



US00RE48012E

(19) **United States**
(12) **Reissued Patent**
Lee et al.

(10) **Patent Number: US RE48,012 E**
(45) **Date of Reissued Patent: *May 26, 2020**

(54) **DISPLAY DEVICE**

(71) Applicant: **LG Innotek Co., Ltd.**, Seoul (KR)
(72) Inventors: **Jung Mok Lee**, Seoul (KR); **Jae Hyun Jin**, Seoul (KR)
(73) Assignee: **LG INNOTEK CO., LTD.**, Seoul (KR)
(*) Notice: This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/696,656**

(22) Filed: **Sep. 6, 2017**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **9,244,209**
Issued: **Jan. 26, 2016**
Appl. No.: **12/969,074**
Filed: **Dec. 15, 2010**

U.S. Applications:

(63) Continuation of application No. 15/668,572, filed on Aug. 3, 2017, which is an application for the reissue of Pat. No. 9,244,209.

(30) **Foreign Application Priority Data**

Dec. 15, 2009 (KR) 10-2009-0124949

(51) **Int. Cl.**
F21V 7/04 (2006.01)
F21V 8/00 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **G02B 6/0026** (2013.01); **G02B 6/0023** (2013.01); **G02F 1/133615** (2013.01)

(58) **Field of Classification Search**
CPC **G02B 6/0023**; **G02B 6/0026**; **G02B 6/009**;
G02B 6/0091; **G02B 6/0068**; **G02B 6/0073**

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,538,340 B2 * 5/2009 Pang et al. 257/21
7,607,815 B2 * 10/2009 Pang 362/612
(Continued)

FOREIGN PATENT DOCUMENTS

JP 10-269822 A 10/1998
JP 2007-005098 A 1/2007

(Continued)

OTHER PUBLICATIONS

Office Action dated in Korean Application No. 10-2009-0124949, filed Oct. 30, 2014.

(Continued)

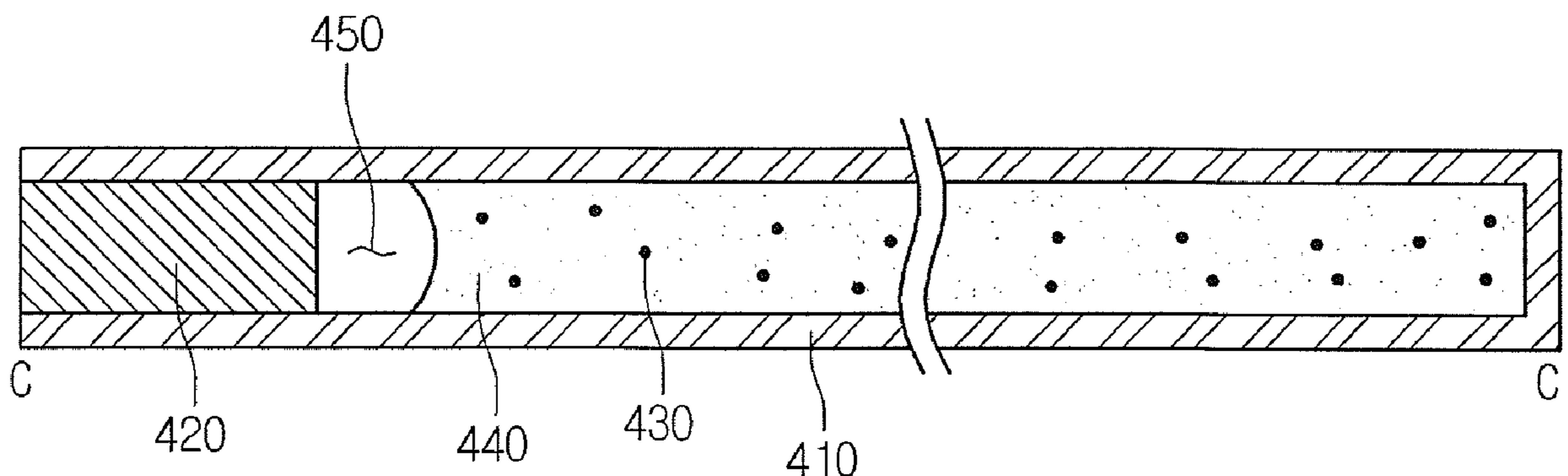
Primary Examiner — James A Menefee

(74) *Attorney, Agent, or Firm* — Saliwanchik, Lloyd & Eisenschenk

(57) **ABSTRACT**

Provided is a display device. The display device includes a circuit substrate, a light source electrically connected to the circuit substrate, the light source being disposed under the circuit substrate, and a light conversion member disposed on a light emitting surface of the light source and a side of the circuit substrate, the light conversion member converting a wavelength of light emitted from the light source. Here, the light conversion member is disposed also on a side surface of the circuit substrate and converts a wavelength of light emitted from the light source. Since the light conversion member is disposed on the side surface of the circuit substrate, the light conversion member may be aligned with the light source without interfering with the circuit substrate. Thus, the display device may effectively convert the wavelength of the light emitted from the light source to realize improved brightness and color impression.

8 Claims, 6 Drawing Sheets



US RE48,012 E

Page 2

- (51) **Int. Cl.**
G02F 1/1335 (2006.01)
G02F 1/13357 (2006.01)
- 2007/0285493 A1 12/2007 Ouderkirk et al.
2008/0173886 A1* 7/2008 Cheon C09K 11/02
257/98
2008/0237540 A1 10/2008 Dubrow
2010/0308354 A1* 12/2010 David et al. 257/98

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,720,159 B2 8/2017 Hyun et al.
9,720,160 B2 8/2017 Hyun
9,766,386 B2 9/2017 Park
9,829,621 B2 11/2017 Park
9,835,785 B2 12/2017 Roh et al.
10,042,103 B2* 8/2018 Yeo G02B 6/002
10,054,730 B2 8/2018 Roh et al.
10,066,810 B2 9/2018 Lee
2006/0186431 A1* 8/2006 Miki et al. 257/100
2006/0244358 A1 11/2006 Kim et al.
2007/0154199 A1* 7/2007 Chu 396/106
2007/0284597 A1* 12/2007 Nawashiro et al. 257/89

FOREIGN PATENT DOCUMENTS

JP 2007-005098 A 1/2007
KR H10-269822 A 10/1998
KR 10-2006-0114523 A 11/2006
KR 10-2007-0037800 A 4/2007

OTHER PUBLICATIONS

Office Action dated Aug. 13, 2019 in U.S. Appl. No. 15/668,572.
Office Action dated in Korean Application No. Oct. 30, 2014, filed
10-2009-0124049.

