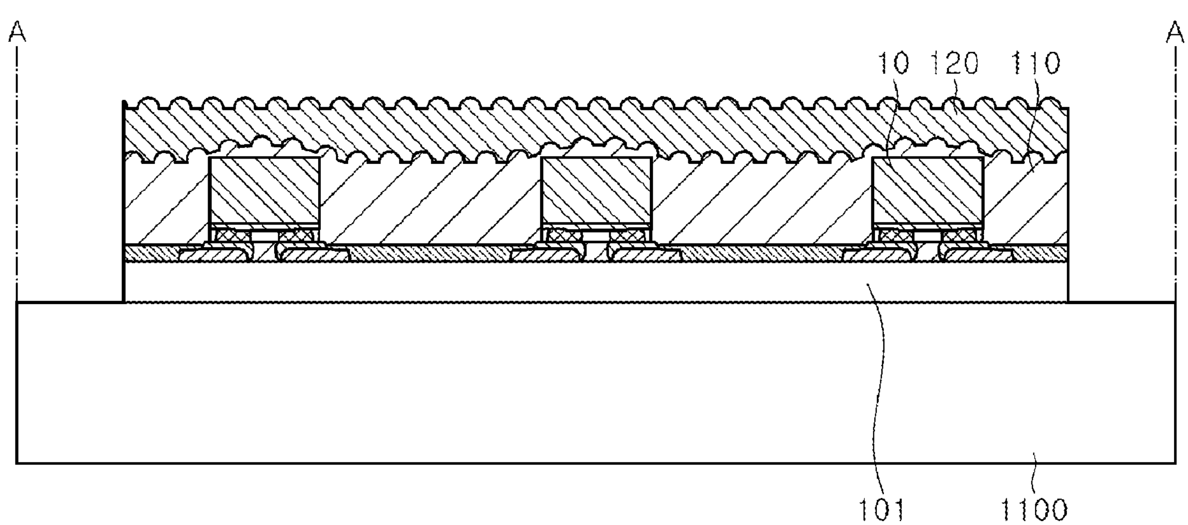
Primary Examiner — Michael Jung
(74) *Attorney, Agent, or Firm* — Perkins Coie LLP

(57) **ABSTRACT**

A method of manufacturing a light emitting module includes mounting a plurality of unit pixels on a module substrate, thermally curing a light diffusion film and a black film, laminating the light diffusion film and the black film, forming a molding layer to surround side surfaces of the plurality of unit pixels by disposing the laminated light diffusion film and the black film on the module substrate, and pressing the light diffusion film and the black film; and cutting and removing edges of the module substrate and the molding layer. The molding layer includes a light diffusion layer and a black molding layer disposed on the light diffusion layer.

20 Claims, 21 Drawing Sheets



(51) **Int. Cl.**
H01L 25/075 (2006.01)
H10H 20/01 (2025.01)

(56) **References Cited**

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FIG. 1A

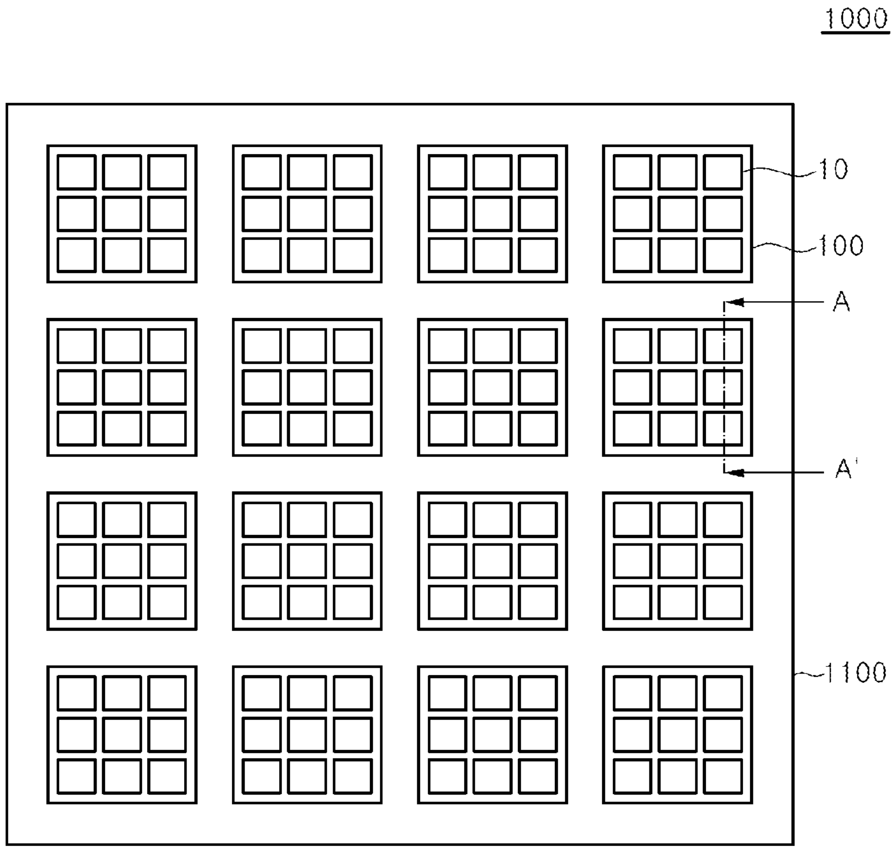


FIG. 1B

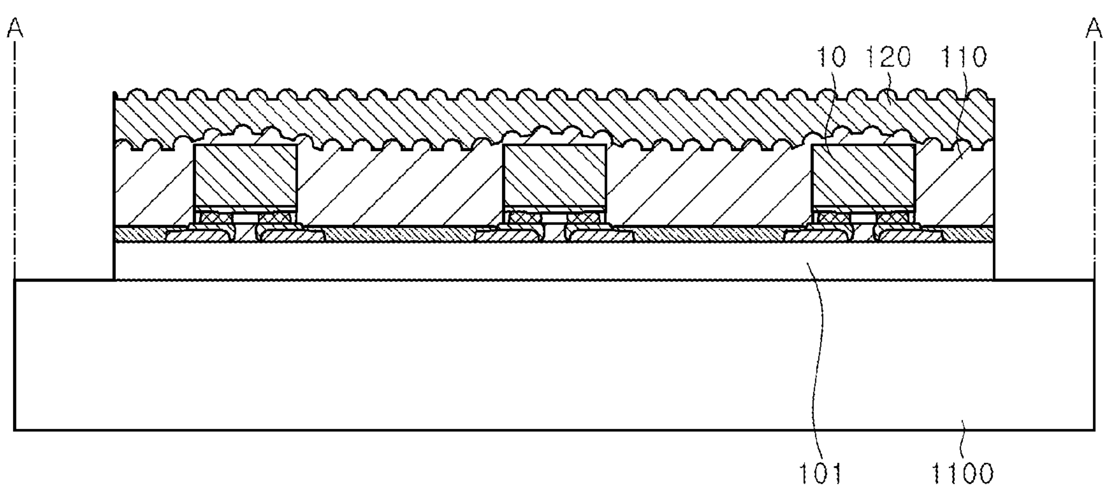
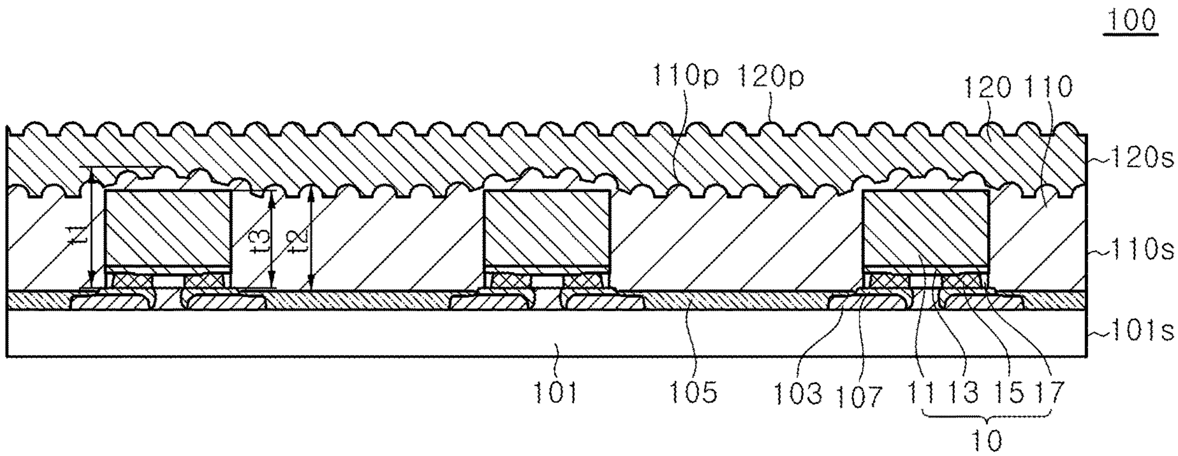


FIG. 2A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110p 120p
120 110
120s
110s
101s
t1
t3
t2
101
105
103 107
11 13 15 17
10

FIG. 2B

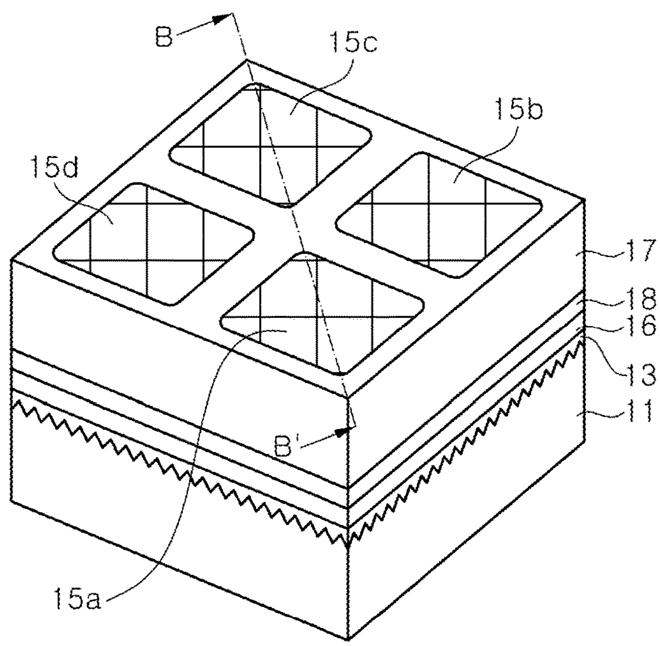

B
15c
15b
15d
17
18
16
13
11
B'
15a

FIG. 2C

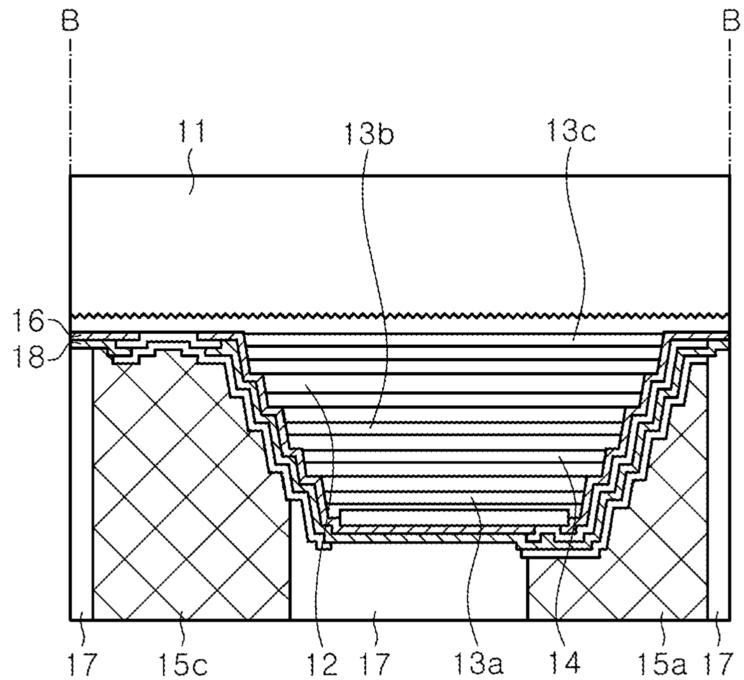


FIG. 2D

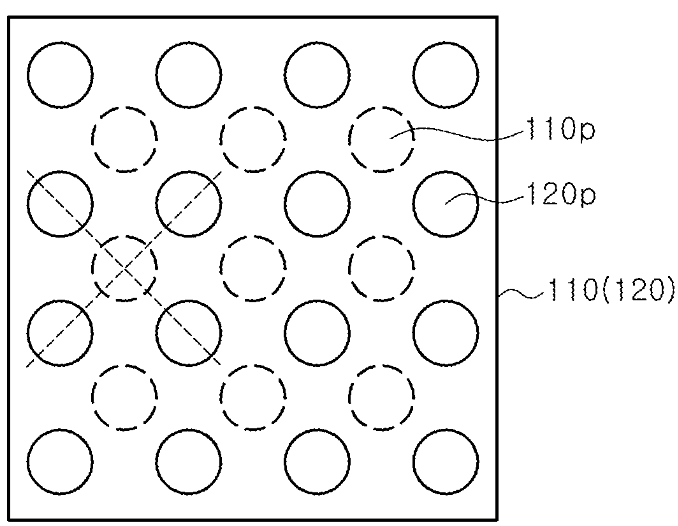


FIG. 3A

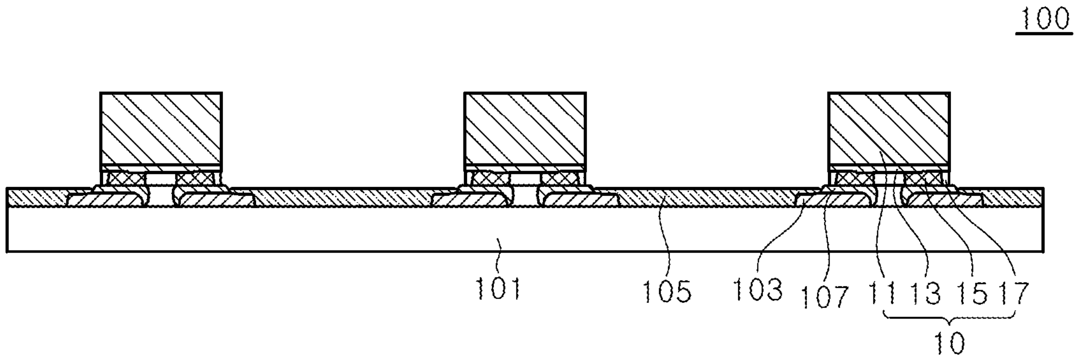


FIG. 3B

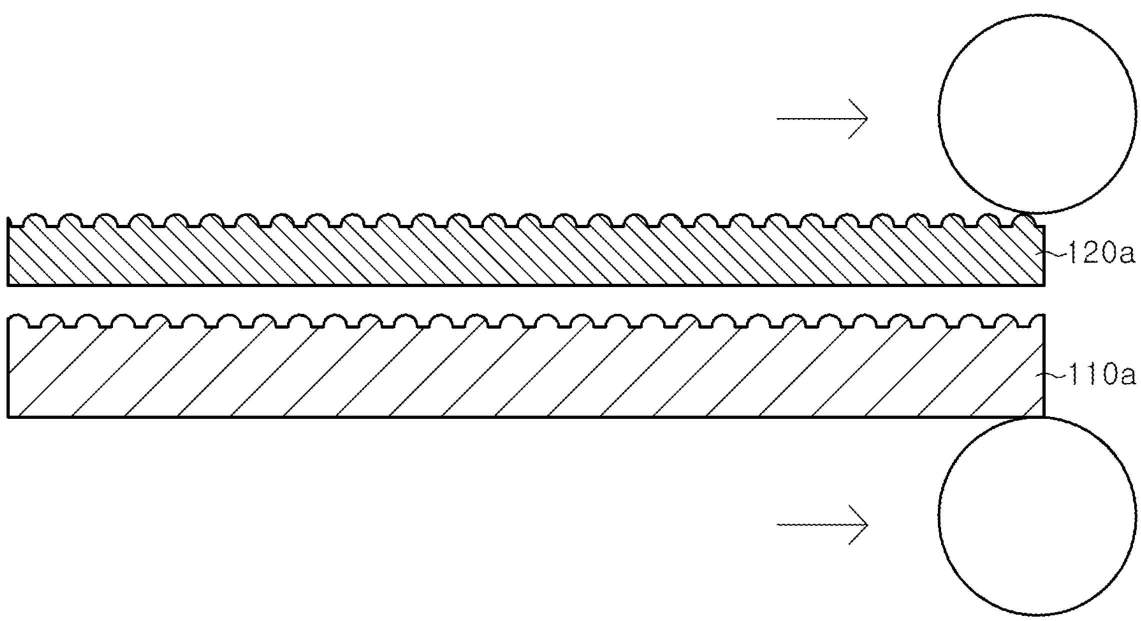
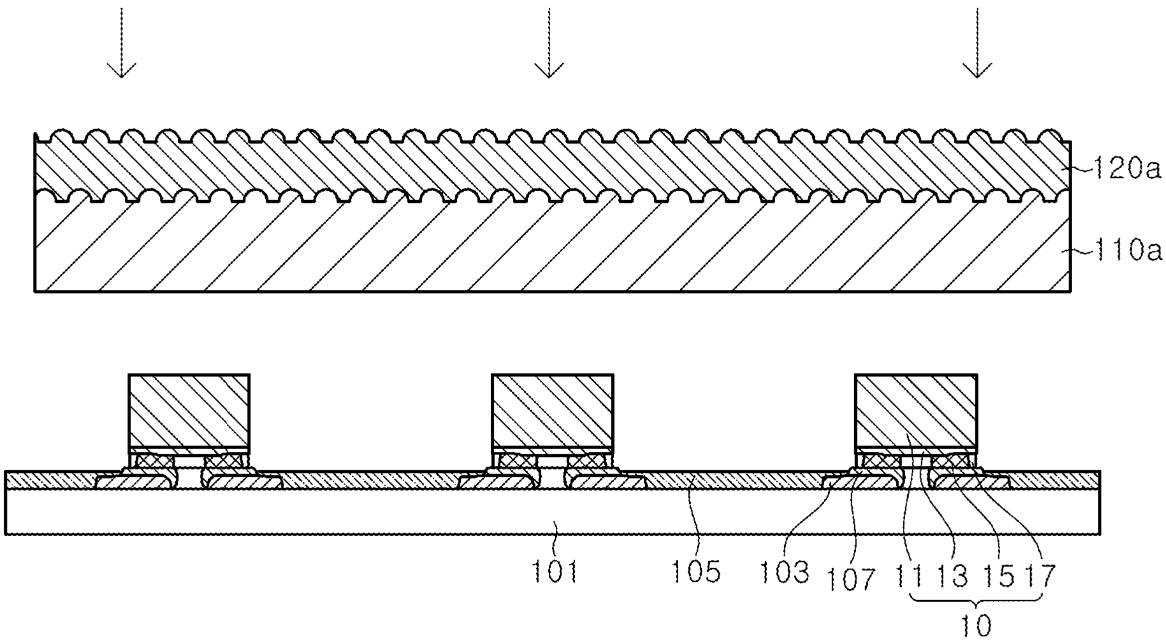
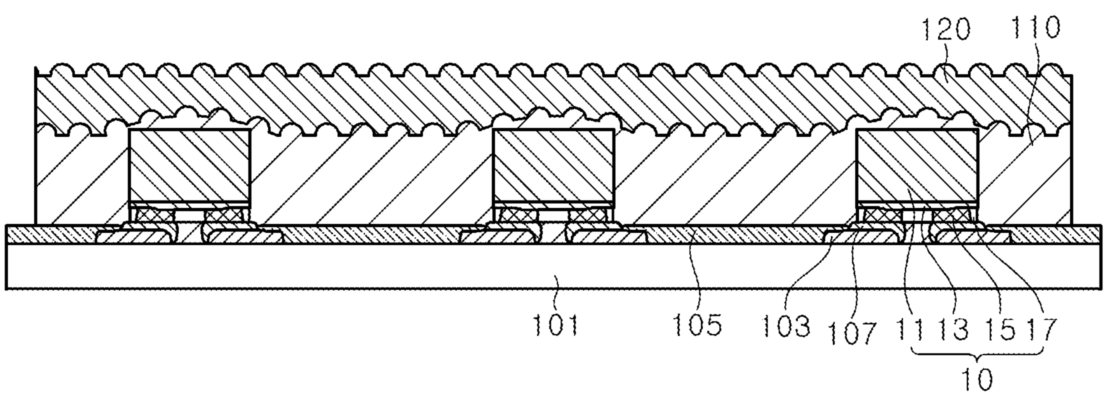


