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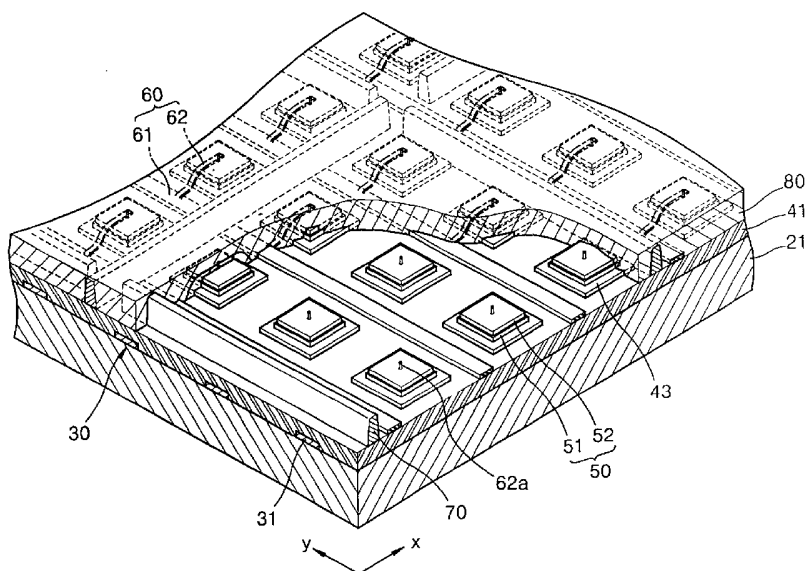
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(54) Title: DISPLAY SYSTEM



(57) Abstract: To manufacture display systems using light emitting diodes (LEDs) in large quantities at low cost, a plurality of LED layers forming pixels are deposited or printed on a substrate in bulk using thin film technology. Each display system includes a substrate; a first electrode unit formed on the substrate in a predetermined pattern; a LED layer comprising a P-type layer, which is formed on the surface of the first electrode unit in a predetermined pattern to be electrically connected to the first electrode unit, and a N-type layer deposited on the P-type layer; a transparent insulation layer formed on the surface of the substrate to be insulated from the first electrode unit by an insulation layer and to have a via-hole corresponding to the LED layer; and a second electrode unit electrically connected to the N-type layer of the LED layer.

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DISPLAY SYSTEM

Technical Field

The present invention relates to a display system, and more particularly, to a display system using a light emitting diode (LED).

Background Art

Display systems for forming an image use a CRT (cathode ray tube), PDP (plasma display panel), LCD, VFD, EL, or light emitting device. With the recent development of microelectronics, expansion of application field of microelectronics, and spread of information systems, display systems are required to be large, thin, and flat.

To obtain thin and flat display systems having high definition, a simple and small structure of pixels, which can provide high brightness, is required. Considering these conditions, it is difficult to obtain a small and thin display system using a CRT having a structure in which electron beams emitted from an electron gun are deflected by a deflection yoke and excite a fluorescent screen. A PDP for a large flat display system has a structure in which an image is formed by exciting a fluorescent material using parent rays (ultraviolet rays), which are generated due to plasma discharge formed by electrodes disposed in a discharge space, so a structure for securing the discharge space is complicated, and an opening rate in the discharge space decreases due to the electrodes. When using an LCD or VFD, a flat and thin display system can be made, but it is difficult to make a large display system. In particular, a large display system using an LCD cannot be made due to the structure of the LCD.

A display system for overcoming the above problems is disclosed in Japanese Patent Publication No. 2001-51623.

Referring to FIG. 1, the display system includes a substrate 1, a

plurality of monolithic light emitting devices 3 having red, green, and blue LEDs on the substrate 1, and a first electrode pattern 4 formed on the substrate 1. Each of the LEDs is separated from other LEDs by a separating part 2. When a predetermined voltage is applied between a first electrode and a second electrode 5 of each LED, the LEDs arranged in a matrix selectively emit light, thereby forming an image.

In the display system, the plurality of monolithic light emitting devices 3 having red, blue, and green LEDs thereon are arranged on the substrate 1 at predetermined intervals, so it is difficult to manufacture the display system. In particular, the LEDs must be planted individually, and the lead line of each second electrode 5 must be wire bonded. Thus, manufacturing is complicated, and it is not easy to make the display system large.

A light emitting display system using an LED is disclosed in Japanese Patent Publication No. hei 8-16114. In the light emitting display system, a plurality of chip-type LEDs are mounted on one side of a substrate having a plurality of a conductive layers, and driving circuits for the chip-type LEDs are mounted on the opposite side of the substrate. Since the chip-type LEDs must be attached to the substrate, a large number of processes are required.

A chip-type LED is disclosed in Japanese Patent Publication No. hei 11-186590. To manufacture the chip-type LED, an LED is installed on a printed substrate, and the LED is coated with epoxy resin.

Korean Patent Publication Nos. 1994-0004397, 1999-0041454, and 209925 are patents relating to a light emitting display system using an LED.

To solve the above-described problems, it is one object of the present invention to provide a display system for simplifying manufacturing processes to improve productivity and increasing the durability, brightness and definition of an image, and a method for

manufacturing the display system.

It is another object of the present invention to provide a display system having improved white balance characteristics by increasing the color purity of red, green, and blue.

5 It is still another object of the present invention to provide a display system in which each pixel has a high brightness by provoking light to be emitted from an LED layer to the front of the display system.

To achieve the above objects of the present invention, in one aspect, there is provided a display system including a substrate; a first
10 electrode unit formed on the substrate in a predetermined pattern; a light emitting diode layer including a plurality of light emitting diode parts, which are epitaxially grown or deposited on the surface of the first electrode unit in a predetermined pattern so that one side of each light emitting diode part is electrically connected to the first electrode unit; a
15 second electrode unit, which is formed on the surface of the substrate in a predetermined pattern to be electrically connected to the opposite side of each light emitting diode part.

The display system also includes a transparent insulation layer having via-holes corresponding to the light emitting diode parts, wherein
20 the second electrode unit is formed on the transparent insulation layer in a predetermined pattern and is electrically connected to the upper surfaces of the light emitting diode parts through the via-holes. The light emitting diode layer comprises a P-type layer, which is epitaxially grown or deposited to be electrically connected to the first electrode unit,
25 and an N-type layer, which is deposited on the surface of the P-type layer to be electrically connected to the second electrode unit. The first electrode unit may include thin film transistors for selectively driving the LED parts.