* cited by examiner

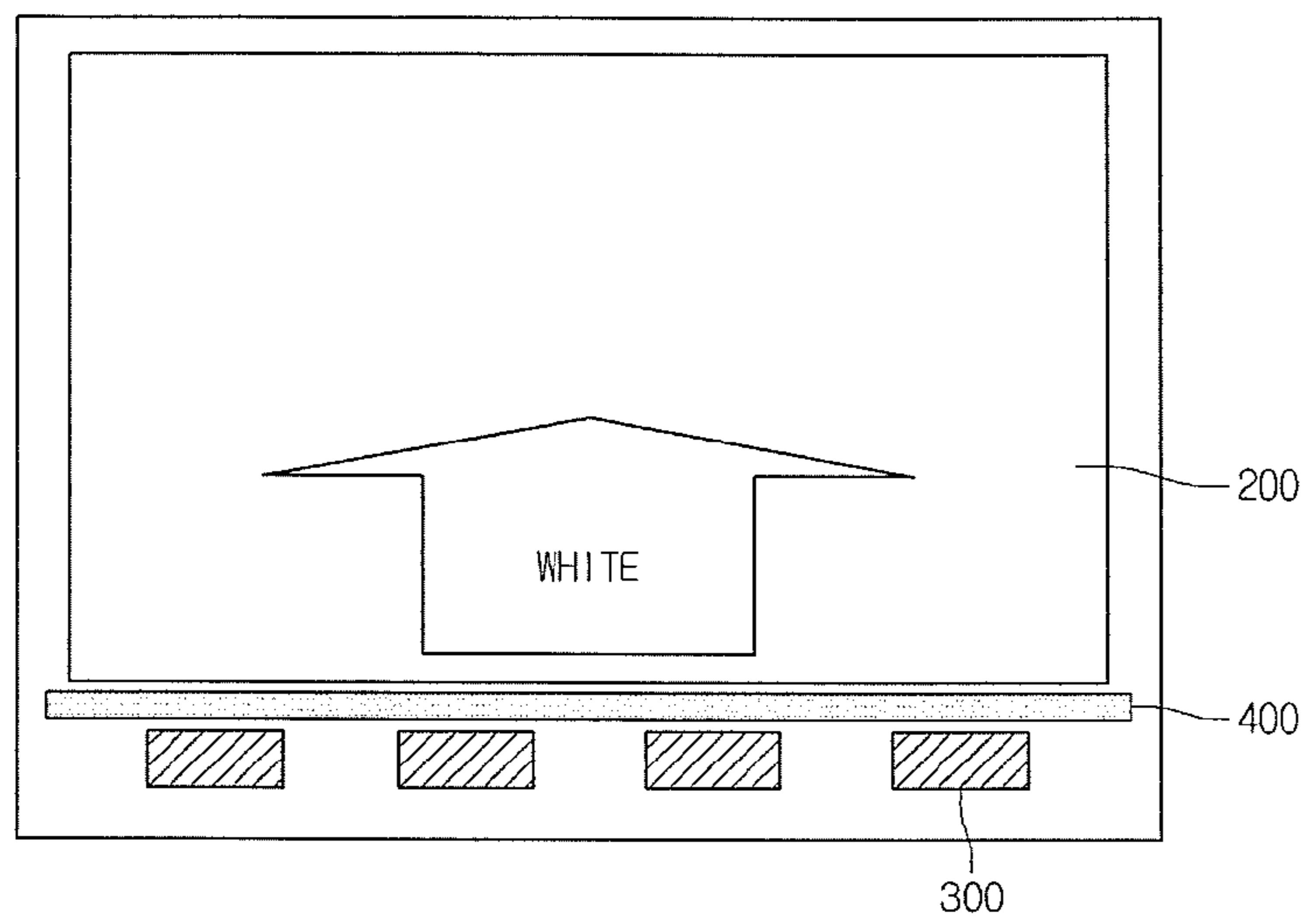


FIG. 1

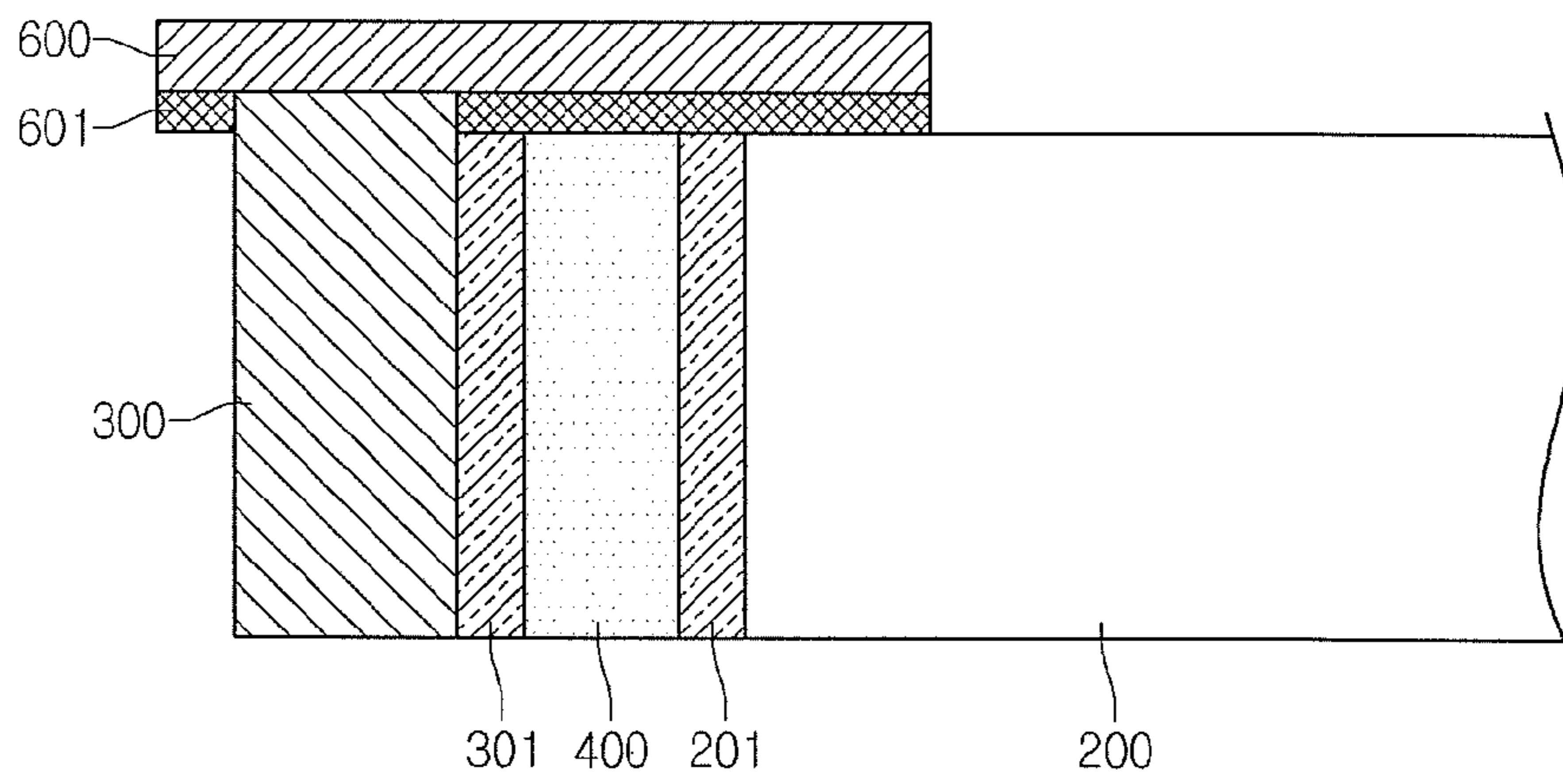


FIG. 2

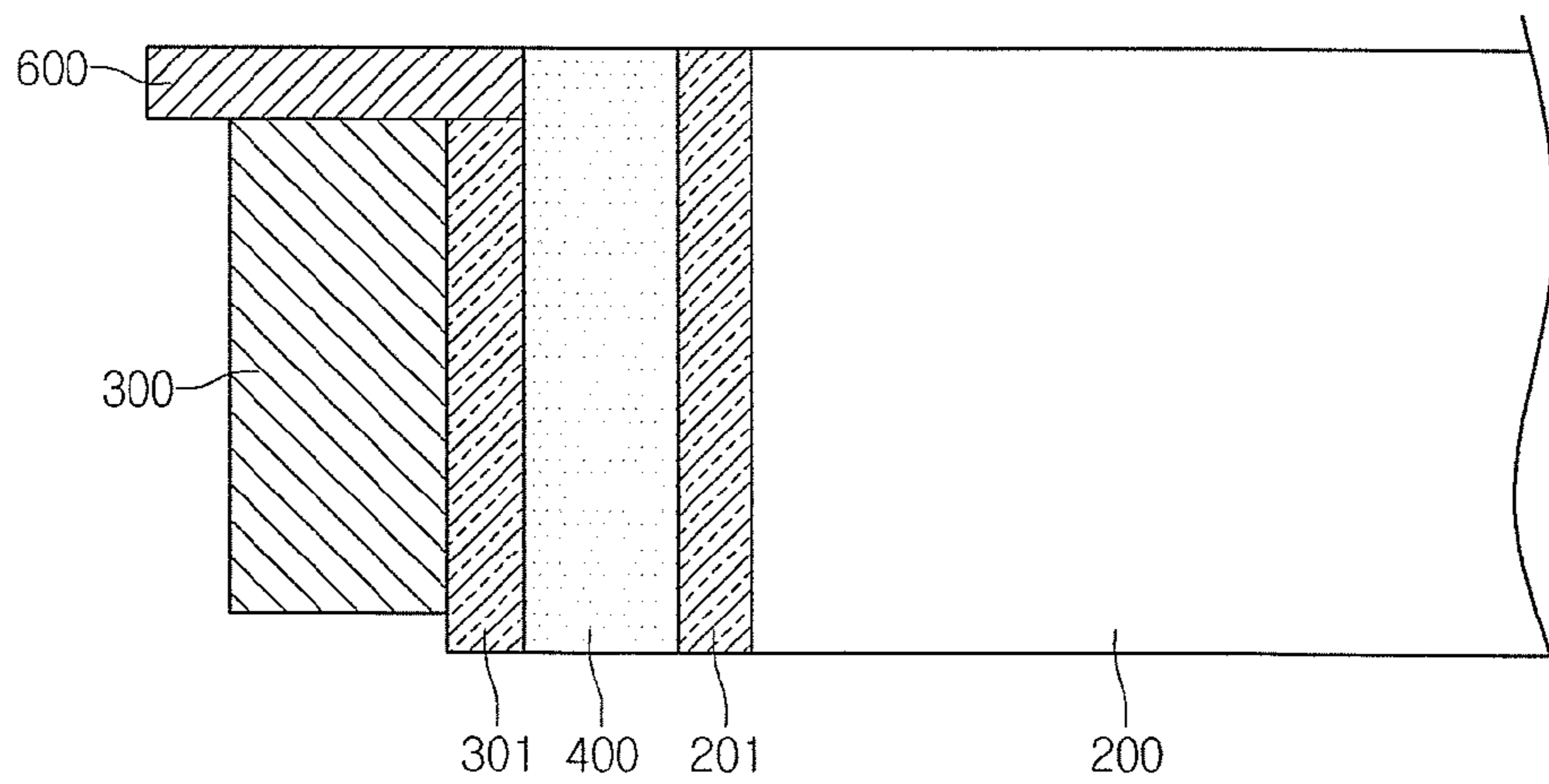


FIG. 3

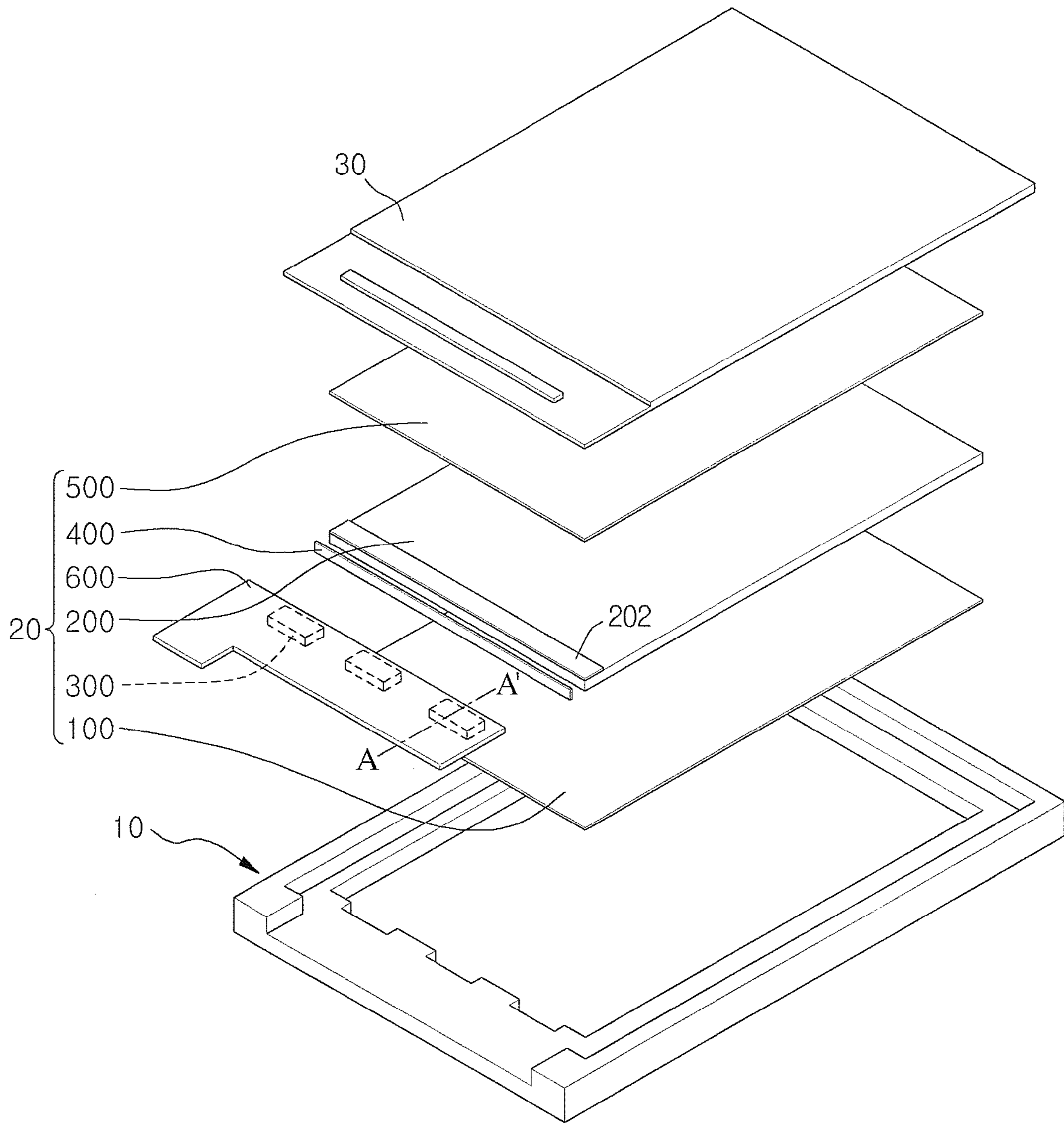


FIG. 4

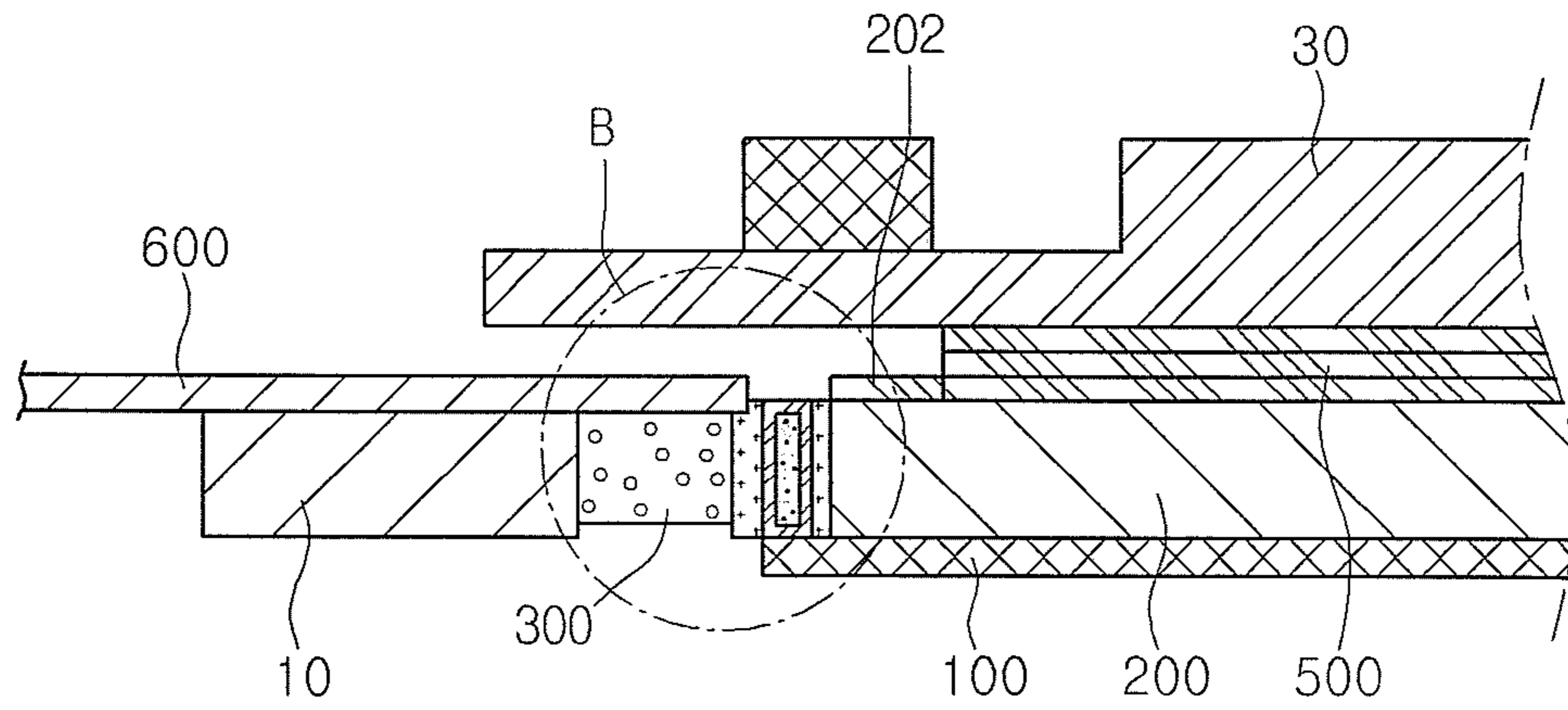


FIG. 5

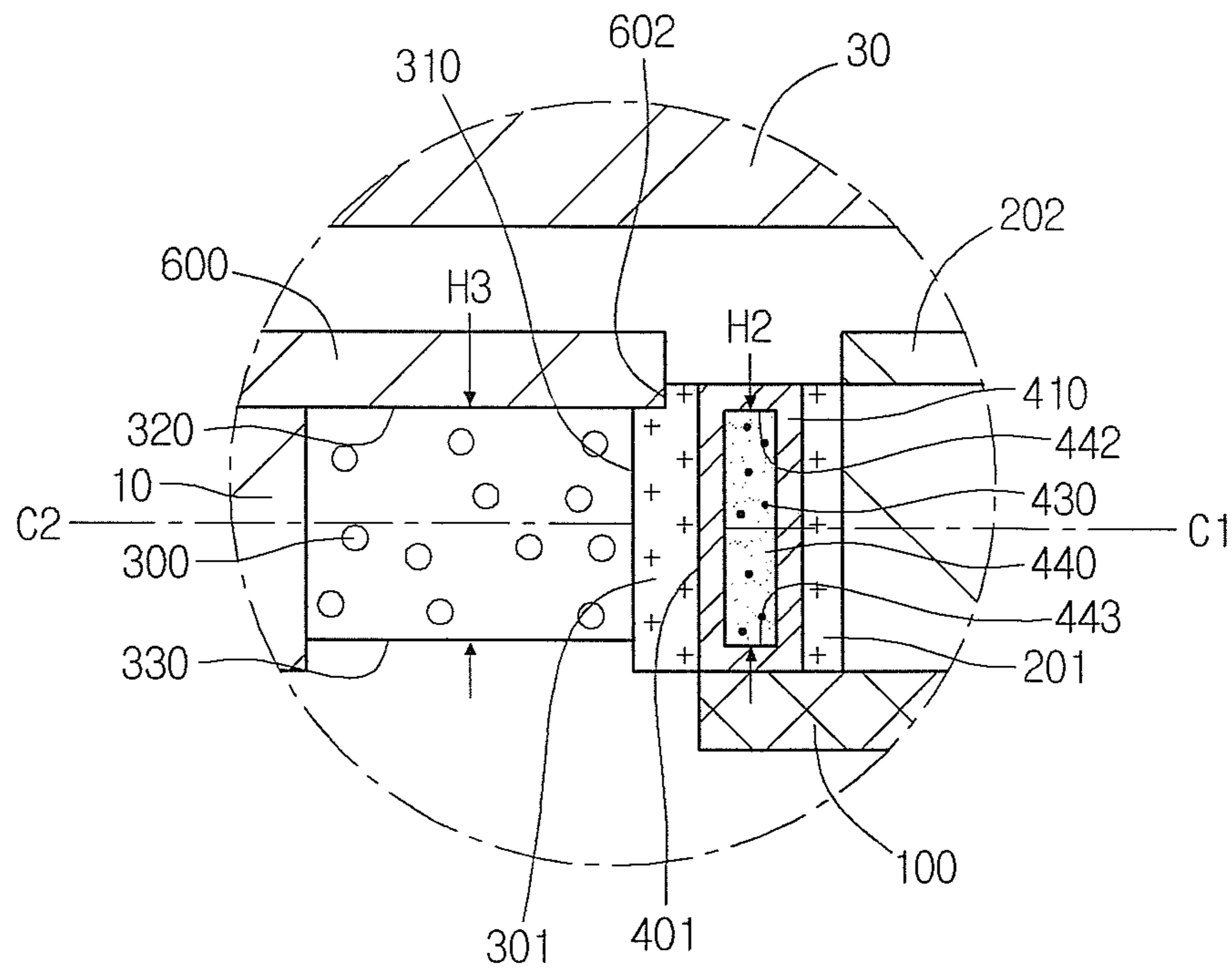


FIG. 6

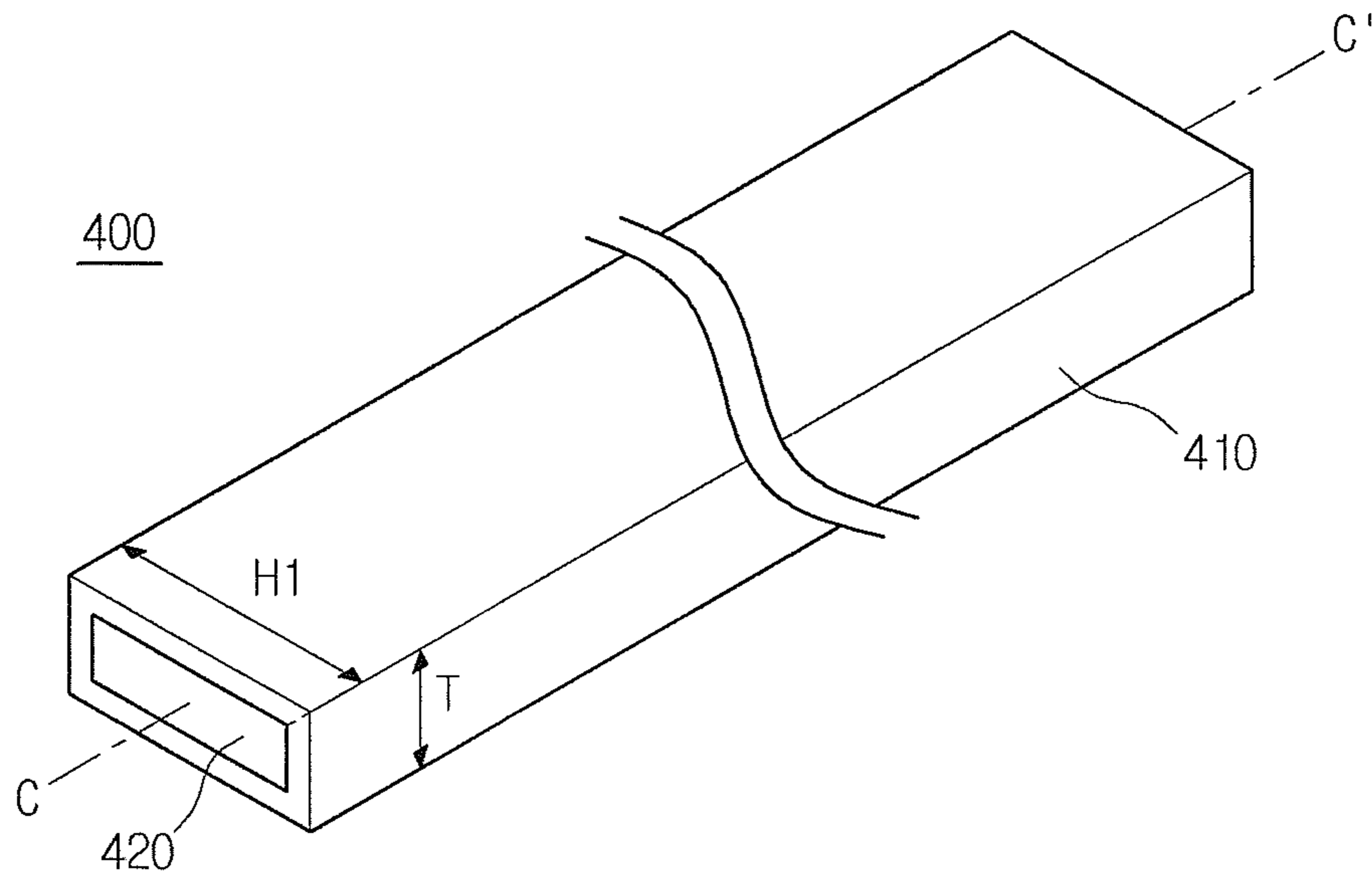


FIG. 7

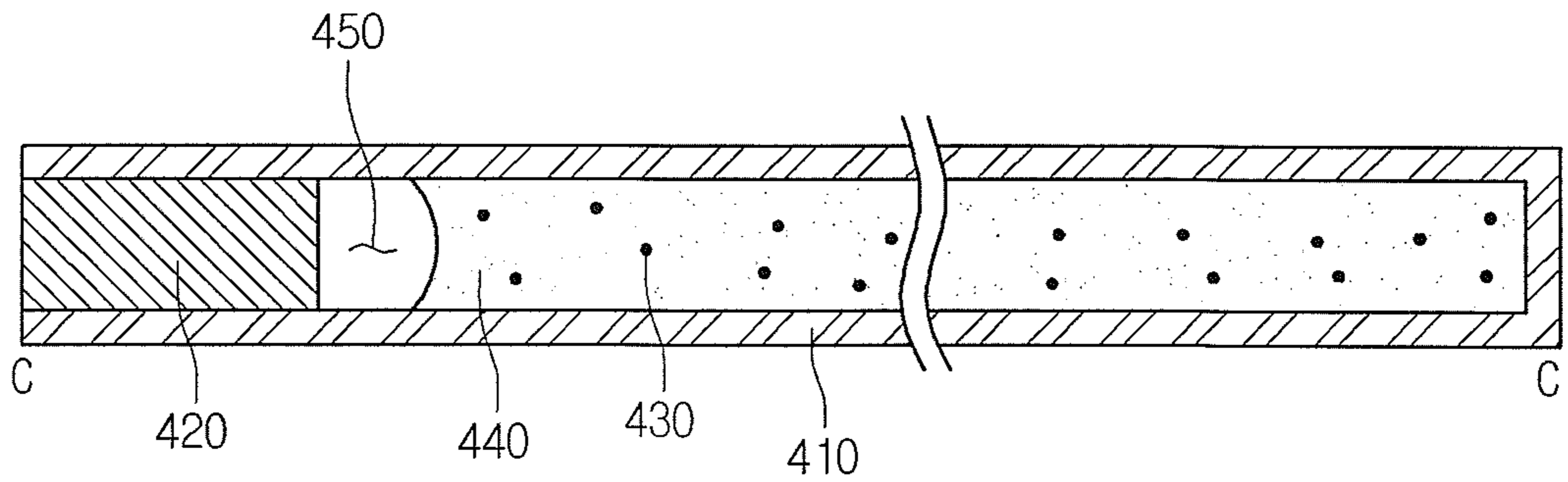


FIG. 8

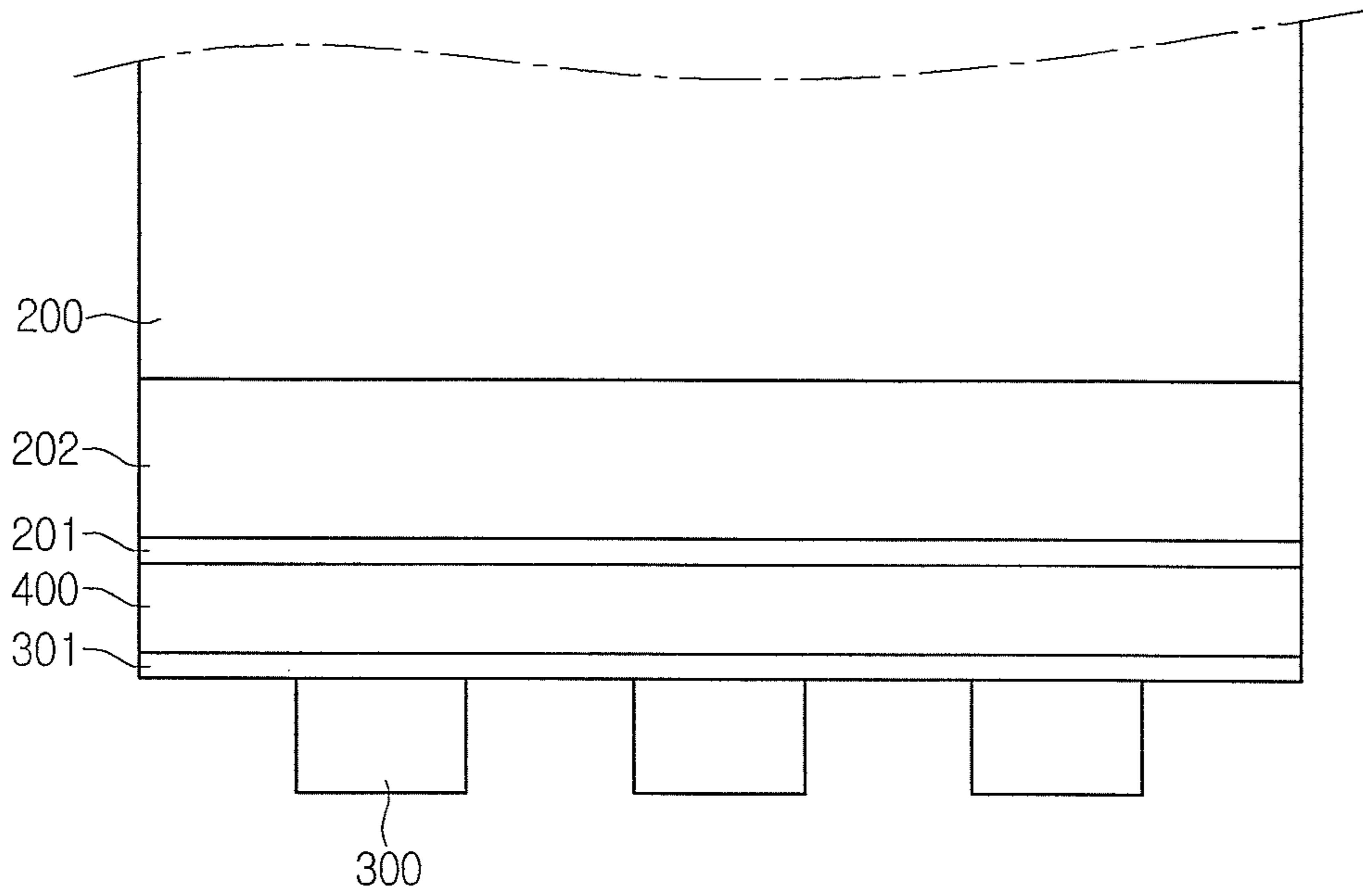


FIG. 9

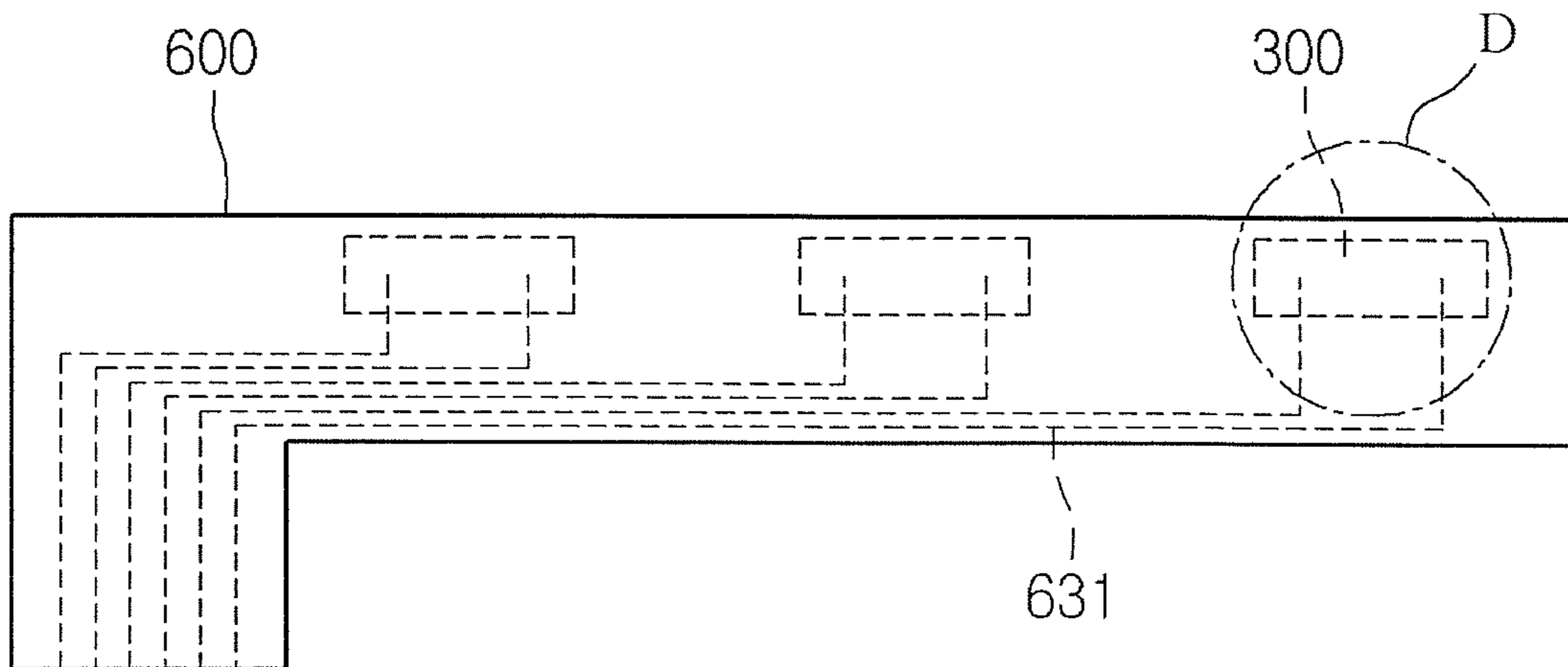


FIG. 10

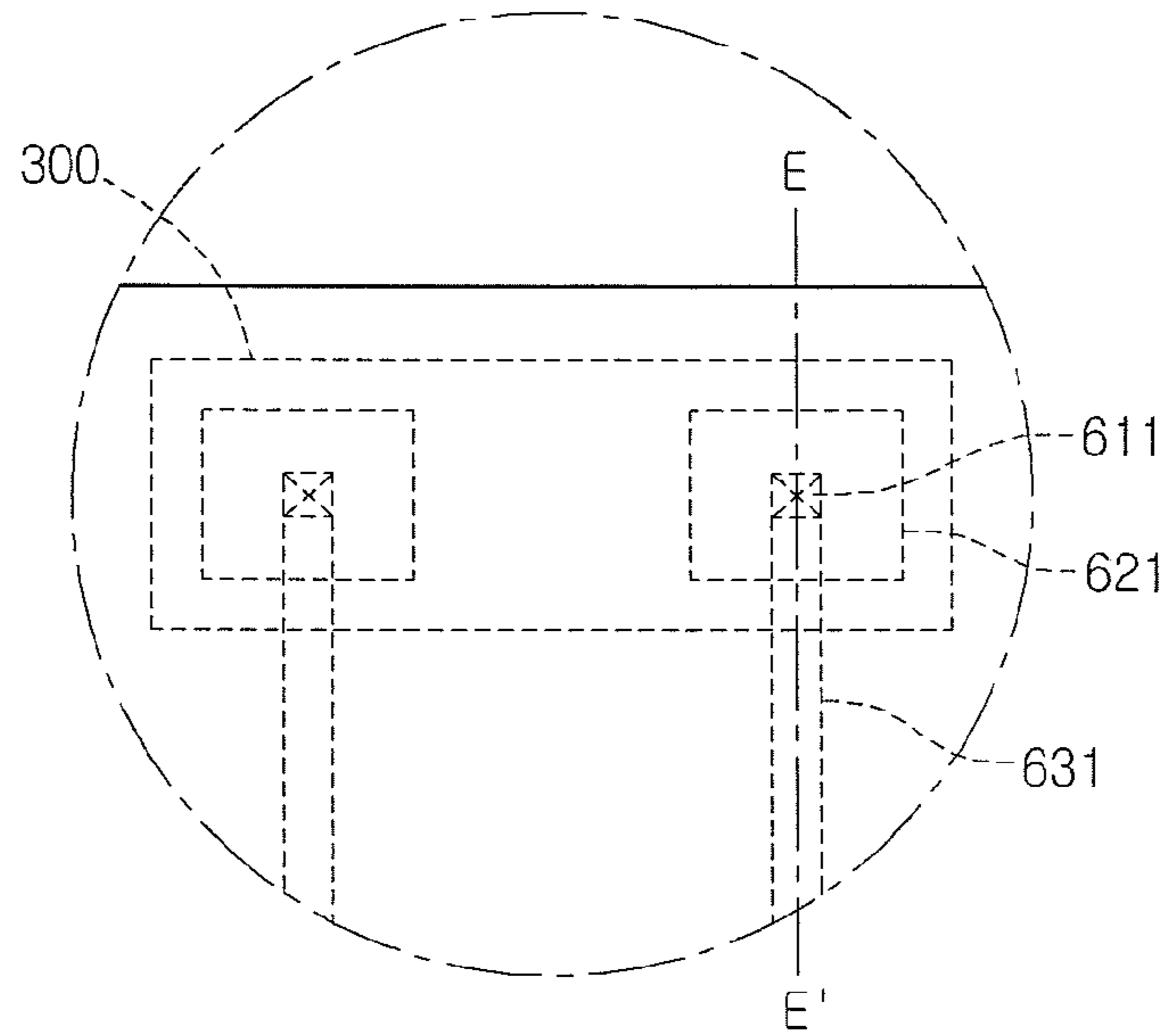


FIG. 11

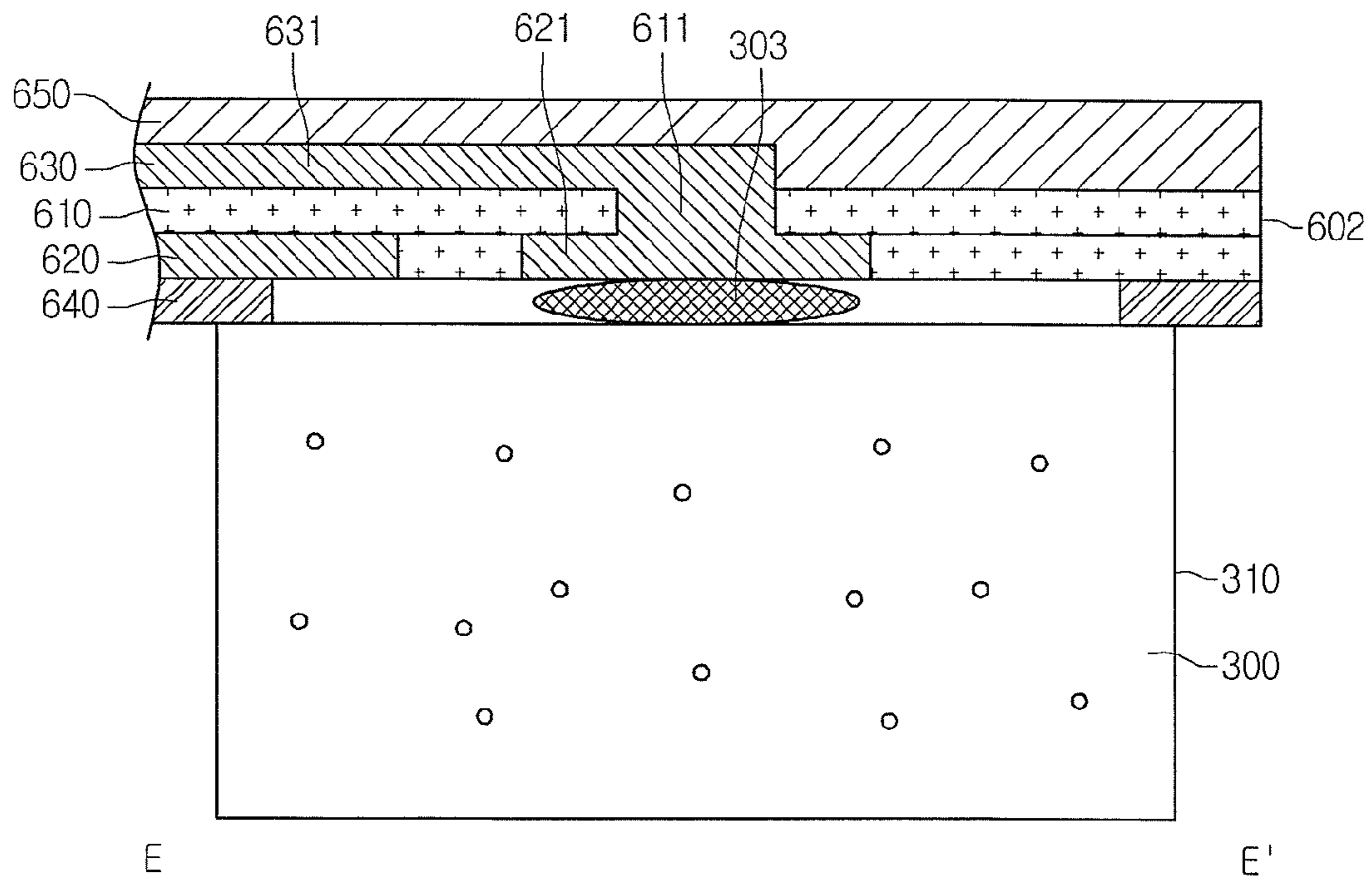


FIG. 12

1

DISPLAY DEVICE

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

CROSS-REFERENCE TO RELATED APPLICATION

[This application] *Notice: More than one reissue application has been filed for the reissue of U.S. Pat. No. 9,244,209. The reissue applications are application Ser. Nos. 15/696,656 (the present application) and 15/668,572. Application Ser. No. 15/696,656 is a continuation reissue of application Ser. No. 15/668,572.*

The present application is a continuation reissue application of U.S. patent application Ser. No. 15/668,572, filed Aug. 3, 2017. The present application is a reissue application of U.S. patent application Ser. No. 12/969,074, filed Dec. 15, 2010, now U.S. Pat. No. 9,244,209, which in turn claims the benefit under 35 U.S.C. §119 of Korean Patent Application No. 10-2009-0124949, filed on Dec. 15, 2009, the contents of which [is] are hereby incorporated by reference in [its] their entirety.

BACKGROUND