FIG. 3C



120a
110a
101
105
103
107
11
13
15
17
10

FIG. 3D



120
110
101
105
103
107
11
13
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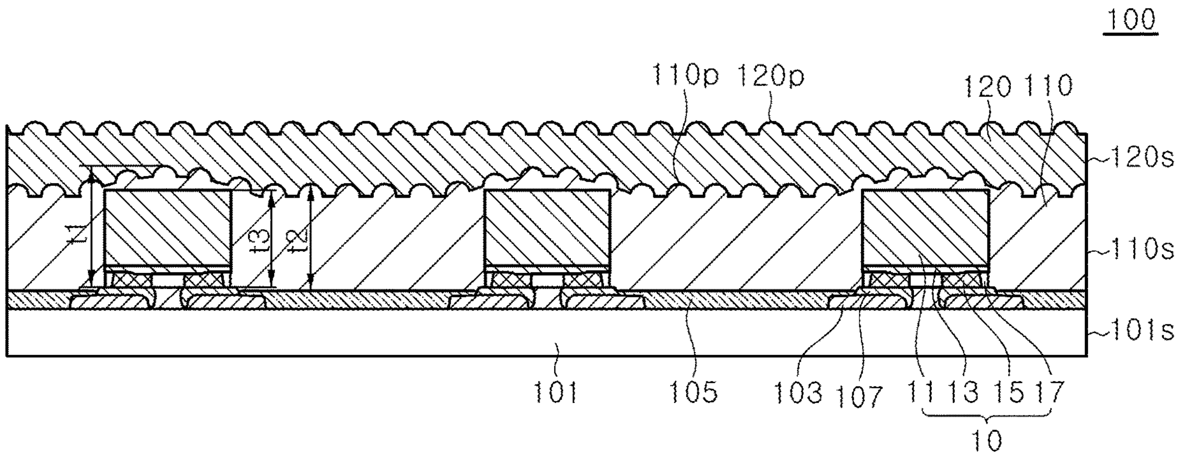
17
10

FIG. 3E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110s
101s
t1
t3
t2
101
105
103
107
11 13 15 17
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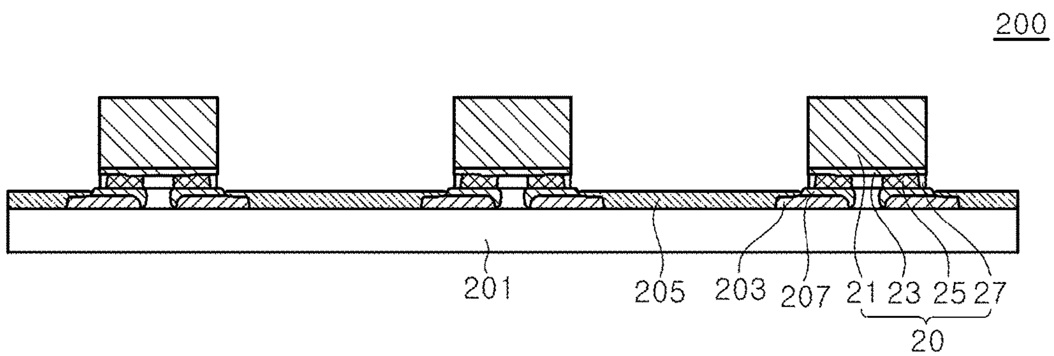
FIG. 4A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207
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20

FIG. 4B

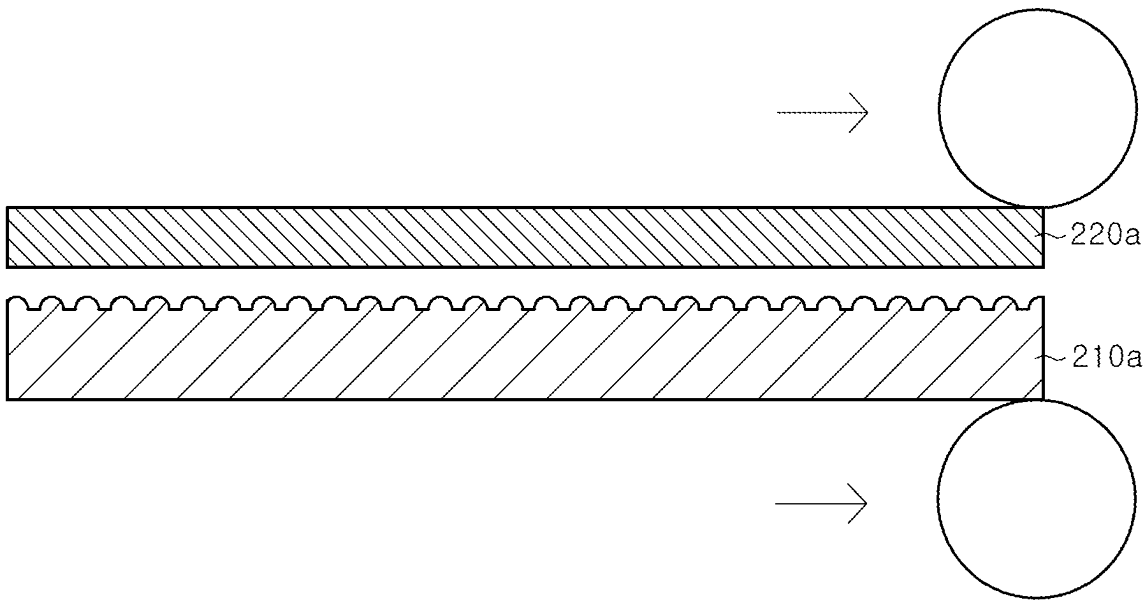


FIG. 4C

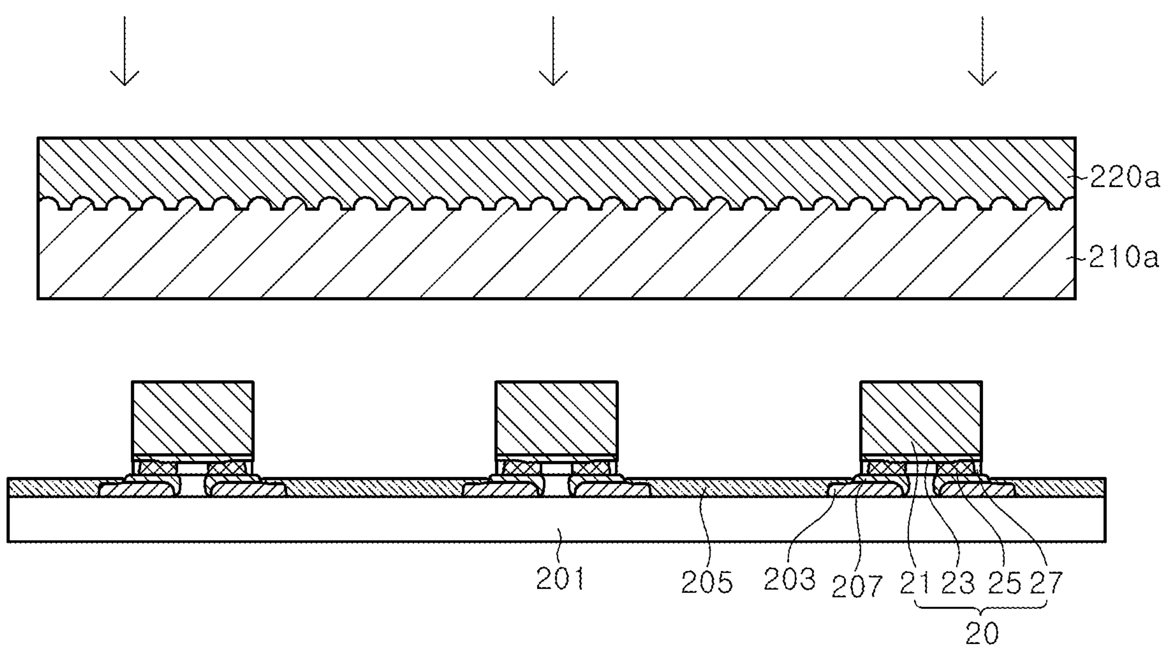
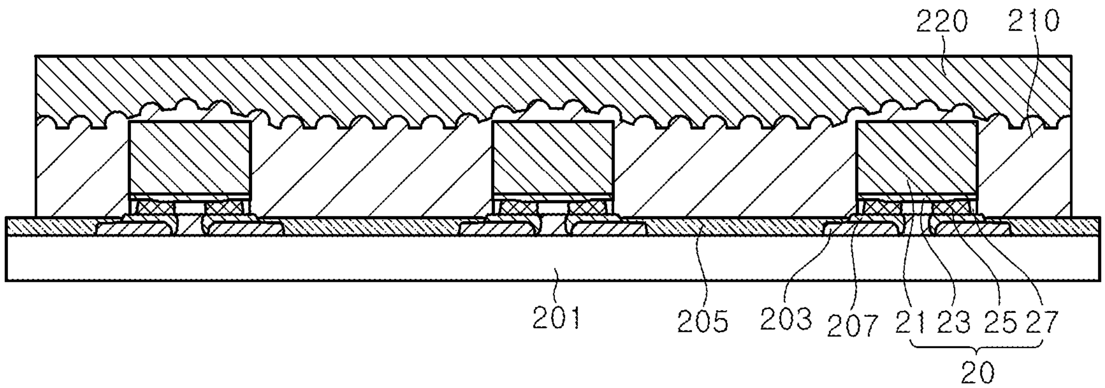


FIG. 4D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21
23
25
27
20

FIG. 4E

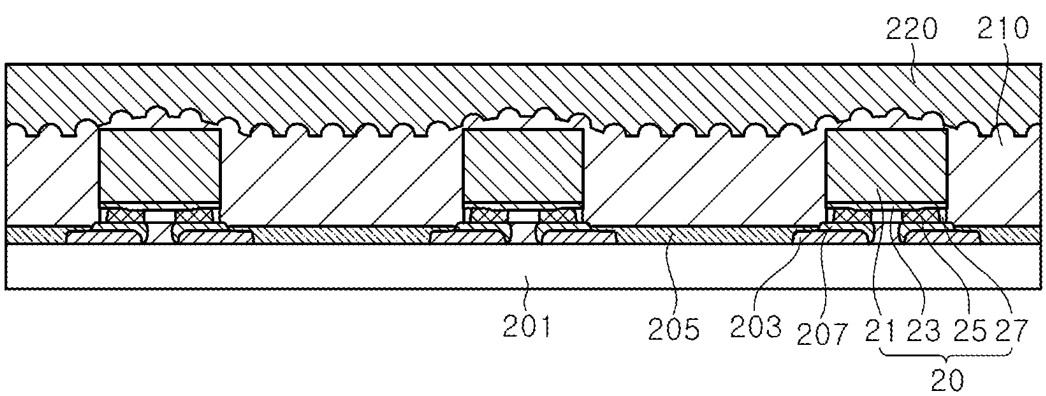
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FIG. 5A

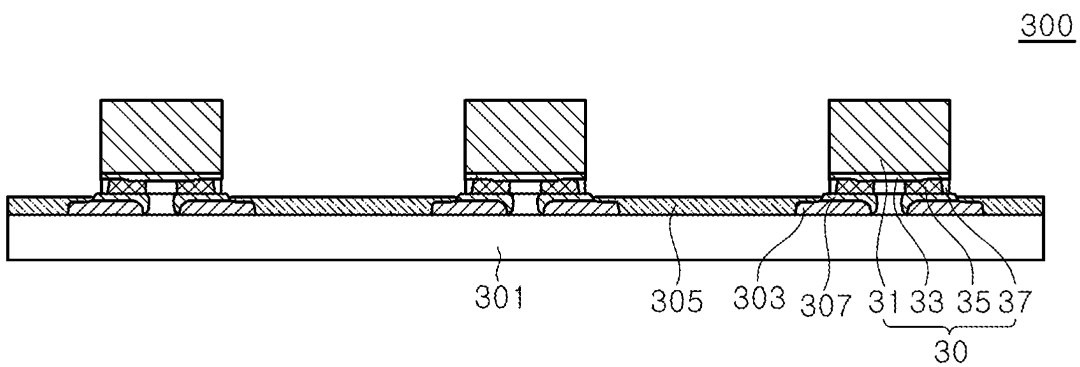


FIG. 5B

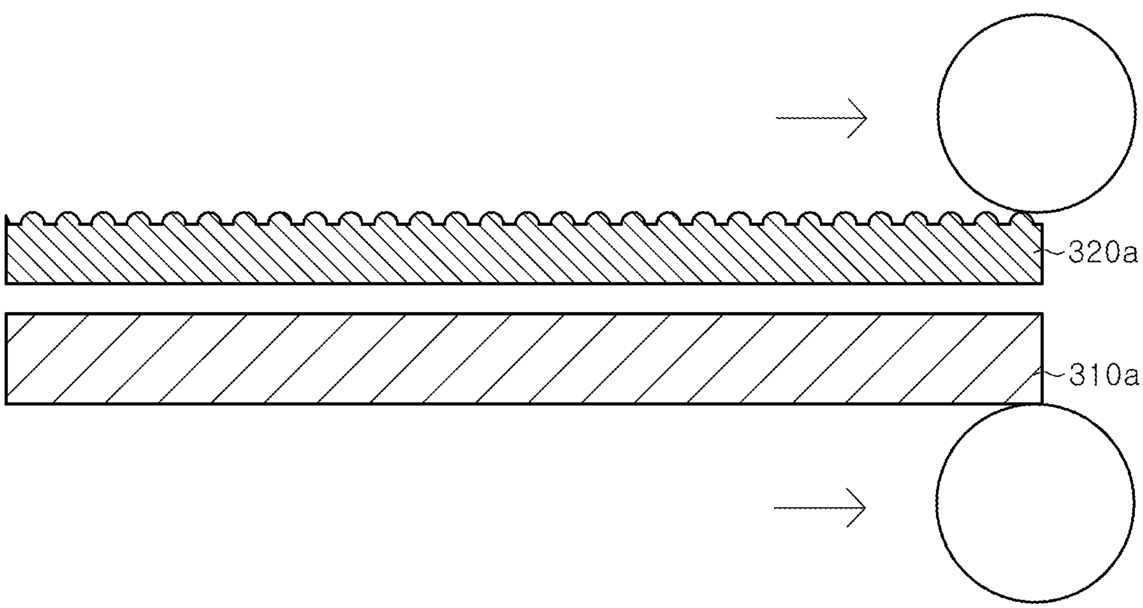


FIG. 5C

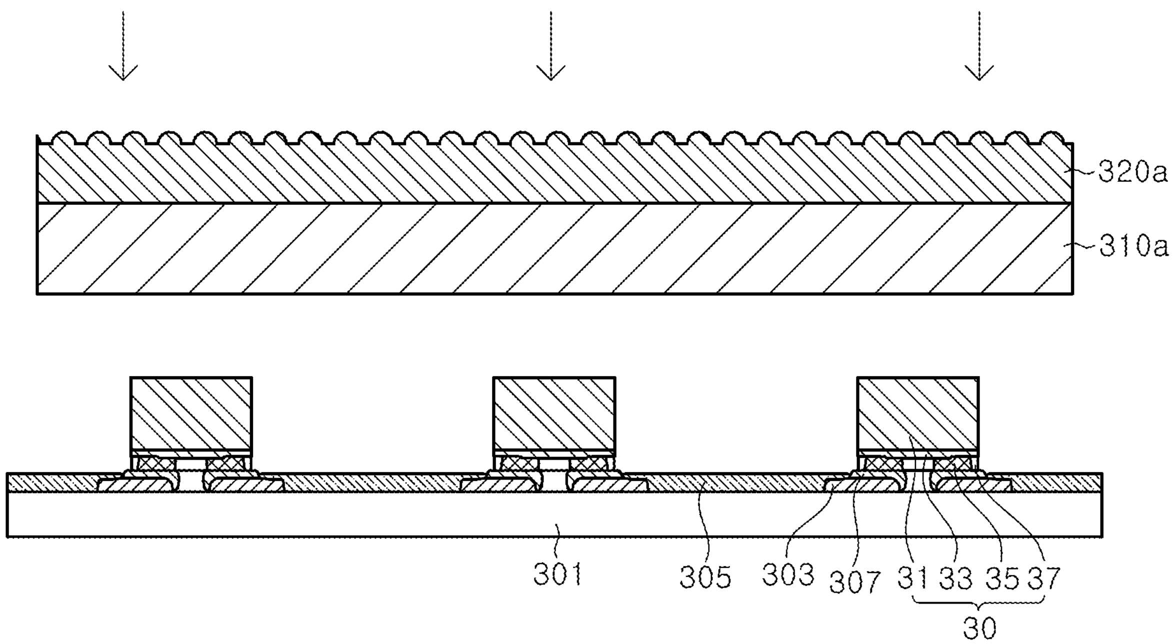
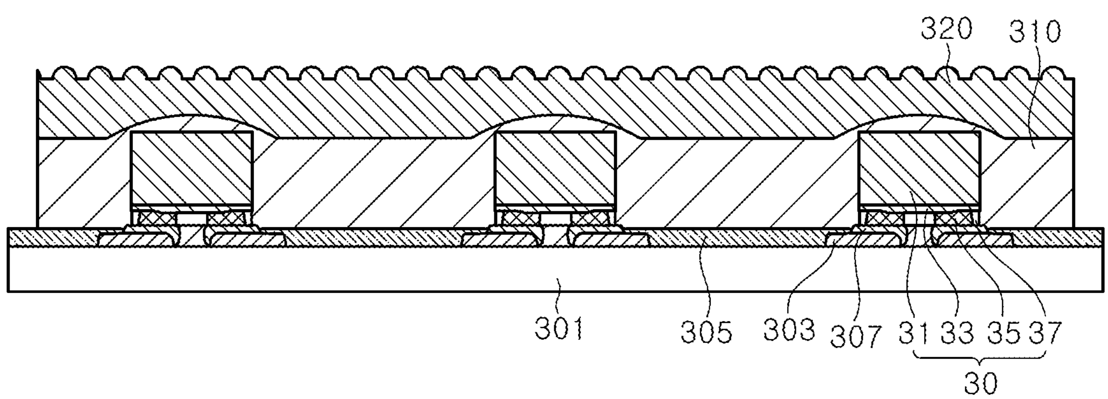

320a
310a
301
305
303
307
31
33
35
37
30

FIG. 5D


320
310
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37
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FIG. 5E