The display system also includes barriers formed in a
30 predetermined pattern in order to optically separate at least three light

emitting diode parts forming a pixel from other light emitting diode parts forming adjacent pixels. The display system also includes a graded layer formed between the first electrode unit and the light emitting diode layer in order to grow single crystals having the same lattice constant as
5 a material of the light emitting diode layer.

In another aspect, there is provided a display system including a substrate; a first electrode unit formed on the surface of the substrate; a light emitting diode layer including a plurality of light emitting diode parts, which is composed of a P-type layer epitaxially grown or deposited on
10 the surface of the first electrode unit in a predetermined pattern and an N-type layer deposited on the P-type layer so that each light emitting diode part is electrically connected to the first electrode unit; a barrier formed around the light emitting diode part and separated from each light emitting diode part by a predetermined distance in order to reflect light
15 emitted from the light emitting diode part to the front of the display system; a transparent insulation layer formed on the surface of the substrate having the light emitting diode layer and the barrier; and a second electrode unit formed on the surface of the transparent insulation layer to be electrically connected to each light emitting diode part.

20 In still another aspect, there is provided a display system including a substrate; a first electrode unit formed on the substrate in a predetermined pattern; an insulation layer formed on the surface of the first electrode unit; a light emitting diode layer comprising a light emitting part, which is formed by stacking a conductive layer, a P-type layer, and
25 an N-type layer on the insulation layer and cutting the stack in a depth direction to expose the insulation layer, and a plurality of light emitting diode parts, each of which is electrically connected to the first electrode unit; and a second electrode unit, which electrically connects the surfaces of the light emitting diode parts and drives the light emitting
30 diode parts.

The display system also includes a barrier formed in an area between adjacent light emitting diode parts.

In still another aspect, there is provided a display system including a substrate; a first electrode unit formed on the substrate in a predetermined pattern; a light emitting diode layer comprising a plurality of light emitting diode parts, which are epitaxially grown or deposited on the surface of the first electrode unit in a predetermined pattern so that one side of each light emitting diode part is electrically connected to the first electrode unit; a barrier separating at least one light emitting diode part from the other light emitting diode parts; a white fluorescent layer formed to correspond to each light emitting diode part, the white fluorescent layer being excited by parent rays emitted from the light emitting diode part; a color filter layer formed on the surface of the white fluorescent layer; and a second electrode unit electrically connected to another side of each light emitting diode part.

In still another aspect, there is provided a display system including a substrate; a first electrode unit formed on the substrate in a predetermined pattern; an insulation layer formed on the surface of the first electrode unit; a conductive layer formed on the surface of the insulation layer to be electrically connected to the first electrode unit; a light emitting diode layer comprising a plurality of light emitting diode parts, each of which is formed by depositing a P-type layer and an N-type layer on the conductive layer and the insulation layer and forming a groove having the shape of a closed loop to surround the P- and N-type layers in an area corresponding to the conductive layer; and a second electrode unit, which electrically connects the surfaces of the light emitting diode parts and drives the light emitting diode parts.

To achieve the above objects of the present invention, there is also provided a method of manufacturing a display system, including preparing a substrate; forming a first electrode unit by performing

deposition or printing on the surface of the substrate in a predetermined pattern; forming a light emitting diode layer having a plurality of light emitting diode parts by depositing a P-type layer and an N-type layer in a predetermined pattern, the light emitting diode parts being electrically
5 connected to the first electrode unit; forming an insulation layer to cover the exposed top surface of the substrate and the first electrode unit; forming a transparent insulation layer so that the light emitting diode layer is covered with the transparent insulation layer; and forming a second electrode unit to be insulated from the first electrode unit by the
10 insulation layer and to be electrically connected to the N-type layer of each light emitting diode part.

Brief Description of the Drawings

FIG. 1 is a perspective view of a conventional display system.
15 FIG. 2 is a partially cut-away perspective view of a part of a display system according to an embodiment of the present invention.
FIG. 3 is a plan view of an example of a first electrode unit.
FIG. 4 is a sectional view of the display system shown in FIG. 2.
FIG. 5 is a sectional view of a display system according to another
20 embodiment of the present invention.
FIG. 6 is a plan view of a display system according to the present invention.
FIGS. 7 and 8A are sectional views of display systems according to other embodiments of the present invention.
25 FIG. 8B is a partial perspective view of a second electrode according to another embodiment of the present invention.
FIG. 9 is a plan view of a display system according to still another embodiment of the present invention.
FIG. 10 is a sectional view of the display system shown in FIG. 9.
30 FIGS. 11, 14, and 15 are partially cut-away perspective views of

parts of display systems according to other embodiments of the present invention.

FIGS. 12, 13, 17, and 18 are sectional views of display systems according to other embodiments of the present invention.

5 FIG. 16 is a sectional view of the display system shown in FIG. 15.

FIGS. 19 through 25 are sectional views of the stages in a method of manufacturing a display system according to the present invention.

Best mode for carrying out the Invention

10 A display system according to the present invention is manufactured by forming light emitting diodes (LEDs) on a substrate using epitaxial growth or deposition. An embodiment of a display system according to the present invention is shown in FIGS 2 through 4.

Referring to the drawings, a display system includes a first
15 electrode unit 30 formed on a substrate 21 in a predetermined pattern. The first electrode unit 30 may be composed of X electrode lines 31, which are formed to be parallel to an X direction in a striped pattern, as shown in FIG. 2. Alternatively, as shown in FIG. 3, the first electrode unit 30 may be composed of data lines 32, which are formed in an X
20 direction on the upper surface of the substrate 21; scan lines 33, which are insulated from the data lines 32; and thin-film transistors 34, which are driven by the scan lines 33 and the data lines 32. The substrate may be formed of glass, plastic, silicon based material, sapphire, or silundum and may be formed of a flexible material.