Embodiments relate to a display device. Light emitting diodes (LEDs) are semiconductor devices that convert electricity into ultraviolet rays, infrared rays, or visible light using characteristics of compound semiconductors. The LEDs are being used for home appliances, remote controllers, large-scale screen, etc.

LED light sources having high brightness are being used for lighting lamps. In addition, since such an LED light source has high energy efficiency, low replacement cost due to a long life cycle, durability against vibration or shock, and does not use toxic substances such as mercury, existing incandescent lamps or fluorescent lamps are being replaced with LED light sources for energy-saving, environmental protection and reducing costs.

Also, LEDs are favorable for light sources of middle or large sized LCD televisions and monitors. The LEDs have superior color purity and low power consumption and allow easy miniaturization when compared to cold cathode fluorescent lamps (CCFLs) mainly used for light sources of the current liquid crystal displays (LCDs). Thus, the prototypes of these LEDs are being mass-produced, and also, researches with respect to the LEDs are being more actively conducted.

Recently, various technologies that use a blue LED and realize white light using a quantum dot (QD) emitting red light and green light as a phosphor are being developed. This is done because the white light realized using the quantum dot has high brightness and superior color reproductivity.

Nevertheless, the need of researches for reducing light losses, which may occur in case where the LED is applied to LED backlight units, and improving color uniformity is on the rise.