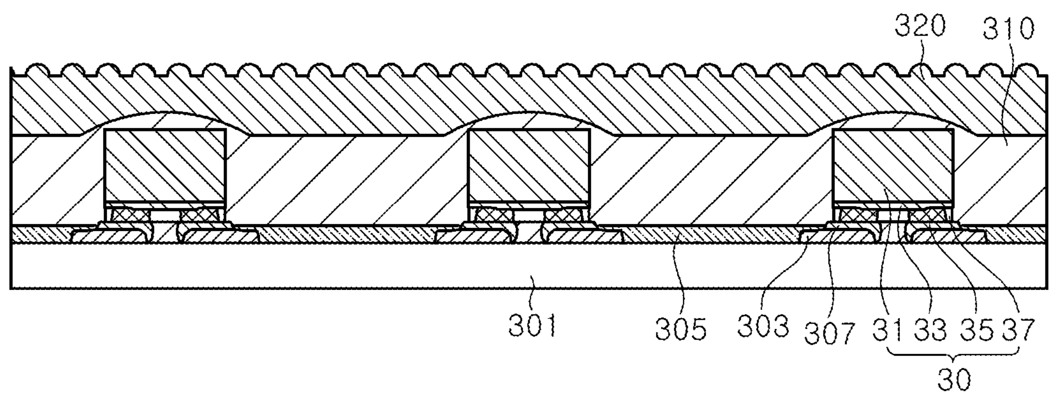


FIG. 6A

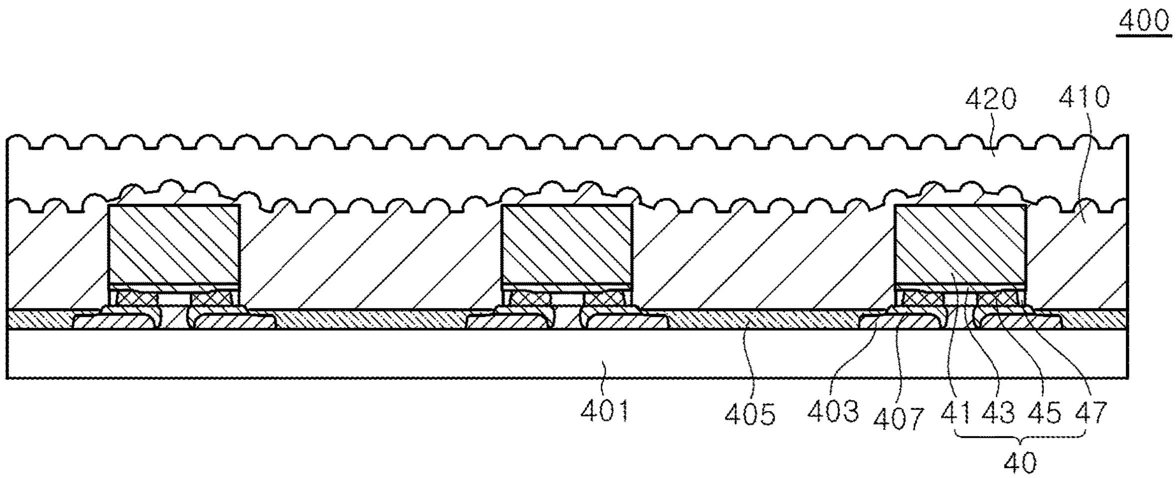


FIG. 6B

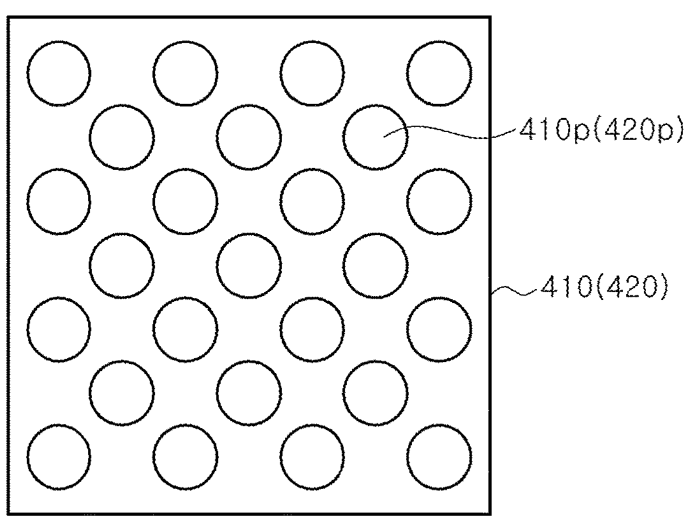


FIG. 7A

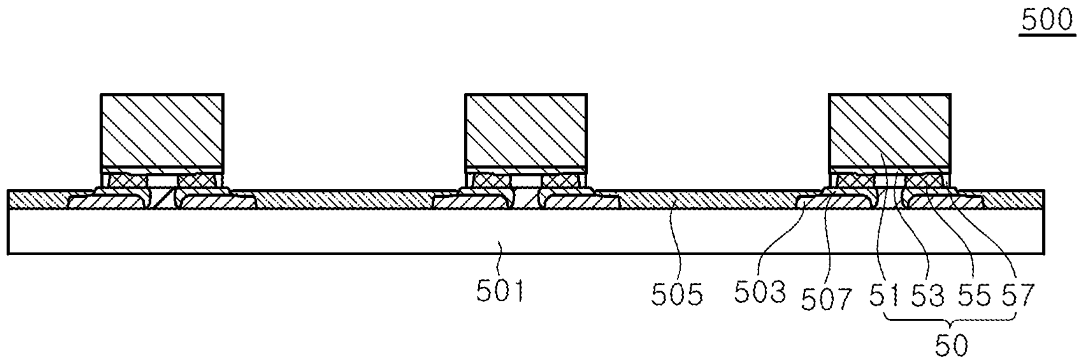


FIG. 7B

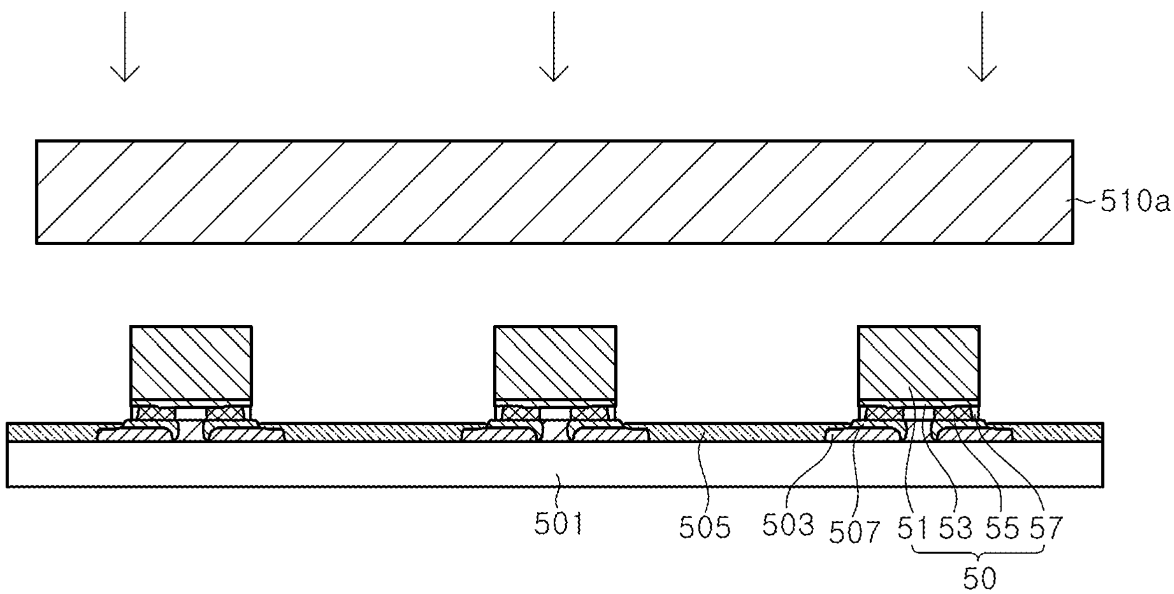


FIG. 7C

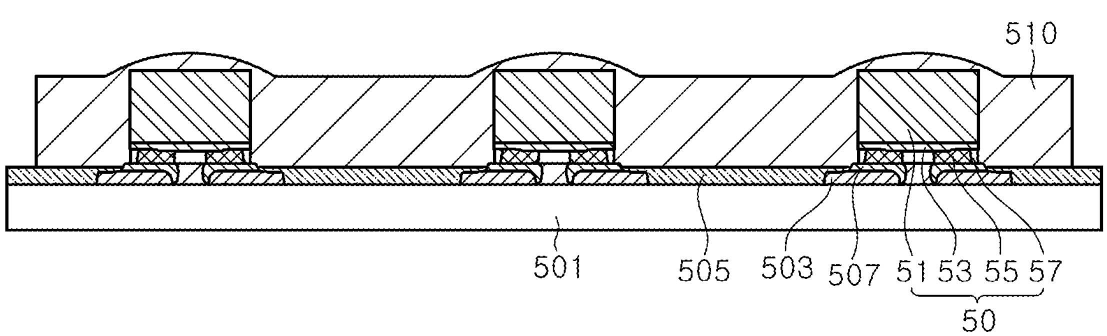


FIG. 7D

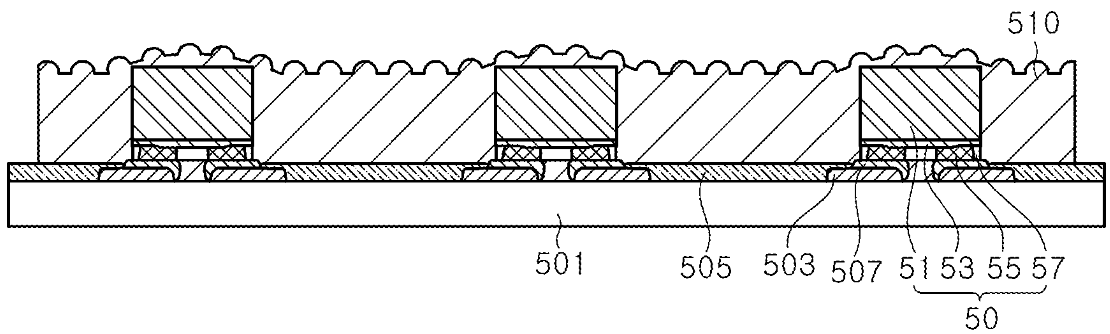

510
501
505
503
507
51
53
55
57
50

FIG. 7E

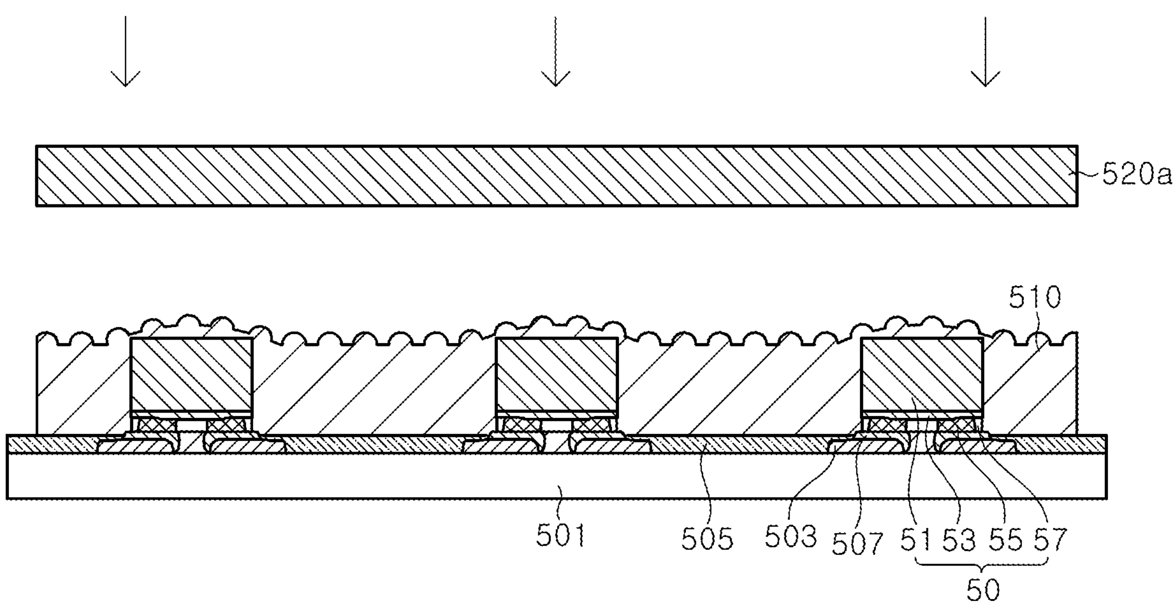
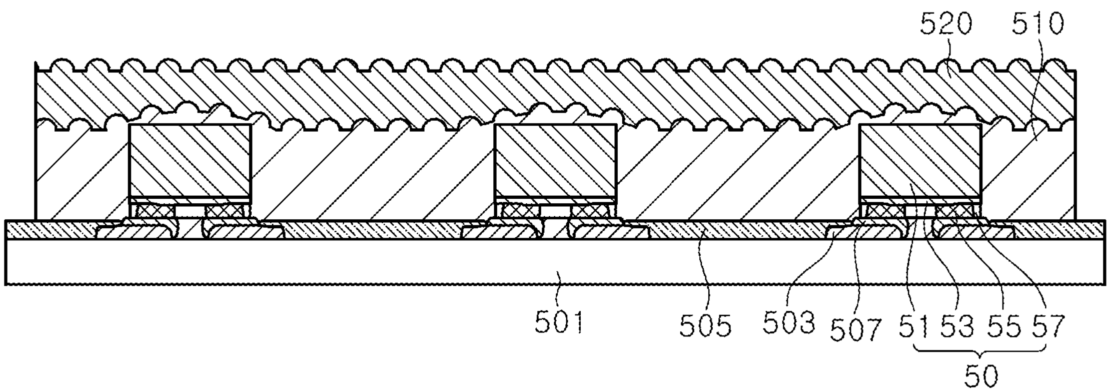

520a
510
501
505
503
507
51
53
55
57
50

FIG. 7F


520
510
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51
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55
57
50

FIG. 7G

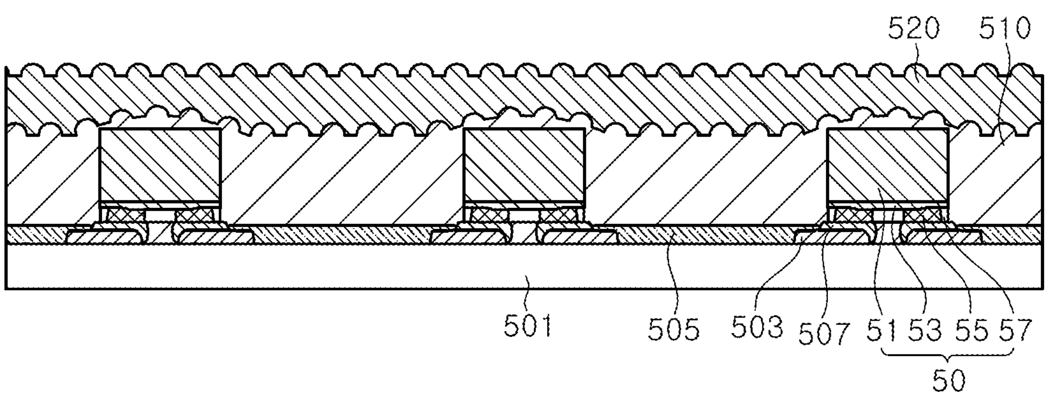
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FIG. 8A

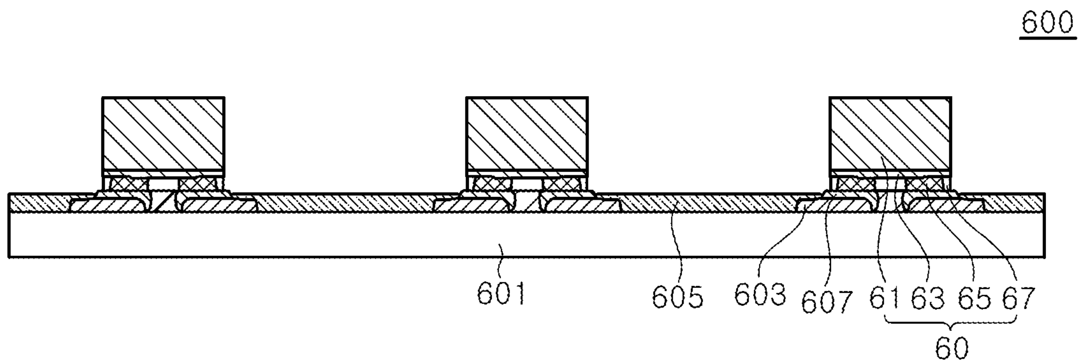


FIG. 8B

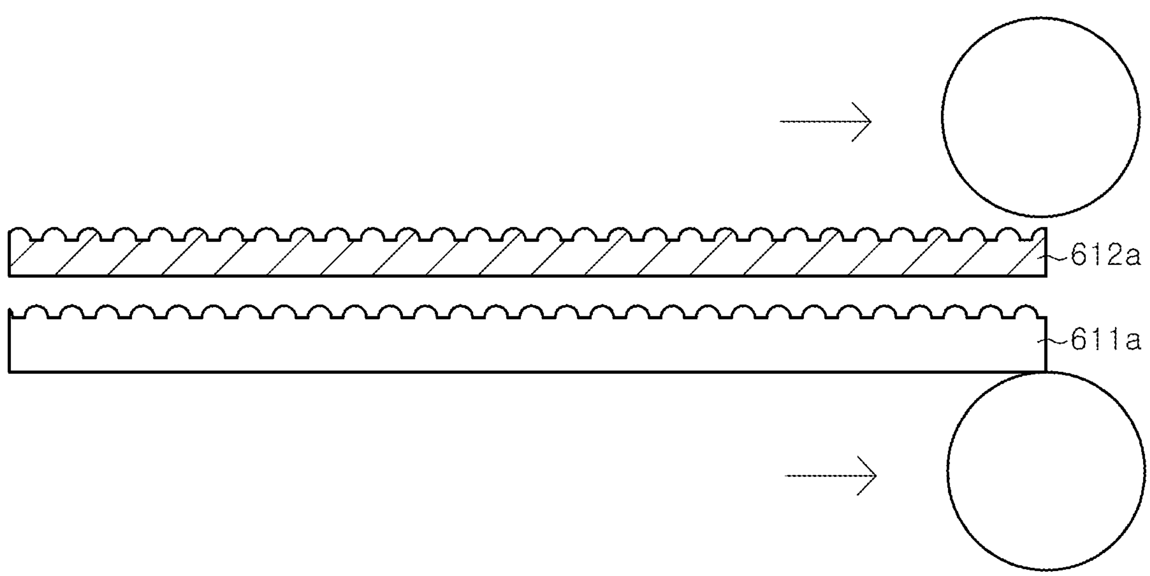
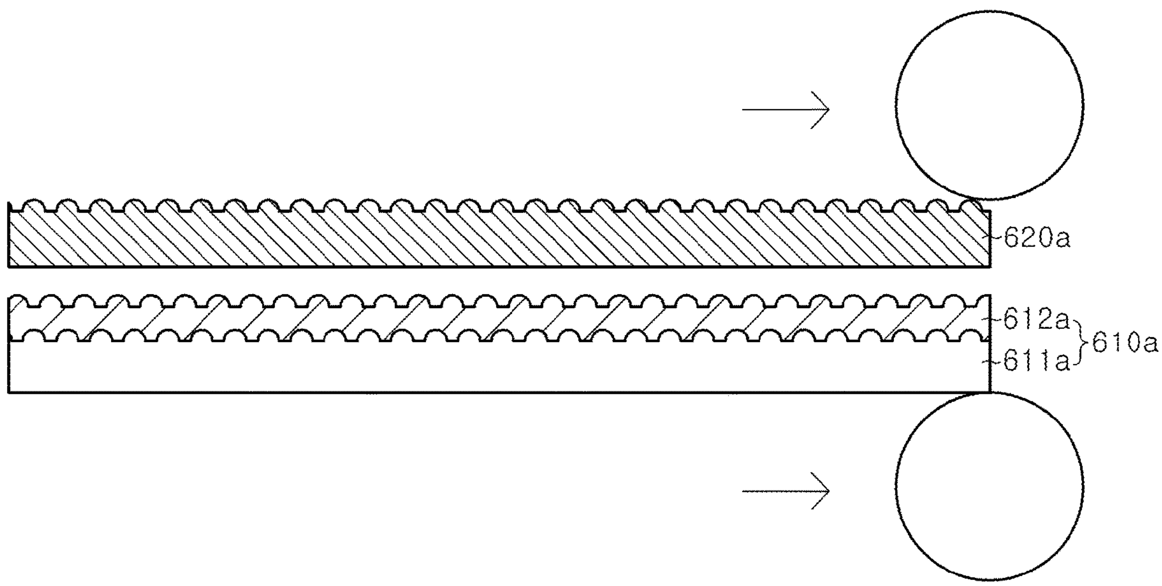


FIG. 8C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612a
610a
611a

FIG. 8D

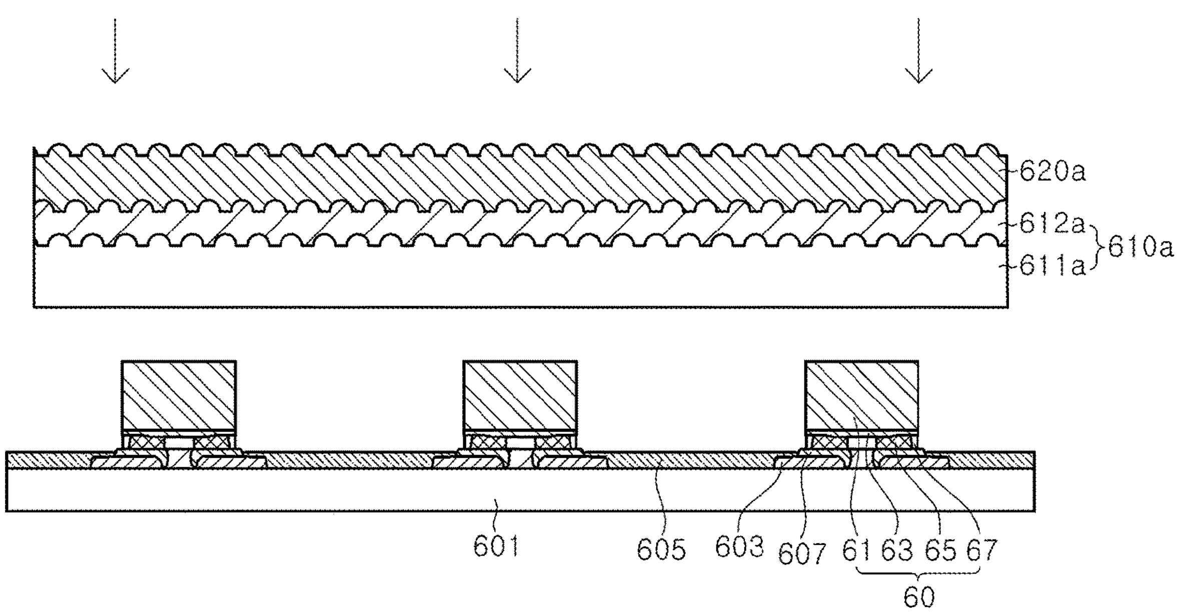
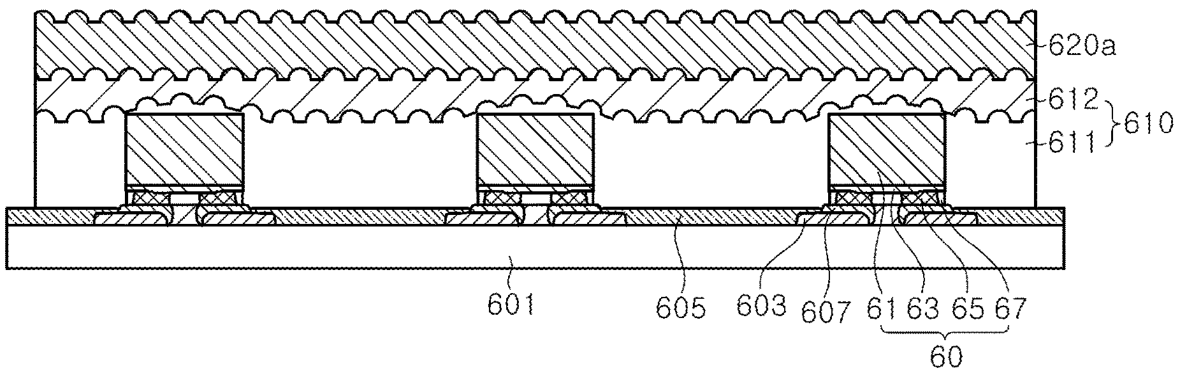