25 An insulation layer 41 is formed on the upper surface of the substrate 21 having the first electrode unit 30. A via-hole 41a is formed in areas of the insulation layer 41 in which the pixels can be formed. A conductive layer 42 is formed in the via-hole 41a to be connected to an X electrode line 31. Only via-holes exposing the X electrode lines 31 over
30 which an LED layer is deposited can be formed in the insulation layer 41.

In particular, when the first electrode unit 30 is composed of the scan lines 33, the data lines 32, and the thin-film transistors 34, a conductive layer connected to the drain (not shown) of each thin-film transistor 34 is exposed through the via-hole 41a in the insulation layer 41.

5 A reflective layer 43 is formed on the insulation layer 41 to surround the conductive layer 42. The reflective layer 43 is formed of silver epoxy. The reflective layer 43 may be formed on the entire surface of the substrate 21.

10 An LED layer 50 forming a pixel for forming an image is deposited on the surface of the conductive layer 42 connected to the X electrode line 31 of the first electrode unit 30. The LED layer 50 includes of a P-type layer 51, which is epitaxially grown or deposited on the surface of the conductive layer 42, and an N-type layer 52, which is deposited on the surface of the P-type layer 51. The P-type layer 51 and the N-type
15 layer 52 may be repeatedly stacked and formed of different kinds of material depending on the type of LED layer 50 desired to be formed, as shown in FIG. 5.

20 A graded layer 42a may also be formed on the surface of the conductive layer 42 in order to smoothly grow the P-type layer 51 during the deposition of the LED layer 50. The graded layer 42a is formed of a material, which has the same lattice constant as a nitride semiconductor material and allows the growth of single crystals. The graded layer 42a may be formed of sapphire powder, silundum powder, or silicon based powder by spreading the powder on the surface of the conductive layer
25 42 and then performing heat treatment using plasma or laser.

30 In the meantime, LED layers 50 formed on conductive layers 42 are arranged such that red, green, and blue LED layers 50 emitting light in red, green, and blue, respectively, form a single pixel. The red, green, and blue LED layers 50 may be arranged in a line or in a delta shape. It is preferable that the pitch between the LED layers 50 is between 0.05

and 5 mm.

The red LED layer is formed of an AlGaInp based material. The green and blue LED layers are formed of ZnCdMgSeS based material.

Each of the LED layers 50 formed on the substrate 21 is covered
5 with a transparent resin layer 54. A second electrode unit 60 is formed
on the surface of the insulation layer 41 in order to supply a
predetermined current to the N-type layer 52 of a corresponding LED
layer 50. The transparent resin layer 54 may be manifested as a color
filter layer 55. In this case, red, green, and blue color filter layers are
10 formed on the surfaces of corresponding red, green, and blue LED layers
50 in order to increase the color purity of light emitted from the red, green,
and blue LED layers 50. The transparent resin layer 54 may be formed
on the surface of the substrate 21 with a uniform thickness so that the
LED layers 50 can be covered with the transparent resin layer 54. In
15 particular, when the LED layers 50 emit monochromatic light, the color
filter layer 55 may be used to form a color image. When the LED layers
50 emit monochromatic light, a white fluorescent layer (not shown) may
be formed on the surface of each LED layer 50 so that the white
fluorescent layer can emit light due to ultraviolet rays generated from the
20 LED layer, and the color filter layer 55 may be formed on the white
fluorescent layer in order to form a color image.

The second electrode unit 60 includes a Y electrode line 61, which
is formed on the insulation layer 41 in a direction orthogonal to the
X-electrode line 31, and a connection electrode 62, which connects the Y
25 electrode line 61 to the N-type layer 52 of the LED layer 50. The Y and
X electrode lines may be formed of aluminum and an aluminum alloy; a
conductive polymer containing aluminum, gold, silver, copper, nickel, or
chrome; or a transparent conductive layer of ITO.

As shown in FIGS. 4 through 6, the connection electrode 62
30 includes a gold wire 62a, which penetrates through the transparent resin

layer 54 and is connected to the N-type layer 52, and an auxiliary electrode 62b, which connects the gold wire 62a protruding from the transparent resin layer 54 to the Y electrode line 61. The Y electrode line 61 and the auxiliary electrode 62b may be simultaneously formed using a deposition process. As shown in FIG. 7, the auxiliary electrode 62b and the gold wire 62a may be formed using deposition. In this case, a conical recess may be formed at an area for the gold wire 62a electrically connected to the N-type layer 52 in the transparent resin layer 54, and then the gold wire 62a may be deposited.

FIG. 8A shows another embodiment of a second electrode unit. Referring to the drawings, the second electrode unit includes a connection electrode 66, which penetrates the color filter layer 55 or the transparent resin layer 54 and is electrically connected to an N-type layer, and a transparent conductive layer 67, which is formed on the insulation layer 41 and the color filter layer 55 or the transparent resin layer 54 to be electrically connected to the connection electrode 66. The connection electrode 66 may be formed of a gold wire and, as shown in FIG. 8B, may be formed by forming a conical recess 66a in the transparent conductive layer 54 or the color filter layer 55 and filling the recess with a transparent conductive material or conductive metal such as gold or silver.

Barriers 70 partitioning areas for pixels are formed on the substrate 21 having the first and second electrode units 30 and 60 or the insulation layer 41 in order to prevent cross-talk, thereby increasing the contrast of an image. Shades of colors can be changed according to the height of the barriers 70, so it is preferable to properly adjust the height of the barriers 70 according to installation requirements of a display system. The barriers 70 may be formed in a lattice or polygonal pattern such that at least one pixel can be defined. The barriers 70 are separated from one another at their corners, as shown in FIG. 2, so they

can be prevented from being noticed as non-light emitting areas. It is preferable to form the barriers 70 of semitransparent or opaque resin taking into account definition and contrast. A reflective film 71 may be formed on the side of each barrier 70 facing LED layers 50.

5 A protective layer 80 is formed of transparent resin on the surface of the substrate 21 having the barriers 70 in order to protect the second electrode units 60 and the LED layers 50. The protective layer 80 may include a light scatterer (not shown), which can scatter light emitted from the LED layers 50. The light scatterer may be formed of glass powder
10 or crystal powder.