BRIEF SUMMARY

Embodiments provide a display device having improved brightness and/or high color reproductivity.

2

In one embodiment, a display device includes: a circuit substrate; a light source electrically connected to the circuit substrate, the light source being disposed under the circuit substrate; and a light conversion member disposed on a light emitting surface of the light source and a side of the circuit substrate, the light conversion member converting a wavelength of light emitted from the light source.

In another embodiment, a display device includes: a light source; and a light conversion member disposed on a light emitting surface of the light source, the light conversion member converting a wavelength of light emitted from the light source, wherein the light conversion member includes: a tube; a host disposed inside the tube; and a plurality of light conversion particles disposed inside the host, wherein the light source corresponds to the host.

In further another embodiment, a display device includes: a light guide plate; a display panel disposed on the light guide plate; a light source disposed on a side surface of the light guide plate; a light conversion member disposed between the light source and the light guide plate; and a circuit substrate electrically connected to the light source, wherein a side surface of the light conversion member faces a side surface of the circuit substrate.

The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view of a backlight unit according to a first embodiment.

FIG. 2 is a sectional view of the backlight unit according to the first embodiment.

FIG. 3 is a sectional view of a backlight unit according to a second embodiment.

FIG. 4 is an exploded perspective view of a liquid crystal display according to a third embodiment.

FIG. 5 is a sectional view taken along line A-A' of FIG. 4.

FIG. 6 is an enlarged sectional view illustrating a portion B of FIG. 5.

FIG. 7 is a perspective view of a light conversion member according the third embodiment.

FIG. 8 is a sectional view taken along line C-C' of FIG. 7.

FIG. 9 is a plan view of a light emitting diode, a light conversion member, a light guide plate, and a reflective layer.

FIG. 10 is a plan view of a FPCB and LEDs.

FIG. 11 is an enlarged view illustrating a portion D of FIG. 10.

FIG. 12 is a sectional view taken along line E-E' of FIG. 11.

DETAILED DESCRIPTION

In the descriptions of embodiments, it will be understood that when a substrate, a frame, a sheet, a layer, or a pattern is referred to as being 'on' a substrate, a substrate, a frame, a sheet, a layer, or a pattern, it can be directly on another layer or substrate, or intervening layers may also be present. Further, it will be understood that when a layer is referred to as being 'under' another layer, it can be directly under another layer, or one or more intervening layers may also be present. Further, the reference about 'on' and 'under' each layer will be made on the basis of drawings. In the drawings,

3

the thickness or size of each layer may be exaggerated, omitted, or schematically illustrated for convenience in description and clarity. Also, the size of each element does not entirely reflect an actual size.