620a
612a
610a
611a
601
605
603
607
61
63
65
67
60

FIG. 8E


620a
612
610
611
601
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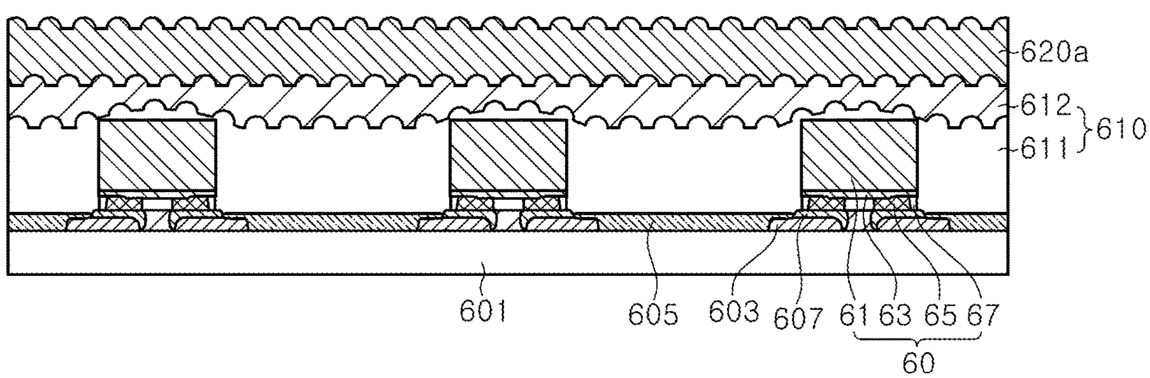
603
607
61
63
65
67
60

FIG. 8F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607
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63
65
67
60

FIG. 9A

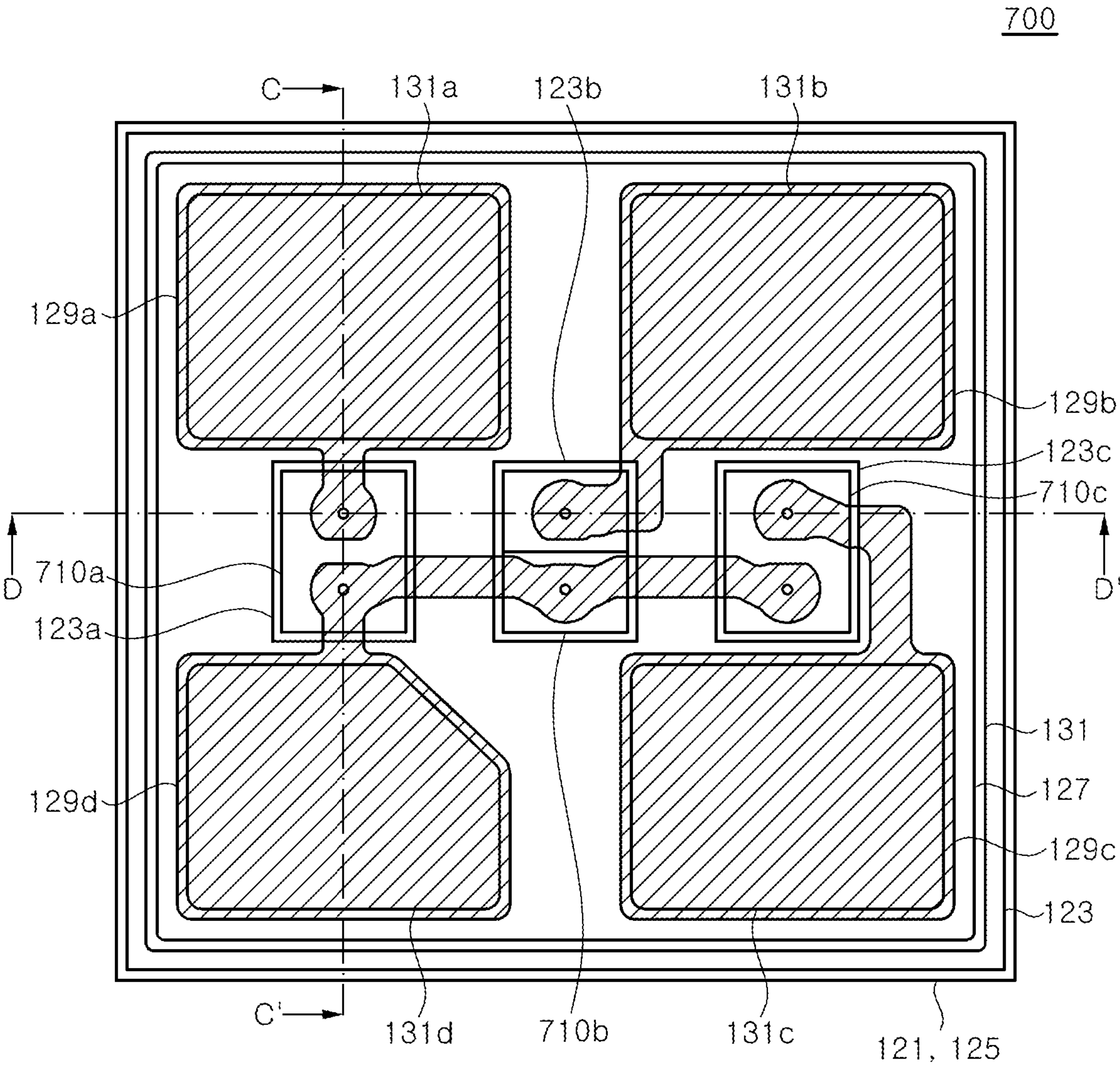
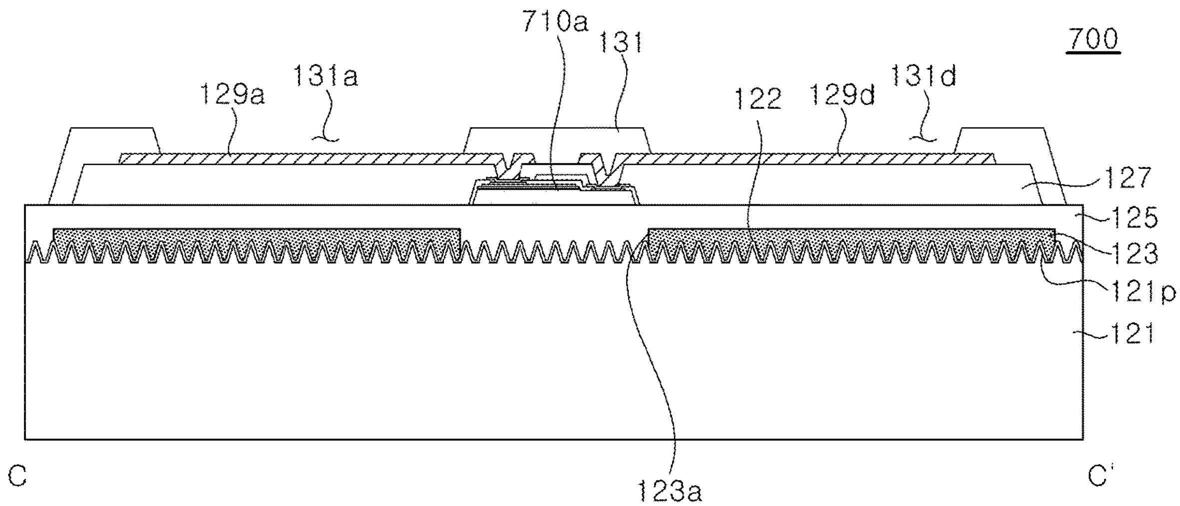
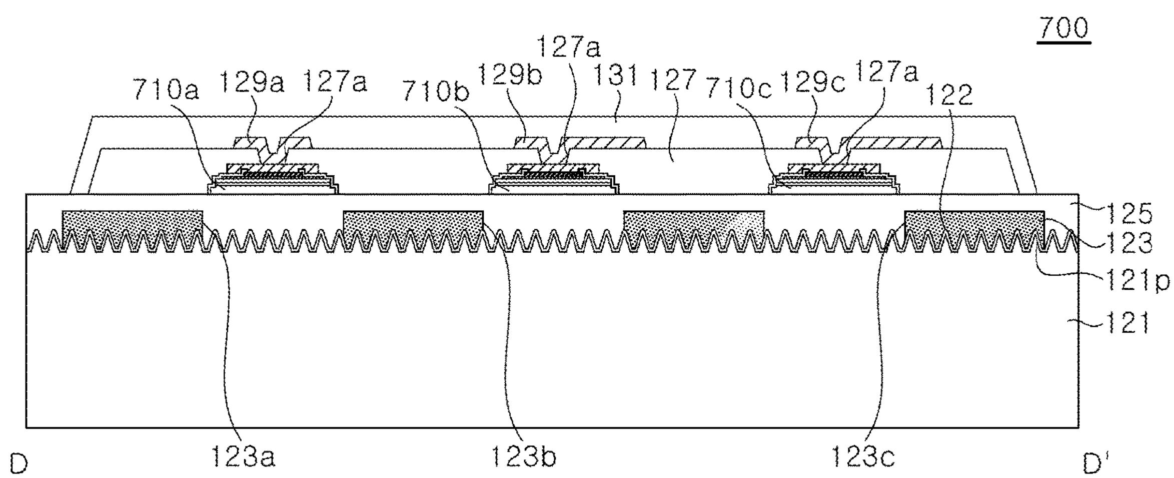

700
C
131a
123b
131b
129a
129b
123c
710c
D
710a
D'
123a
131
127
129d
129c
123
C'
131d
710b
131c
121, 125

FIG. 9B



700
710a
131
129a
131a
122
129d
131d
127
125
123
121p
121
C
C'
123a

FIG. 9C



700
127a
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127a
710b
129b
131
127
710c
129c
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122
125
123
121p
121
D
123a
123b
123c
D'

FIG. 10A

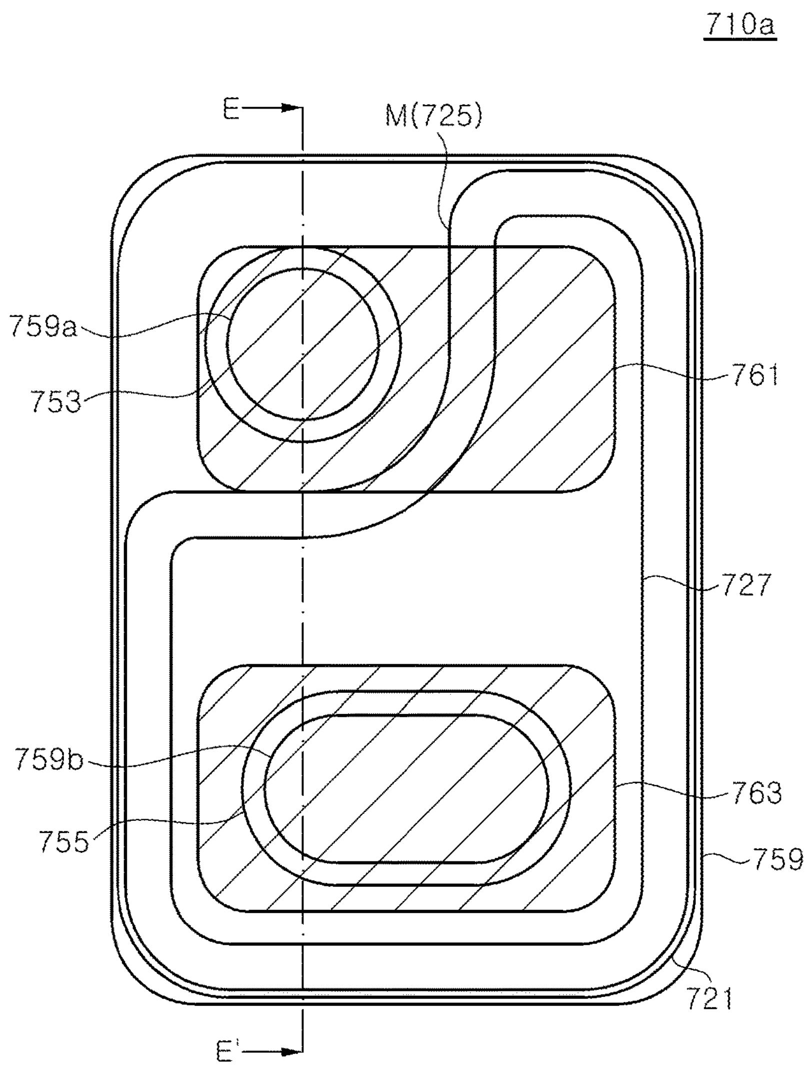
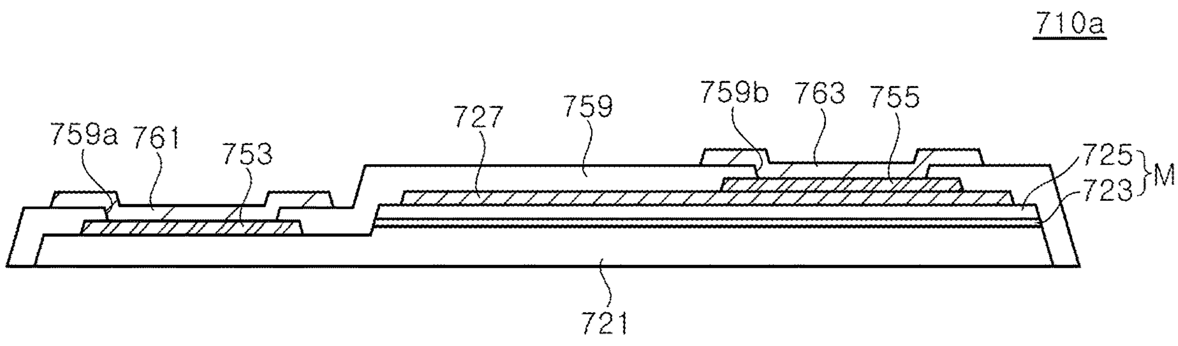


FIG. 10B



LIGHT EMITTING MODULE HAVING MOLDING LAYER INCLUDING LIGHT DIFFUSION LAYER AND BLACK MOLDING LAYER AND DISPLAY DEVICE HAVING THE SAME

CROSS-REFERENCE OF RELATED APPLICATIONS AND PRIORITY

The Present Applications is a nonprovisional application which claims priority to and benefit of U.S. Provisional Application Ser. Nos. 63/161,169 filed Mar. 15, 2021 and 63/306,280 filed Feb. 3, 2022, the disclosure of which are incorporated by reference as if fully set forth herein.

TECHNICAL FIELD

Exemplary embodiments relate to a light emitting module, a method of manufacturing the same, and a display apparatus having the same, and more particularly, to a light emitting module having multiple molding layers, a method of manufacturing the same, and a display apparatus having the same.

BACKGROUND

A light emitting diode is an inorganic semiconductor device that emits light generated through recombination of electrons and holes. Recently, the light emitting diode is used in various fields such as display apparatuses, automobile lamps, general lighting, and the like. The light emitting diode has an advantage such as longer lifespan, lower power consumption, and quicker response than a conventional light source. Utilizing these advantages, it is rapidly replacing the conventional light source.

The light emitting diode has been generally used as a backlight light source in a display apparatus, but a display apparatus that directly realizes images using the light emitting diode has been developed. Such a display is also referred to as a micro LED display. Since the micro LED display does not require a backlight and a bezel portion can be minimized, it can be made compact and thin, and it has favorable luminance, resolution, power consumption, and durability.

In a case of the micro LED display, a micro LED is arranged on a two-dimensional plane corresponding to each sub pixel, and a large number of micro LEDs are mounted on a single substrate. The micro LED is very small with a width of 200 μm or less, and further 100 μm or less. The micro LED display can be fabricated in various resolutions and sizes because a fabrication process thereof is simple. However, there is a need for a technique to secure visibility without distortion or loss of luminance of light emitted from the light emitting diodes after mounting small-sized light emitting diodes on a circuit board. In addition, in order to improve an image quality of the display apparatus using the light emitting diode as a direct light source, a technique for reducing a color change is also required.

SUMMARY

Exemplary embodiments of the present disclosure provide a light emitting module having an improved structure so as to minimize loss of luminance and secure visibility, a method of manufacturing the same, and a display apparatus having the same.

Exemplary embodiments of the present disclosure provide a light emitting module having an improved structure so as to alleviate a color change that may be caused by a circuit board on which a light emitting diode is mounted and minimize loss of luminance, a method of manufacturing the same, and a display apparatus having the same.

A method of manufacturing a light emitting module according to an exemplary embodiment of the present disclosure may include: mounting a plurality of unit pixels on a module substrate; preparing a light diffusion film and a black film, at least one of the light diffusion film and the black film including a pattern on an upper surface thereof; laminating the light diffusion film and the black film; forming a molding layer to surround side surfaces of the plurality of unit pixels by disposing the laminated light diffusion film and the black film on the module substrate, and pressing the light diffusion film and the black film; and removing edges of the module substrate and the molding layer by cutting them, in which the molding layer includes a light diffusion layer and a black molding layer disposed on the light diffusion layer.

Each of the plurality of unit pixels may include a first LED stack, a second LED stack, and a third LED stack stacked in a vertical direction.

The second LED stack may be disposed between the first LED stack and the third LED stack, and the third LED stack may emit light having a shorter wavelength than that of the first LED stack and emit light having a longer wavelength than that of the second LED stack.

Each of the plurality of unit pixels may include at least three light emitting devices emitting light of different colors from one another, and the at least three light emitting devices may be arranged on a same plane.

Laminating the light diffusion film and the black film may include thermally curing the light diffusion film and the black film at a temperature of about 50° C., respectively.

Laminating the light diffusion film and the black film may include roll lamination of the light diffusion film and the black film.

Forming the molding layer may include vacuum laminating the light diffusion film and the black film by pressing them with a uniform pressure at a temperature of about 60° C.

The method of manufacturing the light emitting module may further include laminating the light diffusion film with a transparent film before laminating the light diffusion film and the black film, in which the molding layer may further include a transparent molding layer opposite to the black molding layer and disposed under the light diffusion layer.

The light diffusion layer may include at least one of a thermosetting material and a photosensitive material, and the black molding layer may include at least one of a thermosetting material and a photosensitive material.

The light diffusion layer may include at least one of an acrylic-based, silicone-based, or urethane-based resin, and the black molding layer may include at least one of an acrylic-based, silicone-based, or urethane-based resin.

The light diffusion layer and the black molding layer may include a light absorber or a dye.

The pattern of the light diffusion film may be formed by pressing an upper portion of the thermally cured light diffusion film with a stamp after thermally curing the light diffusion film, and the pattern of the black film may be formed by pressing an upper portion of the thermally cured black film with a stamp after thermally curing the black film.

Elements of the pattern of the light diffusion layer and elements of the pattern of the black molding layer may overlap one another.

The elements of the pattern of the light diffusion layer and the elements of the pattern of the black molding layer may not overlap one another in a vertical direction.