In addition, at least one light scattering layer 83 for scattering light emitted from the LED layers 50 and a conductive film 81 for blocking static electricity and electromagnetic waves may be formed on the surface of the protective layer 80. The conductive film 81 may be
15 formed by depositing a transparent conductive layer entirely or in a radial or latticed pattern on the surface of the protective layer 80. In addition, an external light reflection preventing layer 82 may be formed on the surface of the light scattering layer 83 in order to diffusedly reflect external light. An auxiliary barrier (not shown) having a predetermined
20 height may be formed correspondingly over each barrier 70. An area partitioned by the auxiliary barriers may be filled with a transparent resin layer. In this case, it is preferable to form the light scattering layer 83, the conductive film 81, and the external light reflection preventing layer 82 on the surface of the transparent resin layer.

25 FIGS. 9 and 10 show a display system according to still another embodiment of the present invention. In the embodiments, the same reference numerals denote the same members.

Referring to the drawings, the LED layers 50 are formed by epitaxially growing or depositing the P-type layers 51 and the N-type
30 layers 52 in bulk on the surfaces of the conductive layers 42 exposed

over the insulation layer 41 and electrically connected to the first electrode unit 30. A first protective layer 91 is formed of a transparent resin layer on the surface of the substrate 21 so that the LED layers 50 and the insulation layer 41 can be covered with the first protective layer 91. Gold wires 67a electrically connected to the N-type layers 52 protrude above the first protective layer 91. The second electrode units 60 including a transparent conductive layer 67 are formed on the surface of the first protective layer 91 in a direction orthogonal to the X electrode lines 31 of the first electrode unit 30. The transparent conductive layer 67 is electrically connected to the N-type layer 52 of each LED layer 50. A second protective layer 92 is formed by coating the surface of the first protective layer 91 having the second electrode units 60 formed thereon with a transparent resin. As described above, the light scattering layer 83 and the conductive film 81 may be formed on the surface of the second protective layer 92. The conductive film 81 may be formed of an external light reflection layer, whose surface is processed to prevent the scattering effect of scratches and reflections, or a transparent conductive film in order to block static electricity and electromagnetic waves. Here, the red, green, and blue LED layers 50 may be formed in order to form a color image. In this case, a flat color filter layer (not shown) may be provided in a second electrode unit 60 disposed on each LED layer 50. When a LED layer 50 emits monochromatic light, a white fluorescent layer emitting white light may be formed between the LED layer 50 and the flat color filter layer.

The thus-formed display system may be used as a single module, so a large screen can be realized by connecting a plurality of display systems. Reference numeral 70 denotes a barrier.

In the display system shown in FIGS. 9 and 10, the X and Y electrode lines or scan lines and data lines of the first and second electrode units are connected to one another by a driving circuit for

driving the display system and a flexible printed circuit (FPC). As described above, the display system having a predetermined size is modularized, so a large screen can be realized by connecting a plurality of modularized display systems.

5 In this display system, when a predetermined voltage is applied to the X electrode lines 31 and the Y electrode lines 61 or the data lines, and when a voltage is selectively applied to the scan lines, a predetermined voltage is applied to the P-type layer 51 and N-type layer 52 of each LED layer 50, so current flows in a forward direction.
10 Consequently, electrons from the N-type layer 52 cross into the P-type layer 51, and holes from the P-type layer 51 cross into the N-type layer 52, so the electrons and holes diffuse as minority carriers. The minority carriers recombine with majority carriers during diffusion, emitting light corresponding to an energy difference between the minority carriers and
15 the majority carriers.

With the above-described operation, the red, green, and blue LED layers 50 selectively emit light, forming a color image. Since a color filter layer 55 is formed on each LED layer 50, the color purity of the LED layer 50 can be increased, and furthermore white balance characteristics
20 can be increased. In addition, at least one of the red, green, and blue LED layers 50 constituting each pixel is separated from other red, green, and blue LED layers 50 of other pixels by a barrier 70, so cross-talk between the pixels can be prevented.

FIGS. 11 and 12 show a display system using an ultra-thin LED
25 according to an embodiment of the present invention.

Referring to the drawings, a display system 100 includes a substrate 101. A first electrode unit 102 is formed on the surface of the substrate 101 in a predetermined pattern. A LED layer 103 having LED parts 103a is formed on the substrate 101 having the first electrode unit
30 102. The LED parts 103a are formed by depositing P-type layers on the

first electrode unit 102 at predetermined intervals to be electrically connected to the first electrode unit 102 and epitaxially growing or depositing N-type layers on the respective P-type layers. A barrier 105 is formed to be separated from each LED part 103a by a predetermined distance and to surround each LED part 103a in order to reflect light emitted from the LED parts 103a to the front of the display system.

For the first electrode unit 102, X-electrode lines 102a having the same width as the LED parts 103a are formed on the substrate 101 in a striped pattern parallel to the LED parts 103a. But the first electrode unit 102 is not restricted to the above-described structure and may include thin film transistors for driving the LED parts 103a as described above. The barrier 105 is formed on the entire surface of the substrate 101 to a predetermined thickness and has openings 105a in areas corresponding to the respective LED parts. The sidewall of each opening 105a slants at a predetermined angle. A reflective layer 105b is formed on the inner sidewall and bottom of each opening 105a in order to reflect light emitted from the LED parts 103a to the front of the display system.

The LED parts 103a of the LED layer 103 are connected to one another by a second electrode unit 104. The second electrode unit 104 may include Y electrode lines, which are formed on a transparent insulation layer 106 to be electrically connected to the N-type layers. The transparent insulation layer 106 is formed on the substrate 101 having the LED parts 103a and the barrier 105. However, the second electrode unit 104 is not restricted to the above-described structure. The second electrode unit 104 may be formed by wire bonding. As shown in FIG. 12, a color filter layer 107 may also be provided in order to form a color image using light emitted from the LED parts 103a. In the meantime, when the LED parts 103a emit monochromatic light including ultraviolet rays, a white fluorescent layer 108, which is excited by the

ultraviolet rays emitted from the LED parts 103a and thus emits white light, may be formed within the openings 105a.

The light scattering layer 83 and the external light reflection preventing layer 82 may be formed on the surface of the transparent
5 insulation layer 106 or the color filter layer 107.