FIG. 1 is a view of a backlight unit according to a first embodiment. FIG. 2 is a sectional view of the backlight unit according to the first embodiment. FIG. 3 is a sectional view of a backlight unit according to a second embodiment.

Referring to FIG. 1, a light conversion member 400 in which a plurality of quantum dots, which are converted into light having a red or green wavelength when they receive light having a blue wavelength, is dispersed is disposed at front sides of blue LEDs 300, which constitute a backlight unit according to a first embodiment and emit blue light. When the blue light is irradiated onto the light conversion member 400, mixed light of blue, red, and green light is incident into a light guide plate 200 by the plurality of quantum dots dispersed in the light conversion member 400 to provide white light.

Here, when the white light is provided to the light guide plate 200 using the light conversion member 400, high color reproduction may be realized.

Referring to FIG. 2, the backlight unit may include a flexible printed circuit board (FPCB) 600, which transmits a signal from/into the LEDs 300 and supplies a power, on a top surface of each of the blue LEDs 300 emitting the blue light. An adhesion member 601 may be further disposed on a bottom surface of the FPCB 600.

Referring to FIG. 3, a backlight unit according to a second embodiment may have a structure in which brightness is improved and color reproductivity is increased.

The backlight unit according to the current embodiment includes LEDs 300 emitting blue light, a FPCB 600 connected to an upper end of the LEDs 300 to transmit a signal and supply a power, a light conversion member 400 in which a plurality of quantum dots is dispersed therein, the light conversion member 400 having a bar shape and disposed at front sides of the LEDs 300 connected to the FPCB 600, and a light guide plate 200 attached to a front side of the light conversion member 400. The light conversion member 400 has a width greater than that of each of the LEDs 300.

Here, adhesion layers 201 and 301 may be further disposed between the LEDs 300 and the light conversion member 400 and between the light conversion member 400 and the light guide plate 200.

Specifically, a second adhesion layer 301 is disposed between the LEDs 300 and the light conversion member 400, and a first adhesion layer 201 is disposed between the light conversion member 400 and the light guide plate 200.

The LEDs 300 and the light conversion member 400 and the light conversion member 400 and the light guide plate 200 may be easily coupled to each other by the adhesion layers 201 or 301. Here, the adhesion layers 201 and 301 are formed of a transparent adhesive resin, which transmits light. However, the present disclosure is not limited to materials of the adhesion layers 201 and 301.

Also, the adhesion layers 201 and 301 are disposed between the LEDs 300 and the light conversion member 400 and between the light conversion member 400 and the light guide plate 200 to index-match them to each other.

For the index matching, each of the adhesion layers 201 and 301 may have a refractive index of about 1.1 to about 1.6. Here, when the refractive index is greater than about 1.1, there is an advantage in that a reflectance of light emitted from a light source can be reduced to improve brightness. Also, when the refractive index is less than about 1.6, there is an advantage in that it can inhibit the light

4

emitted from the light source from being increased in refractive and reflective degrees to improve brightness and transmittance.

The backlight unit according to the current embodiment provides the white light used for the liquid crystal display. The backlight unit is attached to a bottom surface of the liquid crystal display.

The LEDs 300 according to the current embodiment is attached to a front end of the light conversion member 400 to emit the blue light.

Specifically, the LEDs 300 emitting the blue light may be blue LEDs.

The FPCB 600 according to the current embodiment is connected to sides of the LEDs 300, e.g., upper or lower ends of the LEDs 300 to transmit a signal and supply a power.

The light conversion member 400 according to the current embodiment has a bar shape and is disposed at front sides of the LEDs 300 to which the FPCB 600 is connected to the upper end thereof.

Here, the bar shape represents a shape having a predetermined thickness and expanded in a length direction, e.g., a plate shape.

As shown in FIG. 3, the light conversion member 400 having the bar shape has a height greater than that of each of the LEDs 300. For example, the light conversion member 400 has the bar shape extending from a lower side of a lower end of each of the LEDs 300 to an upper end of the FPCB 600 connected to the upper end of each of the LEDs 300 and is center-aligned in a height direction of the LEDs 300 to inhibit light emitted from the LEDs 300, i.e., blue light from leaking to the outside, e.g., into the light guide plate 200.

Here, the height of each of the LEDs 300 represents a height from the upper end to the lower end of each of the LEDs 300 in the sectional view of FIG. 3.

The light conversion member 400 includes the plurality of quantum dots therein, i.e., quantum dots, which are converted into light having a red or green wavelength when the blue light is irradiated to emit red and green light.

The plurality of quantum dots is uniformly dispersed in the light conversion member 400, i.e., randomly dispersed in the light conversion member 400.

Specifically, the light conversion member 400 may have a structure in which a quantum dot mixture that is converted into the red or green light when the blue light is irradiated is injected and sealed into a tube.

Mixed light of the blue, red, and green light transmitting the light conversion member 400 is incident into the light guide plate 200 according to the current embodiment to provide the white light to the backlight unit.

An effect of the backlight unit according to the current embodiment including the foregoing components will be described below.

First, when the blue light is emitted from the LEDs 300, i.e., LEDs 300 emitting the blue light, the emitted blue light is incident into the light conversion member 400.

Here, a portion of the light incident into the light conversion member 400 transmits through the light conversion member 400 and is directly incident into the light guide plate 200.

Next, another portion of the light transmitting the light conversion member 400 is irradiated onto the quantum dots that are converted into light having the red wavelength when they receive the blue light, and further another portion of the light transmitting the light conversion member 400 is irra-

5

diated onto the quantum dots that are converted into light having the green wavelength when they receive the blue light.

Here, the light converted into the red and green light by being irradiated onto the quantum dots together with the blue light is incident into the light guide plate **200** to allow the backlight unit to emit the white light, i.e., white light similar to natural light.

FIG. **4** is an exploded perspective view of a liquid crystal display according to a third embodiment. FIG. **5** is a sectional view taken along line A-A' of FIG. **4**. FIG. **6** is an enlarged sectional view illustrating a portion B of FIG. **5**. FIG. **7** is a perspective view of a light conversion member according the third embodiment.

FIG. **8** is a sectional view taken along line C-C' of FIG. **7**. FIG. **9** is a plan view of a light emitting diode, a light conversion member, a light guide plate, and a reflective layer. FIG. **10** is a plan view of a FPCB and LEDs. FIG. **11** is an enlarged view illustrating a portion D of FIG. **10**. FIG. **12** is a sectional view taken along line E-E' of FIG. **11**. Descriptions of this embodiment may be applied to those of the foregoing embodiments except modified portions.

Referring to FIGS. **4** to **12**, a liquid crystal display according to the current embodiment includes a mold frame **10**, a backlight assembly **20**, and a liquid crystal panel **30**.

The mold frame **10** receives the backlight assembly **20** and the liquid crystal panel **30**. The mold frame **10** has a square frame. For example, the mold frame **10** may be formed of plastic or reinforcement plastic.

Also, a chassis surrounding the mold frame **10** and supporting the backlight assembly **20** may be disposed under the mold frame **10**. The chassis may be disposed also on a side surface of the mold frame **10**.

The backlight assembly **20** is disposed inside the mold frame **10** to generate light. Then, the backlight assembly **20** emits the generated light toward the liquid crystal panel **30**. The backlight assembly **20** includes a reflective sheet **100**, a light guide plate **200**, a plurality of light emitting diodes (LEDs) **300**, a light conversion member **400**, a plurality of optical sheets **500**, and a flexible printed circuit board (FPCB) **600**.

The reflective sheet **100** reflects light emitted from the LEDs **300** upward.

The light guide plate **200** is disposed on the reflective sheet **100** and receives the light emitted from the LEDs **300** to reflect the light upward through reflection, refraction, and dispersion.

Referring to FIGS. **5**, **6**, and **9**, a reflective layer **202** is disposed on a top surface of the light guide plate **200**. The reflective layer **202** is disposed on a portion of the top surface of the light guide plate **200**. In detail, the reflective layer **202** is disposed on a side surface of the light guide plate **200** corresponding to a side at which the LEDs **300** are disposed.

Specifically, referring to FIG. **9**, the reflective layer **202** extends in a direction in which the light conversion member **400** extends. The reflective layer **202** reflects the light emitted from the LEDs **300** downward. The reflective layer **202** may be disposed in a region adjacent to the LEDs **300** to inhibit a hot spot phenomenon in which brightness in the region adjacent to the LEDs **300** is abnormally increased from occurring.

Specifically, in the current embodiment, the FPCB **600** is not disposed on the top surface of the light guide plate **200**. Thus, the reflective layer **202** may be coated or deposited on the top surface of the light guide plate **200**. In detail, a paint having high reflectance may be coated on the top surface of

6

the light guide plate **200** to form the reflective layer **202**. Alternatively, a metal such as Ag may be deposited on the top surface of the light guide plate **200** to form the reflective layer **202**.

Although the reflective layer **202** is disposed on only the top surface of the light guide plate **200** in FIGS. **6** and **9**, the present disclosure is not limited thereto. For example, the reflective layer **202** may be disposed also on a top surface of the light conversion member **400**. That is, a paint may be coated also on the top surface of the light conversion member **400** or a metal is deposited also on the top surface of the light conversion member **400**.

The LEDs **300** are disposed on a side surface of the light guide plate **200**. In detail, the LEDs **300** are disposed on a light incident surface.

The LEDs **300** are light sources for generating light. In detail, the LEDs **300** emit light toward the light conversion member **400**.

The LEDs **300** may be blue LEDs **300** generating the blue light or UV LEDs **300** generating ultraviolet ray. That is, the LEDs **300** may generate blue light having a wavelength band of about 430 nm to about 470 nm or ultraviolet ray having wavelength band of about 300 nm to about 40 nm.

The LEDs **300** are mounted on the FPCB **600**. The LEDs **300** are disposed under the FPCB **600**. The LEDs **300** receive a driving signal through the FPCB **600**, and then are driven.

The light conversion member **400** is disposed between the LEDs **300** and the light guide plate **200**. The light conversion member **400** adheres to the side surface of the light guide plate **200**. In detail, the light conversion member **400** is attached to the light incident surface of the light guide plate **200**. Also, the light conversion member **400** may adhere to the LEDs **300**.

The light conversion member **400** receives light emitted from the LEDs **300** to convert a wavelength of the light. For example, the light conversion member **400** may convert blue light into green light and red light. That is, the light conversion member **400** may convert a portion of the blue light into the green light having a wavelength band of about 520 nm to about 560 nm and the other portion of the blue light into the red light having a wavelength band of about 630 nm to about 660 nm.

Also, the light conversion member **400** may convert an ultraviolet ray emitted from the LEDs **300** into blue, green, and red light. That is, the light conversion member **400** may convert a portion of the ultraviolet ray into blue light having a wavelength band of about 430 nm to about 470 nm, another portion of the ultraviolet ray into green light having a wavelength band of about 520 nm to about 560 nm, and further another portion of the ultraviolet ray into red light having a wavelength band of about 630 nm to about 660 nm.