A method of manufacturing a light emitting module may include: mounting a plurality of unit pixels on a module substrate; forming a light diffusion layer to surround side surfaces of the plurality of unit pixels by disposing the light diffusion film on the module substrate, and pressing it; forming a black molding layer by disposing the black film on the light diffusion layer, and pressing it; and removing edges of the module substrate, the light diffusion layer, and the black molding layer by cutting them.

The step of forming the light diffusion layer may include vacuum laminating the light diffusion layer by pressing it with a uniform pressure at a temperature of about 60° C.

The step of forming the black molding layer may include vacuum laminating the black molding layer by pressing it with a uniform pressure at a temperature of about 60° C.

Before the step of forming the black molding layer, a step of forming a pattern in an upper portion of the light diffusion layer may be further included.

A light emitting module according to an exemplary embodiment may include: a module substrate; a plurality of unit pixels disposed on the module substrate; and a molding layer covering the plurality of unit pixels, in which the molding layer may include a light diffusion layer and a black molding layer, at least one of the light diffusion layer and the black molding layer may include a pattern, and a side surface of the module substrate, a side surface of the light diffusion layer, and a side surface of the black molding layer may be located on a same plane.

Each of the light diffusion layer and the black molding layer may include a pattern on an upper surface thereof.

Each element of the pattern may be a hemispherical, conical, or grid pattern.

The light diffusion layer may include a convex portion on the plurality of unit pixels.

Further, the light diffusion layer may include a pattern, and an interval between elements of the pattern on the convex portion may be greater than an interval between the elements of the pattern on the upper surface of the light diffusion layer disposed in a region between the unit pixels.

The black molding layer may include a pattern, and elements of the pattern of the black molding layer may be spaced apart from one another at a substantially constant interval.

A thickness from an uppermost end of the light diffusion layer on the plurality of unit pixels to the module substrate may be greater than or equal to a thickness from the upper surface of the light diffusion layer disposed in the region between the unit pixels to the module substrate.

A thickness of the light diffusion layer disposed in the region between the unit pixels may be greater than a thickness of the unit pixels.

Each of the plurality of unit pixels may include a first LED stack, a second LED stack, and a third LED stack that are vertically stacked, or may include at least three light emitting devices arranged on a transparent substrate.

A display apparatus according to an exemplary embodiment may include a display substrate; and a plurality of light emitting modules arranged on the display substrate, in which each of the light emitting modules may include: a module substrate; and a light diffusion layer and a black molding layer disposed on the module substrate, in which at least one of the light diffusion layer and the black molding layer may include a pattern, a side surface of the module substrate, a side surface of the light diffusion layer, and a side surface of the black molding layer may be located on a same plane.

DESCRIPTION OF DRAWINGS

FIG. **1**A is a plan view illustrating a display apparatus according to an exemplary embodiment.

FIG. **1**B is a schematic cross-sectional view taken along line A-A' of FIG. **1**A.

FIG. **2**A is a schematic partial cross-sectional view illustrating an enlarged view of a light emitting module of FIG. **1**A.

FIG. **2**B is a schematic perspective view illustrating an enlarged view of a unit pixel of FIG. **2**A.

FIG. **2**C is a schematic cross-sectional view taken along line B-B' of FIG. **2**B.

FIG. **2**D is a schematic partial plan view illustrating an enlarged view of the light emitting module of FIG. **2**A.

FIGS. **3**A through **3**E are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to an exemplary embodiment, where:

FIG. **3**A illustrates a plurality of unit pixels mounted on a module substrate;

FIG. **3**B illustrates preparing a light diffusion film and a black film and forming patterns on upper surfaces of the light diffusion film and the black film;

FIG. **3**C illustrates thermally curing each film;

FIG. **3**D illustrates disposing the laminated light diffusion film and the black film on the module substrate and forming a light diffusion layer and a black molding layer; and

FIG. **3**E illustrates completing the light emitting module by cutting edges of the module substrate.

FIGS. **4**A through **4**E are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to another exemplary embodiment, where:

FIG. **4**A illustrates a plurality of unit pixels mounted on a module substrate;

FIG. **4**B illustrates preparing a light diffusion film and a black film and forming patterns on upper surfaces of the light diffusion film and the black film;

FIG. **4**C illustrates thermally curing each film;

FIG. **4**D illustrates forming a light diffusion layer and a black molding layer; and

FIG. **4**E illustrates completing the light emitting module by cutting edges of the module substrate.

FIGS. **5**A through **5**E are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to another exemplary embodiment, where:

FIG. **5**A illustrates a plurality of unit pixels mounted on a module substrate;

FIG. **5**B illustrates preparing a light diffusion film with flat upper and lower surfaces and a black film;

FIG. **5**C illustrates thermally curing each film;

FIG. **5**D illustrates forming a light diffusion layer and a black molding layer; and

FIG. **5**E illustrates manufacturing the light emitting module by cutting the module substrate.

FIG. **6**A is a cross-sectional view illustrating a method of manufacturing a light emitting module according to another exemplary embodiment.

FIG. **6**B is a schematic plan view of FIG. **6**A.

FIGS. 7A through 7G are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to another exemplary embodiment, where:

FIG. 7A illustrates a plurality of unit pixels mounted on a module substrate;

FIG. 7B illustrates disposing a light diffusion film on the plurality of unit pixels;

FIG. 7C illustrates forming a light diffusion layer on the module substrate;

FIG. 7D illustrates forming a first pattern on an upper surface of the light diffusion layer;

FIG. 7E illustrates forming a black molding layer on the light diffusion layer using a black film; and

FIG. 7F illustrates forming a second pattern on an upper surface of the black molding layer; and

FIG. 7G illustrates completing a light emitting module by cutting and removing edges of the module substrate, the light diffusion layer, and the black molding layer.

FIGS. 8A through 8F are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to an exemplary embodiment, where:

FIG. 8A illustrates a plurality of unit pixels mounted on a module substrate;

FIG. 8B illustrates preparing a light diffusion film and a black film by forming a pattern on upper surfaces thereof;

FIG. 8C illustrates an additional step of forming the light diffusion film by laminating a plurality of films;

FIG. 8D illustrates thermally curing the light diffusion film and the black film on the module substrate;

FIG. 8E illustrates disposing the laminated light diffusion film and the black film on the module substrate; and

FIG. 8F illustrates manufacturing the light emitting module by cutting edges of the module substrate.

FIG. 9A is a schematic plan view illustrating a unit pixel according to another exemplary embodiment.

FIG. 9B is a schematic cross-sectional view taken along line C-C' of FIG. 9A.

FIG. 9C is a schematic cross-sectional view taken along line D-D' of FIG. 9A.

FIG. 10A is a schematic plan view illustrating a light emitting device of FIG. 9A.

FIG. 10B is a schematic cross-sectional view taken along line E-E' of FIG. 10A.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Hereinafter, exemplary embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. The following exemplary embodiments are provided by way of example so as to fully convey the spirit of the present disclosure to those skilled in the art to which the present disclosure pertains. Accordingly, the present disclosure is not limited to the embodiments disclosed herein and can also be implemented in different forms. In the drawings, widths, lengths, thicknesses, and the like of elements can be exaggerated for clarity and descriptive purposes. When an element or layer is referred to as being "disposed above" or "disposed on" another element or layer, it can be directly "disposed above" or "disposed on" the other element or layer or intervening elements or layers can be present. Throughout the specification, like reference numerals denote like elements having the same or similar functions.

FIG. 1A is a plan view illustrating a display apparatus **1000** according to an exemplary embodiment, and FIG. 1B is a schematic cross-sectional view taken along line A-A' of FIG. 1A.

Referring to FIGS. 1A and 1B, the display apparatus **1000** may include a panel substrate **1100**, and a plurality of light emitting modules **100**. The light emitting module **100** includes a module substrate **101**, a plurality of unit pixels **10** disposed on the module substrate **101**, and a molding layer covering the plurality of unit pixels. The molding layer may include a light diffusion layer **110** and a black molding layer **120**.

The panel substrate **1100** may be formed of a material such as polyimide (PI), FR4, or glass, and may include a circuit for passive matrix driving or active matrix driving. In addition, the panel substrate **1100** may include an interconnection and a resistor, without being limited thereto, or the panel substrate **1100** may include an interconnection, a transistor, a capacitor, and the like. The panel substrate **1100** may have pads electrically connected to a circuit on an upper surface thereof. The plurality of light emitting modules **100** may be arranged on the panel substrate **1100**.

Although the panel substrate **1100** has been described as including the circuit in the present exemplary embodiment, the panel substrate **1100** does not necessarily include the circuit. For example, the panel substrate **1100** may function as supporting the light emitting modules **100** and include no circuit. Furthermore, the light emitting modules **100** may be arranged on a frame instead of the panel substrate **1100**.

The plurality of light emitting modules **100** may be arranged in a matrix form on the panel substrate **1100**. The plurality of light emitting modules **100** may be arranged in 3×3 as shown in FIG. 1A, without being limited thereto. Alternatively, the plurality of light emitting modules **100** may be arranged in various matrices such as 4×4, 5×5, 6×6 (n×m, n=1, 2, 3, 4, . . . , m=1, 2, 3, 4, . . .).

Each of the light emitting modules **100** may include the module substrate **101**, the plurality of unit pixels **10** arranged on the module substrate **101**, and the molding layer covering the plurality of unit pixels **10**. In addition, the molding layer may include the light diffusion layer **110** disposed to surround the plurality of unit pixels **10** and the black molding layer **120** disposed on the light diffusion layer **110**.

Hereinafter, each element of the display apparatus **1000** and a manufacturing method thereof will be described in detail in an order of the light emitting module **100** disposed in the display apparatus **1000**, and the plurality of unit pixels **10** arranged in the light emitting module **100**.

FIG. 2A is a partial cross-sectional view illustrating an enlarged view of the light emitting module of FIG. 1A, FIG. 2B is a perspective view illustrating an enlarged view of the unit pixel of FIG. 2A, FIG. 2C is a schematic cross-sectional view taken along line B-B' of FIG. 2B, and FIG. 2D is a schematic partial plan view illustrating an enlarged view of the light emitting module of FIG. 2A.

Referring to FIGS. 2A, 2B, and 2C, the light emitting module **100** may include the module substrate **101**, the plurality of unit pixels **10** disposed on the module substrate **101**, the light diffusion layer **110** and the black molding layer **120**.

The module substrate **101** may include a circuit connected to the plurality of unit pixels **10**. In an exemplary embodiment, the module substrate **101** may include, for example, a circuit for electrically connecting the panel substrate **1100** and the plurality of unit pixels **10**. The circuit in the module substrate **101** may be formed in a multi-layered structure. In an exemplary embodiment, the module substrate **101** may include a passive circuit for driving the plurality of unit pixels **10** in a passive matrix driving manner or an active circuit for driving the plurality of unit pixels **10** in an active matrix driving manner. The module substrate **101** may include pads **103** for electrical connection to the unit pixel **100**.

A black protection layer **105** may be disposed on the module substrate **101**, and the black protection layer **105** may be in contact with the module substrate **101**. In more detail, the black protection layer **105** may be formed so as to expose at least portions of the module substrate **101** and the pad **103** on the module substrate **101**. An upper surface of the black protection layer **105** may be substantially flat compared to a lower surface thereof.

The black protection layer **105** may be formed using Photo Solder Resist (PSR) ink containing black dye, and may be patterned through a photolithography without an additional resist solution, without being limited thereto. In addition, the PSR ink may include a polyfunctional monomer, an epoxy resin, and an epoxy curing accelerator.

The black protection layer **105** may block soldering to prevent electrical short-circuiting of adjacent pads, and may protect the module substrate **101**. In addition, the black protection layer **105** may prevent light emitted from the unit pixel **10** from diffusing to a side thereof and absorb external light to improve blackness.

The unit pixel **10** may be mounted on the module substrate **101**. Referring to FIGS. **2**B to **2**D, in the illustrated exemplary embodiment, the unit pixel **10** may include a substrate **11**, a light emitting structure **13**, connection electrodes **15***a*, **15***b* **15***c*, and **15***d*, and a protection layer **17**.

Light emitted from the unit pixel **10** may be emitted upward from the module substrate **101**. For example, light emitted from the unit pixel **10** may be emitted to the outside of the unit pixel **10** through the substrate **11**. The substrate **11** may include a light-transmitting insulating material so as to transmit light generated from the light emitting structure **13**. The substrate **11** may transmit only light having a specific wavelength or may transmit only a portion of light having a specific wavelength. The substrate **11** may be transparent, translucent, or partially transparent to light generated from the light emitting structure **13**. The substrate **11** may be a growth substrate capable of epitaxially growing the light emitting structure **13**, for example, a sapphire substrate. However, the substrate **11** is not limited to the sapphire substrate, and may include various other transparent insulating materials. For example, the substrate may include glass, quartz, silicon, organic polymer, or an organic-inorganic composite material, and it may be, for example, silicon carbide (SiC), gallium nitride (GaN), indium gallium nitride (InGaN), aluminum gallium nitride (AlGaN), aluminum nitride (AlN), gallium oxide (Ga_2O_3), or a silicon substrate. In addition, the substrate may include irregularities on a surface in contact with the light emitting structure **13**, and it may be, for example, a patterned sapphire substrate.

In the illustrated exemplary embodiment, at least a portion of the substrate **11** may remain to form a portion of the unit pixel **10**, without being limited thereto, or after the growth of the semiconductor layers is completed, the substrate **11** may be removed from the semiconductor layers using a technique such as mechanical polishing, laser lift-off, chemical lift-off, or the like. When the substrate **11** is removed, light generated from the light emitting structure **13** may be emitted to an upper portion of the module substrate **101** through the light emitting structure **13**.

The substrate **11** may have an upper surface and a lower surface opposite to each other, and the light emitting structure **13** may be formed on the lower surface of the substrate **11**. When the unit pixel **10** includes the substrate **11**, the light emitting structure **13** may be disposed between the module substrate **101** and the substrate **11**, and light generated from the light emitting structure **13** may pass through the lower surface and upper surface of the substrate **11** sequentially to exit to the outside.

The light emitting structure **13** may have a structure in which LED stacks emitting light having different wavelengths are stacked in a vertical direction, without being limited thereto, or may have an LED stack structure emitting light having a single wavelength.

In an exemplary embodiment, the light emitting structure **13** may include a first LED stack **13***a*, a second LED stack **13***b*, and a third LED stack **13***c* stacked in the vertical direction, as shown in FIG. **2**C. The first, second, and third LED stacks **13***a*, **13***b*, and **13***c* may include a first conductivity type semiconductor layer, an active layer, and a second conductivity type semiconductor layer, respectively. The first and second conductivity type semiconductor layers may have a single-layer structure or a multi-layer structure, and may include a superlattice layer, respectively. In addition, the active layers may have a single quantum well structure or a multiple quantum well structure.

The first, second and third LED stacks **13***a*, **13***b*, and **13***c* may be configured to emit light toward the substrate **11**. Accordingly, light emitted from the first LED stack **13***a* may pass through the second LED stack and the third LED stack **13***b* and **13***c*. The first, second, and third LED stacks **13***a*, **13***b*, and **13***c* may emit light having different peak wavelengths from one another. In general, the LED stack disposed farther from the substrate **11** emits light having a longer wavelength than that of light emitted from the LED stack disposed closer to the substrate **11**, and thus, light loss may be reduced. However, the inventive concepts are not limited thereto. For example, to adjust a color mixing ratio of the first, second, and third LED stacks **13***a*, **13***b*, and **13***c*, the second LED stack **13***b* may emit light having a shorter wavelength than that of light emitted from the third LED stack **13***c*. Accordingly, it is possible to reduce a luminous intensity of the second LED stack **13***b* and increase a luminous intensity of the third LED stack **13***c*, and thus, a luminous intensity ratio of light emitted from the first, second, and third LED stacks **13***a*, **13***b*, and **13***c* may be changed. For example, the first LED stack **13***a* may be configured to emit red light, the second LED stack **13***b* to emit blue light, and the third LED stack **13***c* to emit green light. Accordingly, it is possible to relatively reduce a luminous intensity of blue light and relatively increase a luminous intensity of green light. In addition, the third LED stack **13***c* closer to the substrate **11** may have a light emitting area larger than those of the first and second LED stacks **13***a* and **13***b*. Accordingly, by disposing the third LED stack **13***c* emitting green light closest to the substrate **11**, a relative luminous intensity of green light compared to those of red light and blue light may be further increased. Alternatively, to increase color rendering, the third LED stack **13***c* disposed closest to the substrate **11** may be configured to emit red light, and a stacking order of the first, the second, and the third LED stacks **13***a*, **13***b*, and **13***c* may be modified in various combinations.

When the first LED stack **13***a* emits red light, a peak wavelength of red light may be 600 nm to 670 nm, and the semiconductor layers may include aluminum gallium arsenide (AlGaAs), gallium arsenide phosphide GaAsP), aluminum gallium indium phosphide (AlGaInP), and gallium phosphide (GaP).

When the second LED stack **13**_b_ emits blue light, a peak wavelength of blue light may be 400 nm to 490 nm, and the semiconductor layers may include gallium nitride (GaN), indium gallium nitride (InGaN), or zinc selenide (zinc selenide, ZnSe).

When the third LED stack **13**_c_ emits green light, a peak wavelength of green light may be 500 nm to 590 nm, and the semiconductor layers may include indium gallium nitride (InGaN), gallium nitride (GaN), gallium phosphide (GaP), aluminum gallium indium phosphide (AlGaInP), or aluminum gallium phosphide (AlGaP).

A bonding layer may be formed between each of the LED stacks, and the first, second, and third LED stacks **13**_a_, **13**_b_, and **13**_c_ may be coupled to one another by the bonding layer. A first bonding layer **12** may be disposed between the first and second LED stacks **13**_a_ and **13**_b_, and a second bonding layer **14** may be disposed between the second LED stack **13**_b_ and the third LED stack **13**_c_. The first and second bonding layers **12** and **14** may include a non-conductive material that transmits light. The bonding layers **12** and **14** may include an optically transparent adhesive (OCA), and may include, for example, epoxy, polyimide, SUB, spin-on-glass (SOG), or benzocyclobutene (BCB), without being limited thereto.

According to the illustrated exemplary embodiment, a first insulation layer **16** and a second insulation layer **18** may be disposed on at least portions of side surfaces of the first, second and third LED stacks **13**_a_, **13**_b_, and **13**_c_. At least one of the first and second insulation layers **16** and **18** may include various organic or inorganic insulating materials, such as polyimide, SiO_2, SiNx, Al_2O_3, or the like. For example, at least one of the first and second insulation layers **16** and **18** may include a distributed Bragg reflector (DBR). As another example, at least one of the first and second insulation layers **16** and **18** may include a black organic polymer. In addition, an electrically floating metal reflection layer may be disposed on the first and second insulation layers **16** and **18** to reflect light emitted from the LED stacks **13**_a_, **13**_b_ and **13**_c_ toward the substrate **11**. At least one of the first and second insulation layers **16** and **18** may have a single-layer structure or a multi-layer structure formed of two or more insulation layers having different refractive indices from each other.

In addition, each of the first, second, and third LED stacks **13**_a_, **13**_b_, and **13**_c_ may be driven independently. In more detail, a common voltage may be applied to one of the first and second conductivity type semiconductor layers of each of the LED stacks **13**_a_, **13**_b_, and **13**_c_, and an individual light emitting signal may be applied to another one of the first and second conductivity type semiconductor layers of each of the LED stacks **13**_a_, **13**_b_, and **13**_c_. For example, the first conductivity type semiconductor layer of each LED stack may be an n-type, and the second conductivity type semiconductor layer may be a p-type. Further, the third LED stack **13**_c_ may have a stacked sequence in reverse compared to those of the first and second LED stacks **13**_a_ and **13**_b_.

Each of the p-type semiconductor layers of the LED stacks **13**_a_, **13**_b_, and **13**_c_ may be connected to a fourth connection electrode **15**_d_. The fourth connection electrode **15**_d_ may receive a common voltage from the outside. Meanwhile, the n-type semiconductor layers of the LED stacks **13**_a_, **13**_b_, and **13**_c_ may be connected to a first connection electrode **15**_a_, a second connection electrode **15**_b_, and a third connection electrode **15**_c_, respectively, to receive a respective corresponding light emitting signal through the connection electrodes **15**_a_, **15**_b_, and **15**_c_. In this manner, each of the first, second, and third LED stacks **13**_a_, **13**_b_, and **13**_c_ may be independently driven while having a common p-type structure in which p-type semiconductor layers of the first, second, and third LED stacks **13**_a_, **13**_b_, and **13**_c_ are commonly connected to one electrode. In the present disclosure, the unit pixels **10** have the common p-type structure, without being limited thereto, or they may have a common n-type structure. In addition, the stacking sequence of each LED stack is not limited to that shown in FIG. **2**C but the stacking sequence may be variously modified.