A graded layer 109 may be formed on the surface of the first electrode unit 102 so that the P-type layers or the N-type layers can easily grow. The graded layer 109 may be formed by spreading powder of at least one of the materials, i.e., gold, silver, copper, Al, Ni, Si, C, Ga,
10 N, In, P, As, Cd, Mg, S, Zn, sapphire, crystal, quartz, silundum, silicon family, ZnCdMgSeS, GaP, GaAs, GaAsP, InGaAlP, GaN, p-GaN, and InGaN, which have the same lattice constant as a material of the P-type layers or N-type layers, on the first electrode unit 102, then performing heat treatment using plasma or laser at a predetermined pressure, and
15 then cooling at a predetermined pressure and temperature.

FIG. 13 shows a display system using an ultra-thin LED according to another embodiment of the present invention.

Referring to the drawings, the display system includes a substrate 111, a first electrode unit 112 formed in a predetermined pattern on the
20 surface of the substrate 111, an insulation layer 113 formed on the surface of the first electrode unit 112, and an LED layer 115 formed on the surface of the insulation layer 113. The LED layer 115 includes a plurality of LED parts 115a including a P-type layer 115c and an N-type layer 115d and a light emitting part 115b, which are formed by
25 sequentially stacking a conductive layer 114, the P-type layer 115c, and the N-type layer 115d or the conductive layer 114, the N-type layer 115d, and the P-type layer 115c and cutting the stack in a depth direction to expose the insulation layer 113. Each LED part 115a is electrically connected to the first electrode unit 112.

30 The first electrode unit 112 may be composed of X electrode lines

112a, which are parallel to one another in a striped pattern, or may also include thin film transistors for driving the individual LED parts 115a. Via-holes 113a are formed in portions, at which the LED parts 115a are to be formed, in the insulation layer 113 on the substrate 111 having the first electrode unit 112. The via-holes 113a are filled with a conductive material, thereby forming the conductive layer 114, so the LED parts 115a are electrically connected to the first electrode unit 112.

Preferably, the LED layer 115 is formed by sequentially growing epitaxially or depositing the conductive layer 114, the P-type layer 115c, and the N-type layer 115d on the entire surface of the substrate 111 having the insulation layer 113 and forming grooves 116 to expose the insulation layer 113 in the depth direction of the stack of the conductive layer 114, the P-type layer 115c, and the N-type layer 115d, thereby separating the stack into a plurality of parts corresponding to the LED parts 115a. The independent conductive layers 114 are electrically connected to the first electrode unit 112 through the corresponding via-holes 113a.

As shown in FIG. 14, two grooves 116 may be formed between adjacent LED parts 115a, and a reflective film 116a may be formed on the side of each groove 116 facing the LED parts 115a in order to reflect light to the front of the display system. As shown in FIGS. 15 and 16, a groove 116' having the shape of a closed loop may be formed to surround each LED part 115a so that the LED part 115a connected to the first electrode unit 112 forms an island. Preferably, a reflective film 116b is formed on the inside of the groove 116' such that light emitted from the LED part 115a is reflected to the front of the display system. In this case, it is apparent that the conductive layer 114 or the first electrode unit 112 is divided so that the bottoms of the LED parts 115a are independently and electrically connected to the conductive layer 114 or the first electrode unit 112.

As described above, a graded layer 115e may be formed between each LED part 115a and the conductive layer 114 or the first electrode unit 112 in order to easily grow the P-type layer 115c or the N-type layer 115d.

5 In the meantime, as shown in FIG. 13, a barrier 117 is formed in an area among the LED parts 115a. The bottom of the barrier 117 contacts the surface of the insulation layer 113, and the height of the barrier 117 can be controlled taking into account cross-talk between pixels and/or light reflectance. The sidewalls of the barrier 117 facing
10 the LED parts 115a are formed to slant, and reflective films 117a are formed on the sidewalls, so that light emitted from the LED parts 115a is reflected to the front of the display system.

A second electrode unit 118 is formed on the LED parts 115a in order to connect the LED parts 115a to one another. The first electrode
15 unit 112 and the second electrode unit 118 may be formed so that together they form a matrix. As described above, the first electrode unit 112 may also include thin film transistors for selectively driving the LED parts 115a. A transparent insulation layer 119 is formed on the
20 substrate 111 having the LED parts 115a, the barrier 117, and the second electrode unit 118. A color filter layer 119a, the light scattering layer 83, the external light reflection preventing layer 82, and the conductive film for preventing static electricity may be formed on the
25 surface of the substrate 111 having the transparent insulation layer 119, as described above. This structure is the same as the above-described embodiments, and thus a detailed description thereof will be omitted. When the LED parts 115a emit monochromatic light including ultraviolet rays, the transparent insulation layer 119 may be replaced by a white fluorescent layer, which is excited by the ultraviolet rays to thus emit white light.

30 FIGS. 17 and 18 show a display system using an ultra-thin LED

according to still another embodiment of the present invention. In the embodiments, the same reference numerals denote the same members.

Referring to the drawings, a display system 120 includes a white fluorescent layer 121, which is excited by parent rays, i.e., ultraviolet rays, emitted from the LED parts 115a to thus emit white light, in areas defined by the barrier 105 or 117 separating the LED parts 115a. A color filter layer 122 is formed on the surface of the white fluorescent layer 121. Preferably, the color filter layer 122 is formed such that red, green, and blue can be realized at the portion of the color filter layer 122 corresponding to the white fluorescent layer 121 for each LED part 115a in order to form a color image. The structures of the first electrode unit 102 or 112 and the second electrode unit 104 or 118 are the same as those of the above described embodiments. As shown in FIG. 18, the first electrode unit 102 or 112 may also include thin film transistors 34.

As described above, in the display system 120 according to the present invention, the LED parts 115a selected by the first and second electrode units 102 or 112 and 104 or 118 are driven to emit parent rays, i.e., ultraviolet rays, and the white fluorescent layers 121 are excited by the ultraviolet rays to emit white light. The white light emitted from the white fluorescent layer 121 is filtered by the corresponding color filter layer 122 to have red, green, and blue colors for forming a color image.

As described above, FIGS. 19 through 25 show a method of forming a display system according to an embodiment of the present invention.