Thus, the light transmitting the light conversion member **400** and the light converted by the light conversion member **400** may generate white light. That is, the blue light, the green light, and the red light may be combined with each other to generate the white light, and then, the generated white light may be incident into the light guide plate **200**.

Referring to FIGS. **5** to **8**, the light conversion member **400** includes a tube **410**, a sealing member **420**, a plurality of light conversion particles **430**, and a host **440**.

The tube **410** receives the sealing member **420**, the light conversion particles **430**, and the host **440**. That is, the tube **410** may be a container for receiving the sealing member **420**, the light conversion particles **430**, and the host **440**. Also, the tube **410** has a shape longitudinally extending in one direction.

The tube **410** may have a square tube shape. That is, the tube **410** may have a rectangular shape in a section of a direction perpendicular to a length direction thereof. Also, the tube **410** may have a height **H1** of about 0.6 mm and a thickness **T** of about 0.2 mm. That is, the tube **410** may be a capillary tube.

The tube **410** is transparent. For example, the tube **410** may be formed of a glass. That is, the tube **410** may be a glass capillary tube.

The sealing member **420** is disposed inside the tube **410**. The sealing member **420** is disposed on an end of the tube **410**. The sealing member **420** seals the inside of the tube **410**. The sealing member **420** may be formed of an epoxy resin.

The light conversion particles **430** are disposed inside the tube **410**. In detail, the light conversion particles **430** are uniformly dispersed in the host **440**, and the host **440** is disposed inside the tube **410**.

The light conversion particles **430** convert a wavelength of light emitted from the LEDs **300**. The conversion particles **430** receive the light emitted from the LEDs **300** to convert the wavelength of the light. For example, the light conversion particles **430** may convert the blue light emitted from the LEDs **300** into green light and red light. That is, a portion of the light conversion particles **430** may convert the blue light into the green light having a wavelength band of about 520 nm to about 560 nm, and the other portion of the light conversion particles **430** may convert the blue light into the red light having a wavelength band of about 630 nm to about 660 nm.

On the other hand, the light conversion particles **430** may convert an ultraviolet ray emitted from the LEDs **300** into blue, green, and red light. That is, a portion of the light conversion particles **430** may convert the ultraviolet ray into blue light having a wavelength band of about 430 nm to about 470 nm, another portion of the light conversion particles **430** may convert the ultraviolet ray into green light having a wavelength band of about 520 nm to about 560 nm, and further another portion of the light conversion particles **430** may convert the ultraviolet ray into red light having a wavelength band of about 630 nm to about 660 nm.

That is, when the LEDs **300** are blue LEDs **300** emitting the blue light, the light conversion particles **430** for respectively converting the blue light into the green and red light may be used. On the other hand, when the LEDs **300** are UV LEDs **300** emitting the ultraviolet ray, the light conversion particles **430** for respectively converting the ultraviolet ray into the blue, green, and red light may be used.

The light conversion particles **430** may be a plurality of quantum dots. Each of the quantum dots may include a core nano crystal and a shell nano crystal surrounding the core nano crystal. Also, the quantum dot may include an organic ligand coupled to the shell nano crystal. Also, the quantum dot may include an organic coated layer surrounding to the shell nano crystal.

The shell nano crystal may have two-layered structure. The shell nano crystal is disposed on a surface of the core nano crystal. The quantum dot may convert a wavelength of light incident into the core nano crystal into light having a long wavelength through the shell nano crystal forming a shell layer to improve light efficiency.

The quantum dot may be formed of at least one material of a group II compound semiconductor, a group III compound semiconductor, a group V compound semiconductor, or a group VI compound semiconductor. In detail, the core nano crystal may be formed of CdSe, InGaP, CdTe, CdS, ZnSe, ZnTe, ZnS, HgTe, or HgS. Also, the shell nano crystal

may be formed of CuZnS, CdSe, CdTe, CdS, ZnSe, ZnTe, ZnS, HgTe, or HgS. The quantum dot may have a diameter of about 1 nm to about 10 nm.

The wavelength of the light emitted from the quantum dot may be adjusted according to a size of the quantum dot or a molar ratio of a molecular cluster compound and a nano particle precursor in a synthesis process. The organic ligand may be formed of at least one of pyridine, mercapto alcohol, thiol, phosphine, and phosphine oxide. The organic ligand may stabilize the unstable quantum dot after the synthesis process is performed. After the synthesis process is performed, a dangling bond is formed outside the quantum dot. Thus, the quantum dot may be instable due to the dangling bond. However, one end of the organic ligand may be in a non-bonded state, and the non-bonded one end of the organic ligand may be bonded to the dangling bond to stabilize the quantum dot.

Specifically, when the quantum dot has a radius less than a Bohr radius of an exciton constituted by an electron and hole, which are excited by light and electricity, a quantum confinement effect may occur. Thus, the quantum dot has a discrete energy level to change an intensity of an energy gap. In addition, a charge may be limited within the quantum dot to provide high light emitting efficiency.

The quantum dot may be changed in emission wavelength according to a particle size thereof, unlike a general fluorescent dye. That is, when the particle size is gradually decreased, the quantum dot may emit light having a short wavelength. Thus, the particle size may be adjusted to emit visible light having a desired wavelength. Also, since the quantum dot has an extinction coefficient greater by about 100 times to about 1,000 times than that of the general fluorescent dye and quantum yield greater than that of the general fluorescent dye, the quantum dot may emit very intense light.

The quantum dot may be synthesized by a chemical wet etching process. Here, the chemical wet etching process is a process in which a precursor material is immersed into an organic solvent to grow particles. Thus, the quantum dot may be synthesized through the chemical wet etching process.

The host **440** surrounds the light conversion particles **430**. That is, the light conversion particles **430** are uniformly dispersed into the host **440**. The host **440** may be formed of a polymer. The host **440** is transparent. That is, the host **440** may be formed of a transparent polymer.

The host **440** is disposed inside the tube **410**. That is, the host **440** is filled overall in the tube **410**. The host **440** may be closely attached to an inner surface of the tube **410**.

An air layer may be disposed between the sealing member **420** and the host **440**. The air layer **450** is filled with nitrogen. The air layer **450** may serve as a buffer layer between the sealing member **420** and the host **440**.

The light conversion member **400** adheres to the light guide plate **200**. A first adhesion layer **201** is disposed between the light conversion member **400** and the light guide plate **200**. The light conversion member **400** adheres to a side surface of the light guide plate **200** through the first adhesion layer **201**.

The light conversion member **400** is closely attached to the first adhesion layer **201**. In detail, the tube **410** is closely attached to the first adhesion layer **201**.

The first adhesion layer **201** is transparent. The first adhesion layer **201** may be formed of an epoxy-based resin or an acryl-based resin.

The light conversion member **400** adheres to the LEDs **300**. A second adhesion layer **301** is disposed between the

light conversion member **400** and the LEDs **300**. The light conversion member **400** may adhere to a light emitting surface **310** of each of the LEDs **300** through the second adhesion layer **301**.

The light conversion member **400** is closely attached to the second adhesion layer **301**. In detail, the tube **410** is closely attached to the second adhesion layer **301**. The second adhesion layer **301** is transparent. The second adhesion layer **301** may be formed of an epoxy-based resin or an acryl-based resin.

The second adhesion layer **301** may be disposed also between the FPCB **600** and the light conversion member **400**. That is, the second adhesion layer **301** may adhere also to a side surface **602** of the FPCB **600**.

On the other hand, the side surface **602** of the FPCB **600** may directly contact a side surface **401** of the light conversion member **400**.

The light conversion member **400** may be formed by following processes.

First, the light conversion particles **430** are uniformly dispersed in a resin composition. The resin composition is transparent. The resin composition may be photocurable.

Thereafter, the inside of the tube **410** is decompressed, an inlet of the tube **410** is immersed into the resin composition in which the light conversion particles **430** are dispersed, and an ambient pressure is increased. As a result, the resin composition in which the light conversion particles **430** are dispersed is introduced into the tube **410**.

Thereafter, a portion of the resin composition introduced into the tube **410** is removed, and an inlet portion of the tube **410** is empty. Then, the resin composition introduced into the tube **410** is cured by an ultraviolet ray to form the host **440**.

Thereafter, an epoxy-based resin composition is introduced into the inlet portion of the tube **410**. Then, the introduced epoxy-based resin composition is cured to form the sealing member **420**. The sealing member **420** formation process may be performed under nitrogen atmosphere. Thus, the air layer containing nitrogen may be disposed between the sealing member **420** and the host **440**.

The optical sheets **500** are disposed on the light guide plate **200**. The optical sheets **500** may improve characteristics of transmitted light.

The FPCB **600** is electrically connected to the LEDs **300**. The LEDs **300** may be mounted on the FPCB **600**. The FPCB **600** is flexible and disposed inside the mold frame **10**. The FPCB **600** is disposed on the light guide plate **200**.

The FPCB **600** is connected to a main board for driving the liquid crystal display according to an embodiment. That is, a signal for driving the LEDs **300** may be applied from the main board through the FPCB **600**.

Referring to FIGS. **10** to **12**, the FPCB **600** includes an insulation layer **610**, a first interconnection layer **620**, a second interconnection layer **630**, a first protection layer **640**, and a second protection layer **650**.

The insulation layer **610** is disposed between the first interconnection layer **620** and the second interconnection layer **630**. The insulation layer **610** insulates the first interconnection layer **620** from the second interconnection layer **630**. The insulation layer **610** may be a support layer for supporting the first interconnection layer **620**, the second interconnection layer **630**, the first protection layer **640**, and the second protection layer **650**. The insulation layer **610** may be formed of polyimide.

The first interconnection layer **620** is disposed under the insulation layer **610**. The first interconnection layer **620** is disposed on the LEDs **630**. The first interconnection layer

620 may include a connection pad **621** connected to the LEDs **300**. The LEDs **300** are connected to the connection pad **621** through a solder **303**.

The second interconnection layer **630** is disposed on the insulation layer **610**. The second interconnection layer **630** is disposed on the first interconnection layer **620**. The second interconnection layer **630** may further include a connection wire **631** connected to the connection pad **621**. In detail, the connection wire **631** is connected to the connection pad **621** through a via **611** passing through the insulation layer **610**. Also, the connection wire **631** may pass through a region in which the LEDs **300** are disposed.

The first and second interconnection layers **620** and **630** may be formed of a metal having a low resistance such as copper, aluminum, or an alloy thereof.

The first protection layer **640** covers the first interconnection layer **620**, and the second protection layer **650** covers the second interconnection layer **630**. The first and second protection layers **640** and **650** protect the first and second interconnection layers **620** and **630**, respectively. The first and second protection layers **640** and **650** may be formed of a polymer having high insulativity.

As described above, the FPCB **600** may include two or more interconnection layers **620** and **630**. Thus, the FPCB **600** may realize a complicated wiring structure without extending in a side direction.

That is, since the FPCB **600** has a wiring structure in a vertical direction, a distance between the side surface **602** of the FPCB **600** and the light emitting surface **310** of each of the LEDs **300** may become narrower. In detail, the light emitting surface **310** of each of the LEDs **300** may be disposed on a horizontal plane substantially equal to the side surface **602** of the FPCB **600**.