The protection layer **17** may cover at least a portion of a lower surface of the light emitting structure **13**, and may surround side surfaces of the connection electrodes **15**. In addition, the protection layer **17** may be formed between the connection electrodes **15**_a_, **15**_b_, **15**_c_, and **15**_d_. The protection layer **17** may be formed flush with lower surfaces of the connection electrodes **15**_a_, **15**_b_, **15**_c_, and **15**_d_ by a polishing process or the like. The protection layer **17** may include a black epoxy molding compound (EMC), without being limited thereto. For example, the protection layer **17** may include a photosensitive polyimide dry film (PID). The protection layer **17** may provide a sufficient contact area to the unit pixel **10** so as to facilitate handling as well as so as to protect the light emitting structure **13** from external impacts that may occur while a subsequent process is applied. In addition, the protection layer **17** may prevent light leakage from a side surface of the unit pixel **10** to prevent or at least suppress interference of light emitted from the adjacent unit pixel **10**.

However, the inventive concepts are not limited thereto, and the unit pixel **10** may include at least three light emitting devices emitting light of different colors arranged on the same plane. For example, the three light emitting devices may emit red light, green light, and blue light, respectively, and the light emitting devices of red light, green light, and blue light may be sequentially arranged. This will be described in detail later with reference to FIG. **9**.

The plurality of unit pixels **10** may be mounted on the module substrate **101** by bonding the connection electrode **15** to pads **103** of the module substrate **101** using a bonding agent **107**. The bonding agents **107** may cover at least portions of an upper surface and a side surface of the pad **103** of the module substrate **101**. A portion of the bonding agent **107** formed on an upper surface of the pad **103**, as shown in FIG. **2**A, may be disposed outward from a side surface of the unit pixel **10**.

The bonding agent **107** may be solder. For example, after disposing a solder paste on pads on the module substrate **101** using a screen printing technique, the unit pixel **10** and the module substrate **101** may be bonded through a reflow process. However, the inventive concepts are not limited thereto, and the unit pixel **10** and the module substrate **101** may be connected by eutectic bonding, epoxy bonding, anisotropic conductive film (ACF) bonding, ball grid array (BGA), or the like.

The light diffusion layer **110** may be formed to surround the plurality of unit pixels **10**. The light diffusion layer **110** may be formed on the plurality of unit pixels **10** and the module substrate **101**, and in more detail, may cover a lower surface, a side surface, and an upper surface of the unit pixel **10**. Since the light diffusion layer **110** surrounds the plurality of unit pixels **10** to block light extracted to the side, a viewing angle may be reduced, and it is possible to prevent a boundary line between adjacent unit pixels from being seen.

The light diffusion layer **110** may have a uniform pattern on an upper surface thereof. Elements **110***p* of the pattern may be protrusions, without being limited thereto, or may be concave portions. The light diffusion layer **110** may form uniform patterns **110***p* on an upper surface thereof. In the illustrated exemplary embodiment, the elements **110***p* may have a hemispherical shape, without being limited thereto, it may have, for example, various shapes such as a cone and a grid pattern, or it may be formed in a shape different from that of elements of a pattern **120***p* of the black molding layer **120** which will be described later. The pattern of the elements **110***p* may generate diffused reflection of light emitted from the unit pixel **10** to improve visibility by light scattering, improve light extraction efficiency, and improve clarity and smoothness of a surface. In addition, viewing angle characteristics of the display apparatus **1000** may be improved by refracting light.

The light diffusion layer **110** may be formed by a vacuum lamination process in which an opaque light diffusion film, which is an organic polymer sheet, is disposed on the unit pixel **10** and a high temperature and a high pressure are applied in a vacuum state. Accordingly, at least a portion of the upper surface of the light diffusion layer **110** may include a convex portion on an upper portion of the unit pixel **10**. However, the inventive concepts are not limited thereto, and when a thickness of the light diffusion layer **110** is sufficiently larger than that of the unit pixel **10**, a uniform upper surface without the convex portion may be formed.

As shown in FIG. **2**A, a vertical thickness t**1** from an uppermost end of the convex portion of the light diffusion layer **110** to the module substrate **101** may be greater than a thickness t**3** of the unit pixel **10**. In addition, a vertical thickness t**2** from an upper surface of the element **110***p* of the pattern of the light diffusion layer **110** disposed between each of the unit pixels **10** to the module substrate **101** may be greater than the thickness t**3** of the unit pixel **10**. Herein, the vertical thickness t**2** represents a distance from the element **110***p* of the pattern located in a center between the unit pixels **10** to the module substrate **101**. As such, the thicknesses t**1** and t**2** of the light diffusion layer **110** may be greater than the thickness t**3** of the unit pixel **10**, without being limited thereto, and the light diffusion layer **110** may be formed to have a thickness at least corresponding to the thickness t**3** of the unit pixel **10**, so that the upper surfaces of the light diffusion layer **110** and the unit pixel **10** may be located on the same line. The thickness t**3** of the unit pixel **10** may be, for example, about 10 μm to about 200 μm, and the thickness of the light diffusion layer **110** may be identical to or greater than the thickness of the unit pixel **10**. For example, the thickness of the unit pixel **10** may be about 170 μm, and the thickness of the light diffusion layer **110** may be 170 μm to 200 μm, without being limited thereto.

Meanwhile, in a case that the thicknesses t**1** and t**2** of the light diffusion layer **110** are smaller than the thickness t**3** of the unit pixel **10**, a shape of the pattern may be deformed when the light diffusion layer **110** is formed on the unit pixel **10** by the vacuum lamination process. In addition, as shown in FIG. **2**A, an interval between the elements **110***p* disposed over the unit pixels **10** may be different from an interval between the elements **110***p* disposed in a region between the unit pixels **10**. For example, as shown in FIG. **2**A, the interval between the elements **110***p* disposed over the unit pixels **10** may be greater than the interval between the elements **110***p* disposed in the region between the unit pixels **10**.

A width of the light diffusion layer **110** may be identical to a width of the module substrate **101**. Accordingly, a side surface of the light diffusion layer **110** may be disposed on the same plane as a side surface of the module substrate **101**.

The light diffusion layer **110** may be formed of a film-type material, and may be formed, for example, using a thermosetting resin. However, the inventive concepts are not limited thereto, the light diffusion layer **110** may be formed by jetting, dispensing, or being applied with a material in a form of a molding solution, or may be formed using an ultraviolet curable resin. The material of the light diffusion layer **110** may include an epoxy-based, silicone-based, or urethane-based resin. The material of the light diffusion layer **110** may be transparent, or may be black, white, or gray.

In addition, the light diffusion layer **110** may include a diffusion agent (not shown) or a scattering agent for diffusing light emitted from the unit pixel **10**. As the diffusing agent or the scattering agent included in the light diffusion layer **110** diffuses light emitted from the unit pixel **10**, light loss may be reduced, and a visual image may be improved by alleviating a color tone change by removing an optical distortion of the display apparatus **1000**. In the present disclosure, the diffusing agent may be titanium oxide, without being limited thereto, or may be, for example, calcium carbonate, barium sulfate, silica, acrylic beads, glass beads, or others. A degree of light diffusion may be adjusted by adjusting a density, a size, and a thickness of the diffusion agent.

The light diffusion layer **110** may be a single layer, without being limited thereto, or may be a plurality of layers, and the number of the plurality of layers is not limited. In another exemplary embodiment, the light diffusion layer **110** may include a plurality of layers having different colors form one another.

The black molding layer **120** may cover the upper surface of the light diffusion layer **110** so as to improve optical characteristics of the unit pixel. A width of the black molding layer **120** may be identical to that of the light diffusion layer **110** and that of the module substrate **101**. Accordingly, a side surface **120***s* of the light diffusion layer **120** may be disposed on a same plane as a side surface **110***s* of the light diffusion layer **110** and a side surface **101***s* of the module substrate **101**.

The black molding layer **120** may be formed to have a thickness smaller than that of the light diffusion layer **110**. A sum of the thickness of the black molding layer **120** and the thickness of the light diffusion layer **110** may be about 400 μm or less, for example, about 250 μm when the thickness of the unit pixel **110** is 170 μm. However, the inventive concepts are not limited thereto.

The black molding layer **120** may be disposed so as to maintain blackness of the display apparatus **1000** and so as to reduce reflectivity. The black molding layer **120** may improve uniformity of extracted light by reducing a color tone change caused by the module substrate **101**.

The black molding layer **120** may include a uniform pattern of elements **120***p* on an upper surface thereof. The elements **120***p* may be protrusions, without being limited thereto, or may be concave portions. In the illustrated exemplary embodiment, the elements **120***p* may have a hemispherical shape, without being limited thereto, it may have, for example, various shapes such as a cone and a grid pattern, or it may be formed in a shape different from that of the element **110***p* of the light diffusion layer **110**. The elements **120***p* may generate diffuse reflection of light emitted from the unit pixel **10** to improve visibility by light scattering, improve light extraction efficiency, and improve clarity and smoothness of a surface. In addition, the elements **120***p* refract light, and thus, viewing angle characteristics of the display apparatus **1000** may be improved.

The light diffusion layer **110** may include a convex portion on the unit pixel **10**, and thus, an interval between the elements **110***p* of the pattern on the convex portion may be greater than an interval of the elements **110***p* of the pattern in the region between the unit pixels **10**. In contrast, in the black molding layer **120**, an interval of the elements **120***p* of the pattern in the upper region of the unit pixels **10** and those in the region between the unit pixels may be substantially identical. For example, an upper surface of the black molding layer **120** may not be deformed by the convex portion of the light diffusion layer **110**. Accordingly, a thickness of the black molding layer **120** over the unit pixels **10** may be smaller than that of the black molding layer **120** disposed in the region between the unit pixels **10**. However, the inventive concepts are not necessarily limited thereto.

In an exemplary embodiment of the present disclosure, referring to FIG. **2**D, the elements **110***p* of the pattern of the light diffusion layer **110** and the elements **120***p* of the pattern of the black molding layer **120** may be disposed without overlapping one another in the vertical direction, and may be formed to be spaced apart from one another at equal intervals. For example, a center of one element **110***p* of the light diffusion layer **110** may be disposed at a center of the elements **120***p* of the black molding layer **120** disposed at equal intervals around the one element **110***p*. For example, as shown by a dotted line in FIG. **2**D, one element **110***p* of the light diffusion layer **110** may be located on the same axis as an intersection of a straight line connecting the centers of the elements **120***p* located on each diagonal of the black molding layer **120**. Accordingly, light emitted from the unit pixel **10** is scattered by the pattern of the elements **110***p* of the light diffusion layer **110**, and light traveling in a lateral direction may be scattered again by the pattern of the elements **120***p* of the black molding layer **120**, and thus, light extraction efficiency may be improved by diffuse reflection. However, the inventive concepts are not limited thereto, and in another exemplary embodiment, the elements **110***p* of the light diffusion layer **110** and the elements **120***p* of the black molding layer **120** may overlap with one another in the vertical direction.

The black molding layer **120** may be formed of a film-type material, and may be formed, for example, using a thermosetting resin. However, the inventive concepts are not limited thereto, the black molding layer **120** may be formed by jetting, dispensing, or being applied with a material in a form of a molding solution, or may be formed using an ultraviolet curable resin. The black molding layer **120** may include a base material and a black pigment. The base material may be a thermosetting material, without being limited thereto. The base material may include, for example, at least one of silicone, epoxy, ethylene-vinyl acetate copolymer (EVA), polyvinyl butyral (PVB), and urethane. The black dye may include a black dye such as carbon.

FIGS. **3**A through **3**E are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to an exemplary embodiment.

Referring to FIG. **3**A, a plurality of unit pixels **10** may be mounted on a module substrate **101**. The plurality of unit pixels **10** may be disposed on an upper surface of the module substrate **101** so as to be spaced apart from one another at a regular interval. The plurality of unit pixels **10** may be bonded to the module substrate **101** through, for example, a reflow process.

Connection electrodes **15** of the plurality of unit pixels **10** may be connected to pads **103** formed on the module substrate **101** by a bonding agent **107**, respectively. However, the inventive concepts are not limited thereto, and for example, the connection electrodes **15** of the plurality of unit pixels **10** may be connected to the pads **103** formed on the module substrate **101** by eutectic bonding, epoxy bonding, or the like.

Referring to FIG. **3**B, a light diffusion film **110***a* may be prepared by forming a pattern on an upper surface thereof so as to form a light diffusion layer **110**, and a black film **120***a* may be prepared by forming a pattern on an upper surface thereof so as to form a black molding layer **120**. The black film **120***a* may be disposed on the light diffusion film **110***a*.

In order to form patterns on the light diffusion film **110***a* and the black film **120***a*, after curing each film by applying heat, the patterns may be formed by placing a stamp on each of the light diffusion film **110***a* and the black film **120***a* and pressing the stamp. The stamp may be, for example, a metallic material, without being limited thereto, or may be polydimethylsiloxane (PDMS), an elastomer polymer. However, the inventive concepts are not limited thereto, and the patterns may be formed by a method such as nano-imprinting.

Thereafter, each film may be thermally cured for laminating the light diffusion film **110***a* and the black film **120***a*, and, for example, heat of about 50° C. may be applied. The light diffusion film **110***a* and the black film **120***a* are arranged such that a flat lower surface of the black film **120***a* is in contact with the patterned upper surface of the light diffusion film **110***a*, and the light diffusion film **110***a* and the black film **120***a* may be laminated by roll lamination in which a roll-to-roll process and a lamination process are combined. When laminating the light diffusion film **110***a* and the black film **120***a*, elements **110***p* of the light diffusion film **110***a* and elements **120***p* of the black film **120***a* are disposed so as not to overlap with one another.

Referring to FIGS. **3**C and **3**D, the light diffusion layer **110** and the black molding layer **120** may be formed by disposing the laminated light diffusion film **110***a* and black film **120***a* on the module substrate **101**.

The light diffusion layer **110** and the black molding layer **120** covering the unit pixels **10** may be formed by disposing the laminated light diffusion film **110***a* and the black film **120***a* on the module substrate **101** and by a vacuum lamination process in which a high temperature and a high pressure are applied in a vacuum. In the vacuum lamination process, a plate may be placed on the black film **120***a*, and when a vacuum degree of 1 torr is reached at about 60° C., a pressure of 3 kg/cm^2 may be applied to the plate. The pressurization process proceeds when a target vacuum level is reached, and thus, it is possible to prevent bubbles from being formed in the light diffusion layer **110**.

Thereafter, the light diffusion layer **110** and the black molding layer **120** are left at about 100° C. for 30 minutes, subsequently, at 150° C. for 60 minutes, and then, the light diffusion layer **110** and the black molding layer **120** may be cured using heat.

Referring to FIG. **3**E, the light emitting module **100** may be completed by cutting edges of the module substrate **101**, the light diffusion layer **110**, and the black molding layer **120** and removing them. The light diffusion layer **110** and the black molding layer **120** may be cut using techniques such as dicing, laser cutting, or routing. Accordingly, a cut side surface **110***a* of the light diffusion layer **110** and a cut side surface **120***a* of the black molding layer **120** may be located on the same plane. In the following exemplary embodiments, differences from the above-described exemplary embodiments will be mainly described so as to avoid redundancy of descriptions, and descriptions of the same elements will be briefly described or omitted.

FIGS. **4**A through **4**E are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to another exemplary embodiment.

Referring to FIGS. **4**A through **4**E, a light emitting module **200** may be formed by the same manufacturing method as that described with reference to FIGS. **3**A through **3**E, except for a black molding layer **220**.

In the illustrated exemplary embodiment, a module substrate **201**, pads **203**, a black protection layer **205**, a bonding agent **207**, and unit pixel **20** are identical to the module substrate **101**, the pads **103**, the black protection layer **105**, the bonding agent **107**, and the unit pixel **10** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted. In addition, a substrate **21**, a light emitting structure **23**, connection electrode **25**, and a protection layer **27** are identical to the substrate **11**, the light emitting structure **13**, the connection electrode **15**, and the protection layer **17** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted.

Referring to FIG. **4**B, a light diffusion film **210***a* may be prepared by forming a pattern on an upper surface thereof so as to form a light diffusion layer **210**, and a black film **220***a* may be disposed on the light diffusion layer **210** with flat upper and lower surfaces, so as to form a black molding layer **220**. Thereafter, as shown in FIG. **4**B, the light diffusion film **210***a* and the black film **220***a* may be laminated together by roll lamination in which a roll-to-roll process and a lamination process are combined, while a flat lower surface of the black film **220***a* is in contact with a patterned upper surface of the light diffusion film **210***a*, and the light diffusion layer **210** and the black molding layer **220** may be formed using the laminated light diffusion film **210***a* and the black film **220***a*, as shown in FIG. **4**C. A light emitting module as shown in FIG. **4**E may be fabricated by cutting the module substrate **201**, the light diffusion layer **210**, and the black molding layer **220** which is shown in FIG. **4**D. According to the illustrated exemplary embodiment, as shown in FIG. **4**E, an upper surface of the black molding layer **220** may be flat.

FIGS. **5**A through **5**E are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to another exemplary embodiment.

Referring to FIGS. **5**A through **5**E, a light emitting module **300** may be formed by the same manufacturing method as that described with reference to FIGS. **3**A through **3**E, except for a light diffusion layer **310**.

In the illustrated exemplary embodiment, a module substrate **301**, pads **303**, a black protection layer **305**, a bonding agent **307**, and unit pixel **30** are identical to the module substrate **101**, the pads **103**, the black protection layer **105**, the bonding agent **107**, and the unit pixel **10** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted. In addition, a substrate **31**, a light emitting structure **33**, connection electrode **35**, and a protection layer **37** are identical to the substrate **11**, the light emitting structure **13**, the connection electrode **15**, and the protection layer **17** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted.

Referring to FIG. **5**B, a light diffusion film **310***a* may be prepared with flat upper and lower surfaces so as to form the light diffusion layer **310**, and a black film **320***a* may be prepared by forming a pattern on an upper surface thereof so as to form a black molding layer **320**. The light diffusion layer **310** and the black molding layer **320** may be laminated by disposing the black film **320***a* on the light diffusion film **310***a*, and by laminating them by roll lamination in which a roll-to-roll process and a lamination process are combined as shown in FIG. **5**B, while the flat lower surface of the black film **320***a* is in contact with the flat upper surface of the light diffusion film **310***a* as shown in FIG. **5**C, and the light diffusion layer **310** and the black molding layer **320** as shown in FIG. **5**D may be formed using the laminated light diffusion film **310***a* and black film **320***a*. Alight emitting module as shown in FIG. **5**E may be manufactured by cutting the module substrate **301**, the light diffusion layer **310**, and the black molding layer **320** which are shown in FIG. **5**D. An upper surface of the black molding layer **320** may be in a patterned form.

Meanwhile, when the light diffusion layer **310** and the black molding layer **320** covering the unit pixels **30** are formed by the lamination process, in particular, a vacuum lamination process, the light diffusion layer **310** disposed over the unit pixel **30** may have a convex shape, as shown in FIG. **5**D. The upper surface of the black molding layer **320** may have generally a flat surface, and thus, a thickness of the black molding layer **320** disposed over the unit pixels **30** may be smaller than that of the black molding layer disposed between the unit pixels **30**.

FIGS. **6**A and **6**B are schematic plan view and cross-sectional view illustrating a method of manufacturing a light emitting module according to another exemplary embodiment.

Referring to FIGS. **6**A and **6**B, a light emitting module **400** may be formed by the same manufacturing method as that described with reference to FIGS. **3**A through **3**E, except for an arrangement between elements **410***p* and **420***p* of patterns located on upper surfaces of a light diffusion layer **410** and a black molding layer **420**.

In the illustrated exemplary embodiment, a module substrate **401**, pads **403**, a black protection layer **405**, a bonding agent **407**, and unit pixel **40** are identical to the module substrate **101**, the pads **103**, the black protection layer **105**, the bonding agent **107**, and the unit pixel **10** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted. In addition, a substrate **41**, a light emitting structure **43**, connection electrode **45**, and a protection layer **47** are identical to the substrate **11**, the light emitting structure **13**, the connection electrode **15**, and the protection layer **17** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted.

When a light diffusion film and a black film are laminated so as to form the light diffusion layer **410** and the black molding layer **420**, the elements of the pattern on the light diffusion film and the elements of the pattern on the black film may be arranged so as to overlap with one another. Accordingly, the elements of the pattern of the light diffusion layer **410** and the elements of the pattern of the black molding layer **420** may overlap with one another. As shown in FIG. **6**B, the elements **410***p* of the pattern of the light diffusion layer **410** and the elements **420***p* of the pattern of the black molding layer **420** may be formed to overlap with one another.