As shown in FIG. 19, after cleaning a substrate 21, an X electrode line 31 or drain electrode, scan electrode, and thin film transistor, which is driven by the drain and scan electrodes, of a first electrode unit 30 are formed on the substrate 21 using photolithography, silk printing, or deposition.

After completing the formation of the first electrode unit 30 on the

surface of the substrate 21, an insulation layer 41 having via-holes 41a, in areas where pixels having a predetermined pattern are to be formed, is formed, as shown in FIG. 20. After completing the formation of the insulation layer 41, conductive layers 42 are formed to fill the via-holes 41a connected to the X electrode line 31 or the drain electrode of the thin film transistor and to be deposited on predetermined areas of the surface of the insulation layer 41, as shown in FIG. 21. After completing the formation of the conductive layer 42, a reflective layer 43 is formed on the surface of the insulation layer 41 around the conductive layer 42, as shown in FIG. 22. Preferably, the reflective layer 43 is formed by depositing a silver epoxy. Next, a graded layer 42a is formed on the surface of the conductive layer 42 in order to easily grow a thin film when forming a LED layer.

After completing the formation of the reflective layer 43, as shown in FIG. 23, P-type layers 51 are epitaxially grown or deposited on the surface of the conductive layer 42. Here, the P-type layers 51 may be formed in three stages to separately form LED layers 50 with different colors, i.e., red, green, and blue.

Among the LED layers 50 forming a pixel, the P-type layer 51 of each of the blue and green LED layers 50 is formed by sequentially depositing a ZnSSe layer, a ZnMgSSe layer, a ZnSSe layer, a ZnSe layer, and a ZnTe layer or at least one of these layers on the surface of a corresponding conductive layer 42. An N-type layer 52 is formed on each P-type layer 51 by depositing an N-type ZnSe layer, an N-type ZnSSe layer, and an N-type ZnCdSe light emitting layer or at least one of these layers. Here, the wavelength of light emitted from the ZnCdSe layer can be changed by changing the percentage of Cd so that the ZnCdSe layer can emit blue or green light.

The P-type layer 51 of each of the red LED layers 50 is formed by sequentially depositing an $\text{Al}_y\text{Ga}_{1-y}\text{InP}$ layer, an $\text{Al}_x\text{Ga}_{1-x}\text{InP}$ layer, a

Galnp layer, and a GaAs layer or at least one of these layers on a corresponding conductive layer 42. An N-type layer 52 is formed on the P-type layer 51 by sequentially depositing a Galnp layer, an $\text{Al}_x\text{Ga}_{1-x}\text{Inp}$ layer, and an $\text{Al}_y\text{Ga}_{1-y}\text{Inp}$ layer and then depositing an $\text{Al}_y\text{Ga}_{1-y}\text{Inp}$ layer and a Galnp light emitting layer.

After completing the formation of the LED layers 50 including the P-type layer and the N-type layer, as shown in FIG. 24, a color filter layer 55 is formed in order to increase the color purity of light emitted from each LED layer 50. Preferably, the color filter layer 55 is formed to have an opening partially exposing the N-type layer so that a gold wire of a second electrode unit can be bonded to the N-type layer. Instead of the color filter layer 55, a transparent resin layer may be formed. The transparent resin layer may be formed on the entire surface of the substrate 21 so that the insulation layer 41 and the LED layers 50 can be covered with the transparent resin layer.

After completing the formation of the color filter layers 50 or transparent resin layers, each second electrode unit 60 is formed in two stages: a gold wire bonding stage in which one end of each gold wire 62a is bonded to a corresponding N-type layer 52 and the other end of the gold wire 62a is exposed above the surface of a corresponding color filter layer or transparent resin layer 55, and an electrode forming stage in which a Y electrode line 61 is formed in a direction orthogonal to the X electrode line 31 of the first electrode unit 30 in a predetermined pattern and a connection electrode 62b connecting the Y electrode line 61 to the gold wire 62a is formed. Here, the Y electrode line 61 and the connection electrode 62b may be formed in separate stages. In addition, in the gold wire bonding stage, the gold wire 62a may be formed using deposition. Here, it is preferable that the above-described stages are performed throughout the substrate 21.

After completing the formation of the second electrode units 60,

as shown in FIG. 25, a barrier 70 defining the light emitting area of at least one pixel is formed. The barrier 70 may be formed by repeatedly printing a barrier material such as a frit or using electrodeposition. A reflective layer may be formed on the inner sidewall of the barrier 70.

5 After completing the formation of the barrier 70, a protective layer 80 is formed on the surface of the substrate 21 of a transparent resin or dark-colored resin to increase contrast. A conductive layer for blocking static electricity and electromagnetic waves and an external light reflection preventing layer for preventing the reflection of external light
10 are formed on the surface of the protective layer 80. The external light reflection preventing layer is formed using a non-reflective coating. A method of manufacturing the display system can be changed according to the embodiments of a display system. However, a process of directly and epitaxially growing or depositing an LED layer on a substrate can be
15 commonly used in the embodiments of the present invention.

While this invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein, and the preferred embodiments should be considered in a
20 descriptive sense only and not for purposes of limitation. Therefore, the scope of the invention is defined not by the detailed description of the invention but by the appended claims.

Industrial Applicability

25 In a display system and manufacturing method thereof according to the present invention, a pixel is formed using an LED layer, in which a P-type layer makes a junction with an N-type layer, so the display system has high brightness and very long life. First and second electrode units and LED layers are deposited on a single substrate in bulk, thereby
30 simplifying a manufacturing process. Consequently, productivity can be

increased due to mass production. In addition, the present invention can easily realize a subminiature display system having a pixel smaller than $0.1 \text{ mm} \times 0.1 \text{ mm}$, a computer monitor having high definition, and a system having a large screen. Since the size of a pixel can be easily
5 adjusted to $0.1 \text{ mm} \times 0.1 \text{ mm}$ through $10 \text{ mm} \times 10 \text{ mm}$, the present invention can be applied to various display systems such as indoor or outdoor signboards, interior decoration, moving picture traffic signals, and traffic information boards. In addition, cross-talk between pixels can be prevented due to a barrier, thereby increasing the contrast of an
10 image. Since the present invention realizes the satisfactory definition, color purity, and brightness of an image and the satisfactory durability and electrical characteristics of a display system, the present invention can be applied to indoor and outdoor high-definition display systems in all sizes.