Referring to FIG. **6**, the FPCB **600** is disposed on the LEDs **300**. Also, the FPCB **600** does not extend to a top surface of the light conversion member **400** and a top surface of the light guide plate **200**. That is, the FPCB **600** extends up to the side surface **401** of the light conversion member **400**. Thus, the light conversion member **400** is disposed on a side of the FPCB **600**. That is, the side surface **602** of the FPCB **600** faces the side surface **401** of the light conversion member **400**.

Thus, the FPCB **600** and the LEDs **300** may be freely aligned with each other in a vertical direction with respect to the light conversion member **400**. That is, since the FPCB **600** does not extend up to the top surface of the light conversion member **400**, the LEDs **300** may accurately correspond to the light conversion member **400**.

That is, since the distance between the side surface **602** of the FPCB **600** and the light emitting surface **310** of each of the LEDs **300** is very short, a center **C2** of each of the LEDs **300** and a center of the light conversion member **400** may be easily aligned with each other. That is, the center **C2** of each of the LEDs **300** may correspond to the center of the light conversion member **400**. Here, the center **C2** of each of the LEDs **300** and the center of the light conversion member **400** represent a center of a height direction reference surface.

Referring to FIGS. **5** and **6**, the LEDs **300** are disposed corresponding to the host **400**. In detail, the LEDs **300** are aligned with the light conversion member **400** so that the host **440** corresponds to the light emitting surface **310** through which light is substantially emitted, i.e., the effective light emitting surface **310**. Here, a top surface **320** of each of the LEDs **300** may be disposed at a position lower than that of a top surface of the light conversion member **400**, and a bottom surface **330** of each of the LEDs **300** may

11

be disposed at a position higher than that of a bottom surface of the light conversion member 400.

The LEDs 300 may be disposed within a region in which the host 440 is disposed. That is, the center C2 of each of the LEDs 300 corresponds to the center C1 of the host 440. Here, each of the LEDs 300 may have a height H3 lower than that H2 of the host 440. Alternatively, each of the LEDs 300 may have a height H3 substantially equal to that H2 of the host 440. Similarly, the center C1 of the host represents the center of the height direction reference surface.

Also, the LEDs 300 may be disposed between a top surface 442 and a bottom surface 443 of the host 440. That is, the top surface 320 of each of the LEDs 300 may be disposed at a position lower than that of the top surface 442 of the host 440, and the bottom surface 330 of each of the LEDs 300 may be disposed on a position higher than that of the bottom surface 443 of the host 440.

Here, each of the LEDs 300 may have a height H3 of about 500 μm to about 700 μm . The host 440 may have a height H2 of about 500 μm to about 700 μm .

As described above, since each of the LEDs 300 is disposed corresponding to the host 440, the greater part of light emitted from the LEDs 300 transmits the host 440. Thus, the light emitted from the LEDs 300 may be effectively incident into the light conversion particles 430.

Thus, the liquid crystal display according to the current embodiment may effectively convert the light emitted from the LEDs 300 to realize improved brightness and color reproducibility.

The mold frame 10 and the backlight assembly 20 constitute a backlight unit. That is, the backlight unit includes the mold frame 10 and the backlight assembly 20.

The liquid crystal panel 30 is disposed inside the mold frame 10 and on the optical sheets 500.

The liquid crystal panel 30 adjusts an intensity of the transmitted light to display an image. That is, the liquid crystal panel 300 may be a display panel for display images. The liquid crystal panel 30 includes a TFT substrate, a color filter substrate, a liquid crystal layer between the TFT substrate and the color filter substrate, and polarizing filters.

In the liquid crystal display device according to the embodiments, the light conversion member is disposed on a side of a circuit substrate. That is, the side of the circuit substrate faces the side surface of the light conversion member. Thus, the light conversion member may be easily aligned with the light source without interfering with the circuit substrate.

In detail, the light source may be easily aligned with the host. Specifically, the light source may be disposed between the top surface and the bottom surface of the host, the greater part of light may be incident into the host. As a result, the light emitted from the light source may be effectively incident into the light conversion particles dispersed in the host.

Therefore, the liquid crystal display according to the embodiments may effectively convert the light emitted from the light source to realize the improved brightness and color reproducibility.

Any reference in this specification to "one embodiment," "an embodiment," "example embodiment," etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is

12

within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

[1. A display device comprising:

- a circuit substrate;
- a plurality of light sources electrically connected to the circuit substrate;
- a light conversion member disposed on light emitting surfaces of the light sources and a side of the circuit substrate and separated from the light sources, the light conversion member converting a wavelength of lights emitted from the light sources;
- a light guide plate disposed at a front side of the light conversion member;
- a first adhesion layer in direct physical contact with the light conversion member and the light guide plate; and
- a second adhesion layer in direct physical contact with the light sources and the light conversion member, wherein the first adhesion layer and the second adhesion layer each has a refractive index of from about 1.1 to about 1.6.]

[2. The display device of claim 1, wherein the light conversion member comprises:

- a host;
- a plurality of light conversion particles dispersed in the host;
- a tube surrounding the host and formed of transparent material; and
- a sealing member disposed on an inlet portion of the tube and separated from the host, and wherein a center of each of the light emitting surfaces corresponds to a center of the host.]

[3. The display device of claim 1, wherein the light conversion member has a bar shape having a predetermined thickness and expanded in a length direction.]

[4. The display device of claim 2, wherein the light sources are disposed between a top surface and a bottom surface of the host, and

- wherein the light emitting surfaces of the light sources correspond to the host.]

[5. The display device of claim 1, wherein a side surface of the circuit substrate faces the side surface of the light conversion member.]

- [6. The display device of claim 5, wherein the side surface of the circuit substrate is in direct physical contact with the second adhesion layer.]

[7. The display device of claim 1, wherein the circuit substrate comprises:

- a first interconnection layer comprising a connection pad; and
- a second interconnection layer disposed on the first interconnection layer, wherein the light sources are electrically connected to the connection pad, and

13

the second interconnection layer comprises a connection wire connected to the connection pad.]

[8. The display device of claim 7, wherein the circuit substrate further comprises:

an insulation layer disposed between the first interconnection layer and the second interconnection layer; and a via passing through the insulation layer, the via being connected to the connection pad and the connection wire.]

[9. A display device comprising:

a plurality of light sources;

a light conversion member disposed on a light emitting surface of each of the light sources and separated from the light sources, the light conversion member converting a wavelength of light emitted from the light sources;

a light guide plate disposed at a front side of the light conversion member;

a first adhesion layer in direct physical contact with the light conversion member and the light guide plate; and

a second adhesion layer in direct physical contact with the light sources and the light conversion member,

wherein the first adhesion layer and the second adhesion layer each has a refractive index of from about 1.1 to about 1.6.]

[10. The display device of claim 9, wherein the light conversion member comprises:

the host;

a plurality of light conversion particles dispersed in the host;

a tube surrounding the host and formed of transparent material; and

a sealing member disposed on an inlet portion of the tube and separated from the host, and

wherein a center of each of the light sources corresponds to a center of the host.]

[11. The display device of claim 10, wherein each of the light sources has a height equal to or lower than a height of the host.]

[12. The display device of claim 9, wherein each of the light sources emits blue light, and

the light conversion member converts the blue light into green light or red light.]

[13. The display device of claim 9, wherein each of the light sources has a height of about 500 μm to about 700 μm , and the host has a height of about 500 μm to about 700 μm .]

[14. A display device comprising:

a light guide plate;

a display panel disposed on the light guide plate;

a plurality of light sources disposed on a side surface of the light guide plate;

a light conversion member disposed between the light sources and the light guide plate and separated from the light sources;

a first adhesion layer in direct physical contact with the light conversion member and the light guide plate;

a second adhesion layer in direct physical contact with the light sources and the light conversion member; and

a circuit substrate electrically connected to the light sources,

wherein the first adhesion layer and the second adhesion layer each has a refractive index of from about 1.1 to about 1.6.]

[15. The display device of claim 14, wherein the circuit substrate comprises:

a first interconnection layer comprising a connection pad; and

14

a second interconnection layer disposed on the first interconnection layer,

wherein the light sources are electrically connected to the connection pad, and

the second interconnection layer comprises a connection wire connected to the connection pad.]

[16. The display device of claim 14, wherein the light conversion member comprises:

a host;

a plurality of light conversion particles dispersed in the host;

a tube surrounding the host and formed of transparent material; and

a sealing member disposed on an inlet portion of the tube and separated from the host, and

wherein the light sources are disposed between a top surface and a bottom surface of the host.]

[17. The display device of claim 14, further comprising a reflective layer disposed on the light conversion member and the light guide plate.]

[18. The display device of claim 17, wherein the light conversion member is disposed on the reflective layer.]

[19. The display device of claim 14, further comprising a reflective layer extending in a direction equal to that of the light conversion member, the reflective layer being disposed on the light guide plate.]

[20. The display device of claim 14, wherein a top surface of each of the light sources is disposed at a position lower than that of the light conversion member, and

a bottom surface of each of the light sources is disposed at a position higher than that of the light conversion member.]

21. A method of fabricating a backlight assembly, the method comprising:

providing a reflective sheet;

disposing a light guide plate on the reflective sheet;

disposing an optical sheet on the light guide plate;

disposing a light source at an incident surface of the light guide plate;

fabricating a light conversion member; and

disposing the light conversion member between the light source and the light guide plate,

wherein fabricating the light conversion member comprises:

providing a tube;

mixing a plurality of quantum dots in a curable composition;

injecting the curable composition, having the plurality of quantum dots distributed therein, into the tube, wherein

a first distal end of the tube is open and a second distal end of the tube is sealed;

irradiating the curable composition in the tube with light to cure the curable composition into a host having the plurality of quantum dots distributed therein; and

sealing the first distal end of the tube,

wherein the curable composition is injected and the first distal end is sealed such that an air layer is present between the first distal end and the host.

22. The method of claim 21, wherein the curable composition is a polymer resin.

23. The method of claim 21, wherein sealing the first distal end of the tube comprises introducing a sealing portion to the first distal end.

24. The method of claim 23, wherein the air layer is present between the sealing portion and the host.

25. The method of claim 21, wherein the air layer comprises nitrogen.

26. The method of claim 21, wherein the light with which the curable composition is irradiated is ultraviolet (UV) light.

27. The method of claim 21, wherein the host is in direct contact with the air layer, and wherein at least a portion of a surface of the host in contact with the air layer is curved. 5

28. The method of claim 21, wherein the second distal end of the host is opposite to the first distal end, and wherein the tube comprises:

a first tube portion; 10

a second tube portion adjacent to the first tube portion; and

a midpoint between the first distal end and the second distal end along a first direction that is parallel to a central longitudinal axis of the tube; 15

wherein the first tube portion extends from the first distal end to the midpoint and comprises the air layer and a portion of the host,

wherein the second tube portion extends from the midpoint to the second distal end and comprises a portion of the host, and 20

wherein a length of the portion of the host of the first tube portion, taken in the first direction, is smaller than a length of the portion of the host of the second tube portion, taken in the first direction. 25

* * * * *