Accordingly, as light emitted from the unit pixel **40** is scattered by the pattern of the light diffusion layer **410**, and scattered light passes through the pattern of the black molding layer **420** to generate additional light scattering, it is possible to improve a visual image by alleviating a color tone change by removing an optical distortion of the display apparatus. In addition, a path of light may be changed due to the scattering of light, and the changed path may be extracted to the outside to improve light extraction efficiency.

FIGS. **7**A through **7**G are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to another exemplary embodiment.

Referring to FIGS. **7**A through **7**G, the method of manufacturing a light emitting module is substantially identical to that described with reference to FIGS. **3**A through **3**E, but an order of processes of the manufacturing method may be different.

In the illustrated exemplary embodiment, a module substrate **501**, pads **503**, a black protection layer **505**, a bonding agent **507**, and unit pixel **50** are identical to the module substrate **101**, the pads **103**, the black protection layer **105**, the bonding agent **107**, and the unit pixel **10** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted. In addition, a substrate **51**, a light emitting structure **53**, connection electrode **55**, and a protection layer **57** are identical to the substrate **11**, the light emitting structure **13**, the connection electrode **15**, and the protection layer **17** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted.

Referring to FIG. **7**A, a plurality of unit pixels **50** may be mounted on a module substrate **501**. A description of mounting the plurality of unit pixels **50** is identical to that described with reference to FIG. **3**A, and thus, it will be omitted.

Referring to FIG. **7**B, a light diffusion film **510***a* may be disposed on the plurality of unit pixels **50** so as to form a light diffusion layer **510** as shown in FIG. **7**C. A description of forming the light diffusion layer **510** on the module substrate **501** is identical to that described with reference to FIG. **3**C, and thus it will be omitted. However, in the illustrated exemplary embodiment, the light diffusion layer **510** is formed by vacuum laminating the light diffusion film **510***a* alone on the module substrate **501** without laminating the light diffusion film **510***a* and the black film.

Referring to FIG. **7**C, the light diffusion layer **510** may be formed on the module substrate **501** so as to cover lower surfaces, side surfaces, and upper surfaces of the plurality of unit pixels **50**. An upper surface of the light diffusion layer **510** may include a convex portion over the unit pixel **50**. The convex portion may be formed while being pressed when the light diffusion layer **510** is disposed on the module substrate **501** by vacuum lamination. However, the inventive concepts are not limited thereto, and when a thickness of the light diffusion layer **510** is sufficiently larger than a thickness of the unit pixel **50**, the light diffusion layer **510***a* may form a substantially flat upper surface without the convex portion. For example, the thickness of the unit pixel **50** may be about 10 μm to about 200 μm, and the thickness of the light diffusion layer **510** may be identical to or greater than the thickness of the unit pixel **50**. For example, the thickness of the unit pixel **50** may be about 170 μm, and the thickness of the light diffusion layer **510** may be 170 μm to 200 μm, without being limited thereto.

Referring to FIG. **7**D, a pattern may be formed on an upper surface of the light diffusion layer **510**. A description of forming the pattern on the upper surface of the light diffusion layer **510** is provided with reference to FIG. **3**B. Thereafter, a thermally curing process is performed, which is identical to that described with reference to FIG. **3**D.

Referring to FIG. **7**E, a black molding layer **520** may be formed on the light diffusion layer **510** using a black film **520***a*. The black molding layer **520** may be formed on the light diffusion layer **510** by a vacuum lamination process using the black film **520***a*, and a description thereof is described with reference to FIG. **3**C.

Referring to FIG. **7**F, a pattern may be formed on an upper surface of the black molding layer **520**. As a description of forming the pattern on the upper surface of the black molding layer **520** is identical to that described with reference to FIG. **3**B, it will be omitted.

Referring to FIG. **7**G, a light emitting module **500** may be completed by cutting edges of the module substrate **501**, the light diffusion layer **510**, and the black molding layer **520** and removing them.

FIGS. **8**A through **8**F are schematic cross-sectional views illustrating a method of manufacturing a light emitting module according to an exemplary embodiment.

Referring to FIGS. **8**A through **8**F, the method of manufacturing a light emitting module is substantially identical to that described with reference to FIGS. **3**A through **3**E, except that a light diffusion layer **610** is formed in a plurality of layers.

In the illustrated exemplary embodiment, a module substrate **601**, pads **603**, a black protection layer **605**, a bonding agent **607**, and a unit pixel **60** are identical to the module substrate **101**, the pads **103**, the black protection layer **105**, the bonding agent **107**, and the unit pixel **10** of FIGS. **2**A through **2**C, respectively, and thus, the same descriptions thereof will be omitted. In addition, a substrate **61**, a light emitting structure **63**, connection electrode **65**, and a protection layer **67** are identical to the substrate **11**, the light emitting structure **13**, the connection electrode **15**, and the protection layer **17** of FIGS. **2**A through **2**C, respectively, and thus, same descriptions thereof will be omitted.

Referring to FIG. **8**A, a plurality of unit pixels **60** may be mounted on a module substrate **601**. A description of mounting the plurality of unit pixels **60** is identical to that described with reference to FIG. **3**A, and thus, it will be omitted.

Referring to FIGS. **8**B and **8**C, the method of manufacturing the light emitting module is similar to that described with reference to FIG. **3**B, but the method includes an additional step of forming a light diffusion film **610***a* by laminating a plurality of films **611***a* and **612***a*.

The light diffusion film **610***a* may be formed of, for example, a first light diffusion film **611***a* and a second light diffusion film **612***a*, as shown in FIG. **8**B. A pattern may be formed on at least one of an upper surface of the first light diffusion film **611***a* and an upper surface of the second light diffusion film **612***a*. In an exemplary embodiment, a pattern may be formed on the upper surface of the first light diffusion film **611***a* and the upper surface of the second light diffusion film **612***a*, respectively. The description of forming the pattern is identical to that described with reference to FIG. **3**B, and thus, it will be omitted.

Both the first light diffusion film **611***a* and the second light diffusion film **612***a* may be films that diffuse light, without being limited thereto, or one of them may be a transparent film. For example, the first light diffusion film **611***a* may be a transparent film, the second light diffusion film **612***a* may be a light diffusion film, and a black film **620***a* may be a black film. As a first light diffusion layer **611** is further disposed by the first light diffusion film **611***a*, the plurality of unit pixels **60** may be protected without optical distortion. In addition, as a second light diffusion layer **612** may be formed to be relatively thin, light loss due to light absorption by the second light diffusion layer **612** may be reduced.

In the exemplary embodiment of the present disclosure, the first light diffusion film **611***a* may be a transparent film, and the second light diffusion film **612***a* may be a diffusion film, without being limited thereto. For example, the first light diffusion film **611***a* may be formed of a diffusion film, the second light diffusion film **612***a* may be a transparent film, or both the first and second light diffusion films **611***a* and **612***a* may be diffusion films. When both the first and second light diffusion films **611***a* and **612***a* are the diffusion films, a density, a size, a thickness, a material, and others of a diffusion agent in the first and second light diffusion films **611***a* and **612***a* may be different from one another.

The pattern of the first light diffusion film **611***a* and the pattern of the second light diffusion film **612***a* may be laminated so as not to overlap with each other. For example, similar to that described with reference to FIG. **2**D, a center of elements of the pattern of the first light diffusion film **611***a* may be located on the same axis as a point at which straight lines connecting centers of elements of the pattern of the second light diffusion film **612***a* intersect. In addition, the center of the elements of the second light diffusion film **612***a* may be located on the same axis as a point at which straight lines connecting the centers of the elements of the pattern of the black film **620***a* intersect. In an exemplary embodiment, the elements of the pattern of the first light diffusion film **611***a* and the elements of the pattern of the black film **620***a* may overlap one another, and thus, the center of the elements of the pattern of the first light diffusion film **611***a* may be located on the same axis as the center of the elements of the pattern of the black film **620***a*. However, the inventive concepts are not limited thereto, the patterns of the first light diffusion film **611***a*, the second light diffusion film **612***a*, and the black film **620***a* may all overlap, and the centers of the elements of the films **611***a*, **612***a*, and **620***a* may all be located on the same axis. In another exemplary embodiment, the center of the elements of at least one of the first light diffusion film **611***a*, the second light diffusion film **612***a*, and the black film **620***a* may not overlap with the centers of the elements of the other films.

Referring to FIGS. **8**D and **8**E, a first light diffusion layer **611**, a second light diffusion layer **612**, and a black molding layer **620** covering the unit pixels **60** may be formed on the module substrate **601**. A description of forming the first light diffusion layer **611**, the second light diffusion layer **612**, and the black molding layer **620** is identical to that described with reference to FIG. **3**C, and thus, it will be omitted.

The first and the second light diffusion layers **611** and **612** and the black molding layer **620** may be thermally cured on the module substrate **601**. As a description of the thermally curing step is identical to that described with reference to FIG. **3**D, it will be omitted.

Referring to FIG. **8**F, a light emitting module **600** is completed by cutting edges of the module substrate **601**, the first and second light diffusion layers **611** and **612**, and the black molding layer **620** and removing them.

In the above exemplary embodiments, the unit pixels **10**, **20**, **30**, **40**, **50**, and **60** have been described as including the first through third LED stacks stacked vertically, but the present disclosure is not limited to those unit pixels. For example, the unit pixel may have a structure in which the first through third light emitting devices are arranged in a lateral direction. Hereinafter, an exemplary embodiment having a structure in which first through third light emitting devices are arranged in the lateral direction will be described with reference to the drawings.

FIG. **9**A is a schematic plan view illustrating a unit pixel **700** according to another exemplary embodiment, FIG. **9**B is a schematic cross-sectional view taken along line C-C' of FIG. **9**A, and FIG. **9**C is a schematic cross-sectional view taken along line D-D' of FIG. **9**A.

Referring to FIGS. **9**A, **9**B, and **9**C, the unit pixel **700** may include a transparent substrate **121**, first through third light emitting devices **710***a*, **710***b*, and **710***c*, a surface layer **122**, a light locking layer **123**, an adhesive layer **125**, a step adjustment layer **127**, connection layers **129***a*, **129***b*, **129***c*, and **129***d*, and an insulation material layer **131**.

The unit pixel **700** provides one pixel including the first through the third light emitting devices **710***a*, **710***b*, and **710***c*. The first through third light emitting devices **710***a*, **710***b*, and **710***c* emit light having different colors from one another, and they respectively correspond to sub-pixels.

The transparent substrate **121** is a light-transmitting substrate such as PET, a glass substrate, a quartz substrate, or a sapphire substrate. The transparent substrate **121** is disposed on a light exiting surface of the display apparatus (**1000** of FIG. **1**), and light emitted from the light emitting devices **710***a*, **710***b*, and **710***c* is emitted to the outside through the transparent substrate **121**. The transparent substrate **121** may have an upper surface and a lower surface. The transparent substrate **121** may include a concave-convex pattern **121***p* on a surface opposite to the light emitting devices **710***a*, **710***b*, and **710***c*, that is, the upper surface. The concave-convex pattern **121***p* scatters light emitted from the light emitting devices **710***a*, **710***b*, and **710***c* to increase a viewing angle. In addition, light emitted from the light emitting devices **710***a*, **710***b*, and **710***c* having different viewing angle characteristics may be emitted with a uniform viewing angle by the concavo-convex pattern **121***p*. Accordingly, it is possible to prevent a color change from occurring depending on the viewing angle.

The concave-convex pattern **121***p* may be regular or irregular. In some forms, the concave-convex pattern **121***p* may have, for example, a pitch of 3 μm, a diameter of 2.8 μm, and a height of 1.8 μm. The concave-convex pattern **121***p* may be a pattern that is generally applied to a patterned sapphire substrate, without being limited thereto.

The transparent substrate **121** may also include an anti-reflection coating, may include an anti-glare layer, or may be treated with an anti-glare treatment. The transparent substrate **121** may have a thickness of, for example, 50 μm to 300 μm.

As the transparent substrate **121** is disposed on the light exiting surface, the transparent substrate **121** does not include a circuit. However, the inventive concepts are not limited thereto, and may include a circuit.

Meanwhile, although it is illustrated that one unit pixel **700** is formed on one transparent substrate **121**, a plurality of unit pixels **700** may be formed on one transparent substrate **121**.

The surface layer **122** covers the concave-convex pattern **121***p* of the transparent substrate **121**. The surface layer **122** may be formed along a shape of the concave-convex pattern **121***p*. The surface layer **122** may improve adhesion of the light blocking layer **123** formed thereon. For example, the surface layer **122** may be formed of a silicon oxide film. The surface layer **122** may be omitted depending on a type of the transparent substrate **121**.

The light blocking layer **123** is formed on the upper surface of the transparent substrate **121**. The light blocking layer **123** may be in contact with the surface layer **122**. The light blocking layer **123** may include an absorbing material that absorbs light, such as carbon black. The light absorbing material prevents light generated in the light emitting devices **710***a*, **710***b*, and **710***c* from leaking to a side in a region between the transparent substrate **121** and the light emitting devices **710***a*, **710***b*, and **710***c*, and improves a contrast of the display apparatus.

The light blocking layer **123** may have windows **123***a*, **123***b*, and **123***c* for a light path such that light generated in the light emitting devices **710**a, **710**b, and **710**c is incident on the transparent substrate **121**, and for this purpose, the light blocking layer **123** may be patterned on the transparent substrate **121** so as to expose the transparent substrate **121**. Widths of the windows **123**a, **123**b, and **123**c may be smaller than those of the light emitting devices, without being limited thereto. For example, the widths of the windows **123**a, **123**b, and **123**c may be greater than those of the light emitting devices **710**a, **710**b, and **710**c, and accordingly, a gap may be formed between the light emitting devices **710**a, **710**b, and **710**c and the light blocking layer **123**.

The adhesive layer **125** is attached onto the transparent substrate **121**. The adhesive layer **125** may cover the light blocking layer **123**. The adhesive layer **125** may be attached onto an entire surface of the transparent substrate **121**, without being limited thereto, or may be attached onto a portion of the transparent substrate **121** so as to expose a region near an edge of the transparent substrate **121**. The adhesive layer **125** is used to attach the light emitting devices **710**a, **710**b, and **710**c to the transparent substrate **121**. The adhesive layer **125** may fill the windows **123**a, **123**b, and **123**c formed in the light blocking layer **123**.

The adhesive layer **125** may be formed of a light-transmitting layer, and transmits light emitted from the light emitting devices **710**a, **710**b, and **710**c. The adhesive layer **125** may be formed using an organic adhesive. For example, the adhesive layer **125** may be formed using a transparent epoxy. In addition, the adhesive layer **125** may include a diffuser such as SiO_2, TiO_2, ZnO, or the like so as to diffuse light. The light diffuser prevents the light emitting devices **710**a, **710**b, and **710**c from being viewed from the light exiting surface.

Meanwhile, the first through third light emitting devices **710**a, **710**b, and **710**c are disposed on the transparent substrate **121**. The first through the third light emitting devices **710**a, **710**b, and **710**c may be attached to the transparent substrate **121** by the adhesive layer **125**. The first through the third light emitting devices **710**a, **710**b, and **710**c may be disposed to correspond to the windows **123**a, **123**b, and **123**c of the light blocking layer **123**.

The first through the third light emitting devices **710**a, **710**b, and **710**c may be disposed on a flat surface of the adhesive layer **125** as shown in FIGS. **9**B and **9**C. The adhesive layer **125** may be disposed under lower surfaces of the light emitting devices **710**a, **710**b, and **710**c. In another exemplary embodiment, the adhesive layer **125** may partially cover side surfaces of the first through third light emitting devices **710**a, **710**b, and **710**c.

The first through the third light emitting devices **710**a, **710**b, and **710**c may be, for example, a red light emitting device, a green light emitting device, or a blue light emitting device. A detailed configuration of each of the first through third light emitting devices **710**a, **710**b, and **710**c will be described later in detail with reference to FIGS. **10**A and **10**B.

As shown in FIG. **9**A, the first through third light emitting devices **710**a, **710**b, and **710**c may be arranged side by side to form a horizontal line. In particular, when the transparent substrate **121** is a sapphire substrate, the sapphire substrate may include clean cut surfaces (e.g., m-plane) and remaining cut surfaces (e.g., a-plane) by a crystal plane depending on a cutting direction. For example, when cut in a rectangular shape, two cut surfaces (e.g., m-plane) on both sides may be cut cleanly along the crystal plane, and the other two cut surfaces (e.g., a-plane) disposed vertically to these cut surfaces may not. In this case, the clean cut surfaces of the sapphire substrate **121** may be flush with an arrangement direction of the light emitting devices **710**a, **710**b, and **710**c. For example, in FIG. **9**A, the clean cut surfaces (e.g., m-plane) may be disposed up and down, and the other two cut surfaces (e.g., a-plane) may be disposed on left and right.

In addition, major axis directions of the first through third light emitting devices **710**a, **710**b, and **710**c may be arranged parallel to one another, respectively. Minor axis directions of the first through third light emitting devices **710**a, **710**b, and **710**c may coincide with the arrangement direction of the light emitting devices.

The step adjustment layer **127** covers the first through the third light emitting devices **710**a, **710**b, and **710**c and the adhesive layer **125**. The step adjustment layer **127** has openings **127**a exposing first and second electrode pads **761** and **763** of the light emitting devices **710**a, **710**b, and **710**c. The step adjustment layer **127** assists to securely form the connection layers by uniformly adjusting elevations of surfaces on which the connection layers **129**a, **129**b, **129**c, and **129**d are formed. The step adjustment layer **127** may be formed of, for example, photosensitive polyimide.

The step adjustment layer **127** may be disposed in a region surrounded by an edge of the adhesive layer **125**, without being limited thereto. For example, the step adjustment layer **127** may be formed so as to partially expose the edge of the adhesive layer **125**.

A side surface of the step adjustment layer **127** may be inclined at an angle less than 90 degrees with respect to an upper surface of the adhesive layer **125**. For example, the side surface of the step adjustment layer **127** may have an inclination angle of about 60 degrees with respect to the upper surface of the adhesive layer **125**.

The first through the fourth connection layers **129**a, **129**b, **129**c, and **129**d are formed on the step adjustment layer **127**. The connection layers **129**a, **129**b, **129**c, and **129**d may be connected to the first and second electrode pads **761** and **763** of the first through third light emitting devices **710**a, **710**b, and **710**c through the openings **127**a of the step adjustment layer **127**.

In an exemplary embodiment, as shown in FIGS. **9**A and **9**B, the first connection layer **129**a may be electrically connected to a second conductivity type semiconductor layer of the first light emitting device **710**a, and the second connection layer **129**b may be electrically connected to a second conductivity type semiconductor layer of the second light emitting device **710**b, and the third connection layer **129**c may be electrically connected to a second conductivity type semiconductor layer of the third light emitting device **710**c, and the fourth connection layer **129**d may be commonly electrically connected to the first conductivity type semiconductor layers of the first through the third light emitting devices **710**a, **710**b, and **710**c. The first through the fourth connection layers **129**a, **129**b, **129**c, and **129**d may be formed together on the step adjustment layer **127**, and may include, for example, Au.

In another exemplary embodiment, the first connection layer **129**a may be electrically connected to the first conductivity type semiconductor layer of the first light emitting device **710**a, and the second connection layer **129**b may be electrically connected to the first conductivity type semiconductor layer of the second light emitting device **710**b, the third connection layer **129**c may be electrically connected to the first conductivity type semiconductor layer of the third light emitting device **710**c, and the fourth connection layer **129**d may be commonly electrically connected to the second conductivity type semiconductor layers of the first through third light emitting devices **710**a, **710**b, and **710**c. The first through the fourth connection layers **129***a*, **129***b*, **129***c*, and **129***d* may be formed together on the step adjustment layer **127**.

The insulation material layer **131** may be formed to have a thickness smaller than that of the step adjustment layer **127**. A sum of the thicknesses of the insulation material layer **131** and the step adjustment layer **127** may be 1 μm or more and 50 μm or less, without being limited thereto. Meanwhile, a side surface of the insulation material layer **131** may have an inclination angle less than 90 degrees with respect to the upper surface of the adhesive layer **125**, for example, an inclination angle of about 60 degrees.

The insulation material layer **131** covers the side surfaces of the step adjustment layer **127** and the connection layers **129***a*, **129***b*, **129***c*, and **129***d*. In addition, the insulation material layer **131** may cover a portion of the adhesive layer **125**. The insulation material layer **131** has openings **131***a*, **131***b*, **131***c*, and **131***d* exposing the connection layers **129***a*, **129***b*, **129***c*, and **129***d*, and thus, pad regions of the unit pixel **100** may be defined.

In an exemplary embodiment, the insulation material layer **131** may be a translucent material, and may be formed of an organic or inorganic material. The insulation material layer **131** may be formed of, for example, polyimide. When the insulation material layer **131** together with the step adjustment layer **127** is formed of polyimide, the lower surfaces, side surfaces, and upper surfaces of the connection layers **129***a*, **129***b*, **129***c*, and **129***d* except for the pad regions may be all surrounded by polyimide.