What is claimed is:

1. A display system comprising:
a substrate;
a first electrode unit formed on the substrate in a predetermined
5 pattern;
a light emitting diode layer comprising a plurality of light emitting diode parts, which are epitaxially grown or deposited on the surface of the first electrode unit in a predetermined pattern so that one side of each light emitting diode part is electrically connected to the first
10 electrode unit;
a second electrode unit, which is formed on the surface of the substrate in a predetermined pattern to be electrically connected to the opposite side of each light emitting diode part.
- 15 2. The display system of claim 1, further comprising a transparent insulation layer having via-holes corresponding to the light emitting diode parts, wherein the second electrode unit is formed on the transparent insulation layer in a predetermined pattern and is electrically connected to the upper surfaces of the light emitting diode parts through
20 the via-holes.
3. The display system of claim 1, wherein the light emitting diode layer comprises a P-type layer, which is epitaxially grown or deposited to be electrically connected to the first electrode unit, and an
25 N-type layer, which is deposited on the surface of the P-type layer to be electrically connected to the second electrode unit.
4. The display system of claim 1, wherein the light emitting diode layer comprises red, green, and blue light emitting diode parts to
30 form a pixel of an image.

5 5. The display system of claim 1, wherein the first electrode unit comprises data lines formed on the surface of the substrate, scan lines insulated from the data lines, and thin film transistors driven by the scan lines and the data lines.

10 6. The display system of claim 1, further comprising a transparent insulation layer formed on the surface of the light emitting diode layer, wherein the second electrode unit comprises Y electrode lines, which are formed on the surface of the transparent insulation layer, and connection electrodes, each of which connects each Y electrode line to the N-type layer of a corresponding light emitting diode part.

15 7. The display system of claim 5, wherein each connection electrode is a gold wire formed using deposition.

20 8. The display system of claim 6, wherein each connection electrode comprises a gold wire connected to the N-type layer of each light emitting diode part and a transparent conductive layer connecting the gold wire to a corresponding Y electrode line.

25 9. The display system of claim 1 or 2, further comprising a color filter layer formed on the light emitting diode layer in order to realize colors.

30 10. The display system of claim 9, further comprising a fluorescent layer between the light emitting diode layer and the color filter layer, the fluorescent layer being excited by ultraviolet rays emitted from the light emitting diode layer and thus emitting white light.

11. The display system of claim 1, further comprising barriers formed in a predetermined pattern in order to optically separate at least three light emitting diode parts forming a pixel from other light emitting diode parts forming adjacent pixels.

5

12. The display system of claim 11, further comprising a transparent resin layer formed on the surface of the substrate so that the first and second electrode units, the light emitting diode layer, and the barriers are covered with the transparent resin layer.

10

13. The display system of claim 12, further comprising a conductive coating layer formed on the surface of the transparent resin layer in order to prevent static electricity and electromagnetic wave.

15

14. The display system of claim 12, further comprising an external light reflection preventing layer formed on the surface of the transparent resin layer in order to prevent external light from being reflected.

20

15. The display system of claim 12, further comprising a light scattering layer formed on the surface of the transparent resin layer in order to scatter light emitted from the light emitting diode layer.

16. The display system of claim 1, wherein the light emitting diode parts are composed of a red light emitting diode part formed of an AlGaInp based material, a green light emitting diode part formed of a ZnCdMgSeS based material, and a blue light emitting diode part formed of a ZnCdMgSeS based material.

25

17. The display system of claim 11, wherein the ends of the

30

barriers are separated from one another.

18. The display system of claim 11, wherein the barriers are formed of a semitransparent or opaque resin material.

5

19. The display system of any one of claims 11, 17, and 18, further comprising a reflective film formed on the inner sidewall of each barrier in order to reflect light to the front of the display system.

10 20. The display system of claim 1, wherein the substrate is formed of a flexible material.

21. The display system of claim 1, further comprising a graded layer formed between the first electrode unit and the light emitting diode layer in order to grow single crystals having the same lattice constant as a material of the light emitting diode layer.

15

22. The display system of claim 1, wherein the substrate is formed of one of sapphire and silundum.

20

23. The display system of claim 1, wherein the substrate is formed of a silicon based material.

24. The display system of claim 21, wherein the graded layer is formed of a material selected from the group consisting of sapphire powder, silundum powder, and silicon based powder.

25

25. A display system comprising:

a substrate;

30

a first electrode unit formed on the surface of the substrate;

a light emitting diode layer comprising a plurality of light emitting diode parts, which are epitaxially grown or deposited on the surface of the first electrode unit in a predetermined pattern so that each light emitting diode part is electrically connected to the first electrode unit;

5 a barrier formed around the light emitting diode part and separated from each light emitting diode part by a predetermined distance in order to reflect light emitted from the light emitting diode part to the front of the display system;

10 a transparent insulation layer formed on the surface of the substrate having the light emitting diode layer and the barrier; and

a second electrode unit formed on the surface of the transparent insulation layer to be electrically connected to each light emitting diode part.

15 26. The display system of claim 25, further comprising a color filter layer formed on the transparent insulation layer.

20 27. The display system of claim 26, further comprising a fluorescent layer formed between the transparent insulation layer and the color filter layer, the fluorescent layer being excited by ultraviolet rays and thus emitting white light.

25 28. The display system of claim 25, further comprising a light scattering layer formed on the surface of the transparent insulation layer in order to scatter light.

30 29. The display system of claim 25, wherein the second electrode unit comprises Y electrode lines, which are formed on the surface of the transparent insulation layer, and connection electrodes connecting the Y electrode lines to N-type layers of corresponding light

emitting diode parts.

30. The display system of claim 29, wherein each connection electrode is formed by filling a groove with a conductive metal, the
5 groove being formed to have the shape of a reversed truncated cone in an area on the transparent insulation layer corresponding to a corresponding light emitting diode part.

31. The display system of claim 25, wherein the light emitting
10 diode parts are composed of a red light emitting diode part formed of an AlGaInp based material, a green light emitting diode part formed of a ZnCdMgSeS based material, and a blue light emitting diode part formed of a ZnCdMgSeS based material.