Meanwhile, the unit pixel **700** may be mounted on the module substrate using a bonding agent such as solder, and the bonding agent may bond the connection layers **129***a*, **129***b*, **129***c*, and **129***d* exposed to the openings **131***a*, **131***b*, **131***c*, and **131***d* of the insulation material layer **131** and the pads on the module substrate.

According to the illustrated exemplary embodiment, the unit pixel **700** does not include separate bumps, and the connection layers **129***a*, **129***b*, **129***c*, and **129***d* are used as bonding pads. However, the inventive concepts are not limited thereto, and bonding pads covering the openings **131***a*, **131***b*, **131***c*, and **131***d* of the insulation material layer **131** may be formed. In an exemplary embodiment, the bonding pads may be formed so as to partially cover the light emitting devices **710***a*, **710***b*, and **710***c* outside upper regions of the first through the fourth connection layers **129***a*, **129***b*, **129***c*, and **129***d*.

In the illustrated exemplary embodiment, the light emitting devices **710***a*, **710***b*, and **710***c* have been described as being attached to the transparent substrate **121** by the adhesive layer **125**, but the light emitting devices **710***a*, **710***b*, and **710***c* may be coupled to the transparent substrate **121** by using another coupler instead of the adhesive layer **125**. For example, the light emitting devices **710***a*, **710***b*, and **710***c* may be coupled to the transparent substrate **121** using spacers, and thus, gases or liquids may fill a region between the light emitting devices **710***a*, **710***b*, and **710***c* and the transparent substrate **121**. An optical layer that transmits light emitted from the light emitting devices **710***a*, **710***b*, and **710***c* may be formed by these gases or liquids. The above-mentioned adhesive layer **125** is also an example of the optical layer. Herein, the optical layer is formed of a material different from those of the light emitting devices **710***a*, **710***b*, and **710***c*, for example, gases, liquids, or solids, and thus, the material thereof is distinguished from those of the semiconductor layers in the light emitting devices **710***a*, **710***b*, and **710***c*.

The unit pixel **700** according to the illustrated exemplary embodiment may replace the unit pixels **100**, **200**, **300**, **400**, **500**, and **600** described above. Accordingly, a plurality of unit pixels **700** may be arranged on the module substrate, and the light diffusion layer and the black molding layer having various structures described above may cover the unit pixels **700**.

FIG. **10**A is a schematic plan view illustrating a light emitting device of FIG. **9**A, and FIG. **10**B is a schematic cross-sectional view taken along line E-E' of FIG. **10**A. Herein, a light emitting device **710***a* has been exemplarily described, but as light emitting devices **710***b* and **710***c* also have substantially similar structures, repeated descriptions thereof will be omitted.

Referring to FIGS. **10**A and **10**B, the light emitting device **710***a* may include a light emitting structure including a first conductivity type semiconductor layer **721**, an active layer **723**, and a second conductivity type semiconductor layer **725**, an ohmic contact layer **727**, a first contact pad **753**, a second contact pad **755**, an insulation layer **759**, a first electrode pad **761**, and a second electrode pad **763**.

The light emitting device **710***a* may have a rectangular shape having a major axis and a minor axis in plan view. For example, a length of the major axis may be 100 μm or less, and a length of the minor axis may be 70 μm or less. The light emitting devices **710***a*, **710***b*, and **710***c* may have a substantially similar shape and size. The shape of the light emitting device **710***a* is not limited to a rectangular shape having the major axis length and the minor axis length, but may be another external shape such as a square shape.

The light emitting structure, that is, the first conductivity type semiconductor layer **721**, the active layer **723**, and the second conductivity type semiconductor layer **725** may be grown on a substrate. The substrate may be various substrates that can be used for growing semiconductors, such as a gallium nitride substrate, a GaAs substrate, a Si substrate, a sapphire substrate, in particular a patterned sapphire substrate. The growth substrate may be separated from the semiconductor layers using techniques such as mechanical polishing, laser lift-off, chemical lift-off, or the like. However, the inventive concepts are not limited thereto, and a portion of the substrate may remain to constitute at least a portion of the first conductivity type semiconductor layer **721**.

In an exemplary embodiment, in a case of the light emitting device **710***a* emitting red light, the semiconductor layers may include aluminum gallium arsenide (AlGaAs), gallium arsenide phosphide (GaAsP), aluminum gallium indium phosphide (AlGaInP), or gallium phosphide (GaP).

In a case of the light emitting device **710***b* emitting green light, the semiconductor layers may include indium gallium nitride (InGaN), gallium nitride (GaN), gallium phosphide (GaP), aluminum gallium indium phosphide (AlGaInP), or aluminum gallium phosphide (AlGaP).

In an exemplary embodiment, in a case of the light emitting device **710***c* emitting blue light, the semiconductor layer may include gallium nitride (GaN), indium gallium nitride (InGaN), or zinc selenide (ZnSe).

The first conductivity type and the second conductivity type have opposite polarities, when the first conductivity type is n-type, the second conductivity type is p-type, or when the first conductivity type is p-type, the second conductivity type becomes n-type.

The first conductivity type semiconductor layer **721**, the active layer **723**, and the second conductivity type semiconductor layer **725** may be grown on the substrate in a chamber using a known method such as metal organic chemical vapor deposition (MOCVD). In addition, the first conductivity type semiconductor layer **721** includes n-type impurities (e.g., Si, Ge, Sn), and the second conductivity type semiconductor layer **725** includes p-type impurities (e.g., Mg, Sr, Ba). In a case of the light emitting device **710***b* or **710***c* emitting green light or blue light, the first conductivity type semiconductor layer **721** may include GaN or AlGaN containing Si as a dopant, and the second conductivity type semiconductor layer **725** may include GaN or AlGaN containing Mg as a dopant.

Although the first conductivity type semiconductor layer **721** and the second conductivity type semiconductor layer **725** are illustrated as a single layer, respectively, in FIGS. **10**A-**10**B, but these layers may be multi-layered and may also include a superlattice layer. The active layer **723** may include a single quantum well structure or a multiple quantum well structure, and a composition ratio of a compound semiconductor is adjusted so as to emit a desired wavelength. For example, the active layer **723** may emit blue light, green light, red light, or ultraviolet light.

The second conductivity type semiconductor layer **725** and the active layer **723** may have a mesa M structure and be disposed on the first conductivity type semiconductor layer **721**. The mesa M may include the second conductivity type semiconductor layer **725** and the active layer **723**, and may include a portion of the first conductivity type semiconductor layer **721** as shown in FIG. **10**B. The mesa M may be disposed on a partial region of the first conductivity type semiconductor layer **721**, and an upper surface of the first conductivity type semiconductor layer **721** may be exposed around the mesa M.

In the illustrated exemplary embodiment, the mesa M is formed so as to expose the first conductivity type semiconductor layer **721** around the mesa M. In another exemplary embodiment, a through hole may be formed through the mesa M to expose the first conductivity type semiconductor layer **721**.

In an exemplary embodiment, the first conductivity type semiconductor layer **721** may have a flat light exiting surface. In another exemplary embodiment, the first conductivity type semiconductor layer **721** may have a concave-convex pattern by surface texturing on the light exiting surface side. The surface texturing may be performed, for example, by patterning using a dry or wet etching process. For example, cone-shaped protrusions may be formed on the light exiting surface of the first conductivity type semiconductor layer **721**, and a height of the cone may be about 2 μm to about 3 μm, a distance between the cones may be about 1.5 μm to about 2 μm, and a diameter of a bottom of the cone may be about 3 μm to about 5 μm. The cone may also be truncated, in which an upper diameter of the cone may be about 2 μm to about 3 μm.

In another exemplary embodiment, the concave-convex pattern may include a first concave-convex pattern and a second concave-convex pattern additionally formed on the first concave-convex pattern.

By forming the concave-convex pattern on the surface of the first conductivity type semiconductor layer **721**, total internal reflection may be reduced to increase light extraction efficiency. Surface texturing may be performed on the first conductivity type semiconductor layers of all of the first, second, and third light emitting devices **710***a*, **710***b*, and **710***c*, and thus, viewing angles of light emitted from the first, second, and third light emitting devices **710***a*, **710***b*, and **710***c* may become uniform. However, the inventive concepts are not limited thereto, and at least one of the light emitting devices **710***a*, **710***b*, and **710***c* may have a flat surface without including the concave-convex pattern.

The ohmic contact layer **727** is disposed on the second conductivity type semiconductor layer **725** to be ohmic contact with the second conductivity type semiconductor layer **725**. The ohmic contact layer **727** may be formed of a single layer or multiple layers, and may be formed of a transparent conductive oxide film or a metallic film. The transparent conductive oxide film may include, for example, ITO, ZnO, or the like and the metallic film may include metals such as Al, Ti, Cr, Ni, Au, Ge, Pt, or the like and alloys thereof.

The first contact pad **753** is disposed on the exposed first conductivity type semiconductor layer **721**. The first contact pad **753** may be in ohmic contact with the first conductivity type semiconductor layer **721**. For example, the first contact pad **753** may be formed of an ohmic metal layer in ohmic contact with the first conductivity type semiconductor layer **721**. The ohmic metal layer of the first contact pad **753** may be appropriately selected depending on a semiconductor material of the first conductivity type semiconductor layer **721**. The first contact pad **753** may be omitted.

The second contact pad **755** may be disposed on the ohmic contact layer **727**. The second contact pad **755** is electrically connected to the ohmic contact layer **727**. The second contact pad **755** may be omitted.

The insulation layer **759** covers the mesa M, the ohmic contact layer **727**, the first contact pad **753**, and the second contact pad **755**. The insulation layer **759** has openings **759***a* and **759***b* exposing the first contact pad **753** and the second contact pad **755**. The insulation layer **759** may be formed of a single layer or multiple layers. The insulation layer **759** may include an insulating material such as SiO_2, SiNx, Al_2O_3, or the like, and further, the insulation layer **759** may include a distributed Bragg reflector in which insulation layers having different refractive indices are stacked. For example, the distributed Bragg reflector may include at least two insulation layers selected from SiO_2, Si_3N_4, SiON, TiO_2, Ta_2O_5, Nb_2O_5, and MgF_2.

The distributed Bragg reflector reflects light emitted from the active layer **723**. The distributed Bragg reflector may exhibit a high reflectivity over a relatively wide wavelength range including a peak wavelength of light emitted from the active layer **723**, and may be designed in consideration of an incident angle of light. In an exemplary embodiment, the distributed Bragg reflector may have a higher reflectivity for light incident at an angle of incidence of 0 degree compared to that of light incident at other angles of incidence. In another exemplary embodiment, the distributed Bragg reflector may have a higher reflectivity for light incident at another specific angle of incidence compared to that of light incident at the angle of incidence of 0 degree. For example, the distributed Bragg reflector may have a higher reflectivity for light incident at an angle of incidence of 10 degrees compared to that of light incident at the angle of incidence of 0 degree.

Meanwhile, the light emitting structure of the blue light emitting device **710***c* has higher internal quantum efficiency than the light emitting structures of the red light emitting device **710***a* and the green light emitting device **710***b*. Accordingly, the blue light emitting device **710***c* may exhibit a light extraction efficiency higher than that of the red and green light emitting devices **710***a* and **710***b*. Accordingly, it may be difficult to properly maintain a color mixing ratio of red light, green light, and blue light.

To adjust the color mixing ratio of red light, green light, and blue light, the distributed Bragg reflectors applied to the light emitting devices **710***a*, **710***b*, and **710***c* may be formed to have different reflectivities from one another. For example, the blue light emitting device **710***c* may have a distributed Bragg reflector having a relatively low reflectivity compared to those of the red and green light emitting devices **710***a* and **710***b*. For example, the distributed Bragg reflector formed in the blue light emitting device **710***c* may have a reflectivity of 95% or less at the incident angle of 0 degrees for blue light generated in the active layer **723**, and further 90% or less, the distributed Bragg reflector formed in the green light emitting device **710***b* may have a reflectivity of about 95% or more and 99% or less at the incident angle of 0 degrees for green light, and the distributed Bragg reflector formed in the red light emitting device **710***a* may have a reflectivity of 99% or more at the incident angle of 0 degrees for red light.

In an exemplary embodiment, the distributed Bragg reflectors applied to the red, green, and blue light emitting devices **710***a*, **710***b*, and **710***c* may have a substantially similar thickness. For example, a difference in thicknesses between the distributed Bragg reflectors applied to these light emitting devices **710***a*, **710***b*, and **710***c* may be less than 10% of a thickness of a thickest distributed Bragg reflector. By reducing the difference in thicknesses of the distributed Bragg reflectors, process conditions applied to the red, green, and blue light emitting devices **710***a*, **710***b*, and **710***c*, for example, a process of patterning the insulation layer **759** may be set similarly, and furthermore, it is possible to prevent a fabrication process of the unit pixel from becoming complicated. Furthermore, the distributed Bragg reflectors applied to the red, green, and blue light emitting devices **710***a*, **710***b*, and **710***c* may have a substantially similar stacking number. However, the inventive concepts are not limited thereto.

In another exemplary embodiment, different light emitting devices **710***a*, **710***b*, and **710***c* may include different insulation layers **759** from one another. For example, the red light emitting device **710***a* may have the distributed Bragg reflector described above, and the green and blue light emitting devices **710***b* and **710***c* may have a single insulation layer **759**.

The first electrode pad **761** and the second electrode pad **763** are disposed on the insulation layer **759**. The first electrode pad **761** may extend from an upper portion of the first contact pad **753** to an upper portion of the mesa M, and the second electrode pad **763** may be disposed in an upper region of the mesa M. The first electrode pad **761** may be connected to the first contact pad **753** through the opening **759***a*, and the second electrode pad **763** may be electrically connected to the second contact pad **755**. The first electrode pad **761** may be directly in ohmic contact with the first conductivity type semiconductor layer **721**, and in this case, the first contact pad **753** may be omitted. In addition, when the second contact pad **755** is omitted, the second electrode pad **763** may be directly connected to the ohmic contact layer **727**.

The first and/or second electrode pads **761** and **763** may be formed of a single-layered or multi-layered metal. As a material of the first and/or second electrode pads **761** and **763**, metals such as Al, Ti, Cr, Ni, Au, or and alloys thereof may be used. For example, the first and second electrode pads **761** and **763** may include a Ti layer or a Cr layer on an uppermost end, and an Au layer thereunder.

Although the light emitting device **710***a* according to an exemplary embodiment of the present disclosure has been briefly described with the drawings, the light emitting device **710***a* may further include a layer having an additional function in addition to the above-described layer. For example, various layers such as a reflection layer that reflects light, an additional insulation layer to insulate a specific element, and a solder prevention layer to prevent diffusion of solder may be further included.

In addition, in forming a flip-chip type light emitting device, the mesa may be formed in various shapes, and locations or shapes of the first and second electrode pads **761** and **763** may also be variously modified. Moreover, the ohmic contact layer **727** may be omitted, and the second contact pad **755** or the second electrode pad **763** may directly contact the second conductivity type semiconductor layer **725**.

Although some embodiments have been described herein, it should be understood that these embodiments are provided for illustration only and are not to be construed in any way as limiting the present disclosure. It should be understood that features or components of an exemplary embodiment can also be applied to other embodiments without departing from the spirit and scope of the present disclosure.

The invention claimed is:

1. A light emitting module, comprising:
a module substrate;
a protection layer disposed on the module substrate and exposing portions of the module substrate and pads, the protection layer configured to block soldering of the pads and prevent an electrical short circuit between the pads;
a plurality of unit pixels disposed on the module substrate, each unit pixel including a connection electrode electrically connected to the pads; and
a molding layer covering the plurality of unit pixels, wherein:
the molding layer further includes a light diffusion layer and a black molding layer,
at least one of the light diffusion layer or the black molding layer includes one or more patterns, and
a side surface of the module substrate, a side surface of the light diffusion layer, and a side surface of the black molding layer are located on a same plane.

2. The light emitting module of claim **1**,
wherein the light diffusion layer includes a first pattern on an upper surface of the light diffusion layer and the black molding layer includes a second pattern on an upper surface surface of the black molding layer.

3. The light emitting module of claim **1**,
wherein each element of the one or more patterns includes a hemispherical pattern, a conical pattern, or a grid pattern.

4. The light emitting module of claim **1**,
wherein the light diffusion layer includes a convex portion on the plurality of unit pixels.

5. The light emitting module of claim **4**, wherein:
the light diffusion layer further includes a first pattern; and
a first interval between first elements of the first pattern on the convex portion is greater than a second interval between second elements of the first pattern,
the second elements of the first pattern formed on an upper surface of the light diffusion layer and disposed in a region between the plurality of unit pixels.

6. The light emitting module of claim **5**, wherein:
the black molding layer includes a second pattern, and
elements of the second pattern of the black molding layer are spaced apart from one another at a substantially constant interval.

7. The light emitting module of claim **1**,

wherein a first thickness from an uppermost end of the light diffusion layer on the plurality of unit pixels to the module substrate is greater than or equal to a second thickness from an upper surface of the light diffusion layer disposed in a region between the plurality of unit pixels to the module substrate.

8. The light emitting module of claim **7**,

wherein the second thickness of the light diffusion layer disposed in the region between the plurality of unit pixels is greater than a height of each of the plurality of unit pixels.

9. The light emitting module of claim **1**,

wherein each of the plurality of unit pixels includes:

a first LED stack, a second LED stack, and a third LED stack that are vertically stacked, or

at least three light emitting devices arranged on the same plane.

10. A display apparatus, comprising:

a display substrate; and

a plurality of light emitting modules arranged on the display substrate, each of the plurality of light emitting modules including a light emitting module that comprises:

a module substrate;

a protection layer disposed on the module substrate and exposing portions of the module substrate and pads, the protection layer configured to block soldering of the pads and prevent an electrical short circuit between the pads;

a plurality of unit pixels disposed on the module substrate, each unit pixel including a connection electrode electrically connected to the pads; and

a molding layer covering the plurality of unit pixels, wherein:

the molding layer further includes a light diffusion layer and a black molding layer,

at least one of the light diffusion layer or the black molding layer includes one or more patterns, and

a side surface of the module substrate, a side surface of the light diffusion layer, and a side surface of the black molding layer are located on a same plane.

11. The display apparatus of claim **10**,

wherein the light diffusion layer includes a first pattern on an upper surface of the light diffusion layer and the black molding layer includes a second pattern on an upper surface surface of the black molding layer.

12. The display apparatus of claim **10**,

wherein each element of the one or more patterns includes a hemispherical pattern, a conical pattern, or a grid pattern.

13. The display apparatus of claim **10**,

wherein the light diffusion layer includes a convex portion on the plurality of unit pixels.

14. The display apparatus of claim **13**, wherein:

the light diffusion layer further includes a first pattern; and

a first interval between first elements of the first pattern on the convex portion is greater than a second interval between second elements of the first pattern,

the second elements of the first pattern formed on an upper surface of the light diffusion layer and disposed in a region between the plurality of unit pixels.

15. The display apparatus of claim **14**, wherein:

the black molding layer includes a second pattern, and

elements of the second pattern of the black molding layer are spaced apart from one another at a substantially constant interval.

16. The display apparatus of claim **10**,

wherein a first thickness from an uppermost end of the light diffusion layer on the plurality of unit pixels to the module substrate is greater than or equal to a second thickness from an upper surface of the light diffusion layer disposed in a region between the plurality of unit pixels to the module substrate.

17. The display apparatus of claim **16**,

wherein the second thickness of the light diffusion layer disposed in the region between the plurality of unit pixels is greater than a height of each of the plurality of unit pixels.

18. The display apparatus of claim **10**,

wherein each of the plurality of unit pixels includes:

a first LED stack, a second LED stack, and a third LED stack that are vertically stacked, or

at least three light emitting devices arranged on the same plane.

19. A light emitting module, comprising:

a module substrate;

a plurality of unit pixels disposed on the module substrate; and

a molding layer covering the plurality of unit pixels, wherein:

the molding layer further includes a light diffusion layer and a black molding layer,

at least one of the light diffusion layer or the black molding layer includes one or more patterns, and

a side surface of the module substrate, a side surface of the light diffusion layer, and a side surface of the black molding layer are located on a same plane,

wherein the light diffusion layer includes a convex portion on the plurality of unit pixels, and

wherein the light diffusion layer further includes a first pattern,

wherein a first interval between first elements of the first pattern on the convex portion is greater than a second interval between second elements of the first pattern, and

wherein the second elements of the first pattern formed on an upper surface of the light diffusion layer and disposed in a region between the plurality of unit pixels.

20. The light emitting module of claim **19**, wherein:

the black molding layer includes a second pattern, and

elements of the second pattern of the black molding layer are spaced apart from one another at a substantially constant interval.

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