15 32. The display system of claim 25, further comprising a reflective film formed on the inner sidewall of the barrier in order to reflect light to the front of the display system.

33. The display system of claim 25, further comprising a
20 graded layer formed between the first electrode unit and the light emitting diode layer in order to grow single crystals having the same lattice constant as a material of a P- or N-type layer forming the light emitting diode layer.

25 34. The display system of claim 25, wherein the substrate is formed of a silicon based material.

35. The display system of claim 33, wherein the graded layer is
30 formed of a material selected from the group consisting of sapphire powder, silundum powder, and silicon based powder.

36. A display system comprising:
a substrate;
a first electrode unit formed on the substrate in a predetermined
5 pattern;
an insulation layer formed on the surface of the first electrode unit;
a light emitting diode layer comprising a light emitting part, which
is formed by stacking a conductive layer, a P-type layer, and an N-type
layer on the insulation layer and cutting the stack in a depth direction to
10 expose the insulation layer, and a plurality of light emitting diode parts,
each of which is electrically connected to the first electrode unit; and
a second electrode unit, which electrically connects the surfaces
of the light emitting diode parts and drives the light emitting diode parts.

15 37. The display system of claim 36, further comprising a barrier
formed in an area between adjacent light emitting diode parts.

38. The display system of claim 36, further comprising a
reflective film formed on the inner sidewall of the barrier in order to reflect
20 light emitted from the light emitting diode parts to the front of the display
system.

39. The display system of claim 36, further comprising a color
filter which filters light emitted from the light emitting diode parts to form a
25 color image.

40. The display system of claim 39, further comprising a
fluorescent layer between each of the light emitting diode parts and the
color filter layer, the fluorescent layer being excited by ultraviolet rays
30 emitted from the light emitting diode layers and thus emitting white light.

41. The display system of claim 37, further comprising a transparent insulation layer formed on the surface of the substrate so that the light emitting diode layer, the barrier, and the second electrode unit are covered with the transparent insulation layer.

42. The display system of claim 41, further comprising a light scattering layer formed on the transparent insulation layer.

43. The display system of claim 36, wherein the light emitting diode parts are composed of a red light emitting diode part formed of an AlGaInp based material, a green light emitting diode part formed of a ZnCdMgSeS based material, and a blue light emitting diode part formed of a ZnCdMgSeS based material.

44. The display system of claim 36, further comprising a graded layer formed between the first electrode unit and the light emitting diode layer in order to grow single crystals having the same lattice constant as a material of the P- or N-type layer forming the light emitting diode layer.

45. The display system of claim 44, wherein the graded layer is formed of a material selected from the group consisting of sapphire powder, silundum powder, and silicon based powder.

46. A display system comprising:
a substrate;
a first electrode unit formed on the substrate in a predetermined pattern;
a light emitting diode layer comprising a plurality of light emitting

diode parts, which are epitaxially grown or deposited on the surface of the first electrode unit in a predetermined pattern so that one side of each light emitting diode part is electrically connected to the first electrode unit;

5 a white fluorescent layer formed to correspond to each light emitting diode part, the white fluorescent layer being excited by parent rays emitted from the light emitting diode part;

 a color filter layer formed on the surface of the white fluorescent layer; and

10 a second electrode unit electrically connected to another side of each light emitting diode part.

47. The display system of claim 46, further comprising a barrier separating at least one light emitting diode part from the other light emitting diode parts.

48. The display system of claim 47, further comprising a reflective film formed on the inner sidewall of the barrier in order to reflect light emitted from the light emitting diode parts to the front of the display system.

49. The display system of claim 46, further comprising a light scattering layer formed on the surface of the color filter layer in order to scatter light.

25

50. The display system of claim 46, further comprising a graded layer formed between the first electrode unit and the light emitting diode layer in order to grow single crystals having the same lattice constant as a material of a P- or N-type layer forming the light emitting diode layer.

30

51. The display system of claim 46, wherein the parent rays emitted from the light emitting diode parts are ultraviolet rays.

5 52. A display system comprising:
a substrate;
a first electrode unit formed on the substrate in a predetermined pattern;
an insulation layer formed on the surface of the first electrode unit;
10 a conductive layer formed on the surface of the insulation layer to be electrically connected to the first electrode unit;
a light emitting diode layer comprising a plurality of light emitting diode parts, each of which is formed by depositing a P-type layer and an N-type layer on the conductive layer and the insulation layer and forming
15 a groove having the shape of a closed loop to surround the P- and N-type layers in an area corresponding to the conductive layer; and
a second electrode unit, which electrically connects the surfaces of the light emitting diode parts and drives the light emitting diode parts.

20 53. The display system of claim 52, further comprising a reflective film formed on the inside of each groove corresponding to a light emitting diode part in order to reflect light emitted from the light emitting diode part to the front of the display system.

25 54. The display system of claim 52, further comprising a fluorescent layer formed at each groove, the fluorescent layer being excited by ultraviolet rays emitted from a corresponding light emitting diode part and thus emitting white light, and a color filter layer formed on the surface of the light emitting diode layer, the color filter layer filtering
30 the white light to form a color image.

55. The display system of claim 52, further comprising a transparent insulation layer on the surface of the substrate so that the light emitting diode layer, a barrier, and the second electrode layer are covered with the transparent insulation layer and a light scattering layer formed on the surface of the transparent insulation layer.

56. The display system of claim 52, further comprising a graded layer formed between the first electrode unit and the light emitting diode layer in order to grow single crystals having the same lattice constant as a material of the P- or N-type layer forming the light emitting diode layer.

57. A method of manufacturing a display system, comprising:
preparing a substrate;
forming a first electrode unit by performing deposition or printing on the surface of the substrate in a predetermined pattern;
forming a light emitting diode layer having a plurality of light emitting diode parts by depositing a P-type layer and an N-type layer in a predetermined pattern, the light emitting diode parts being electrically connected to the first electrode unit;
forming a transparent insulation layer so that the light emitting diode layer is covered with the transparent insulation layer; and
forming a second electrode unit on the transparent insulation layer so that the second electrode unit is electrically connected to the N-type layer of each light emitting diode part.

58. The method of claim 57, wherein each of the P- and N-type layers is formed using repetitive deposition.

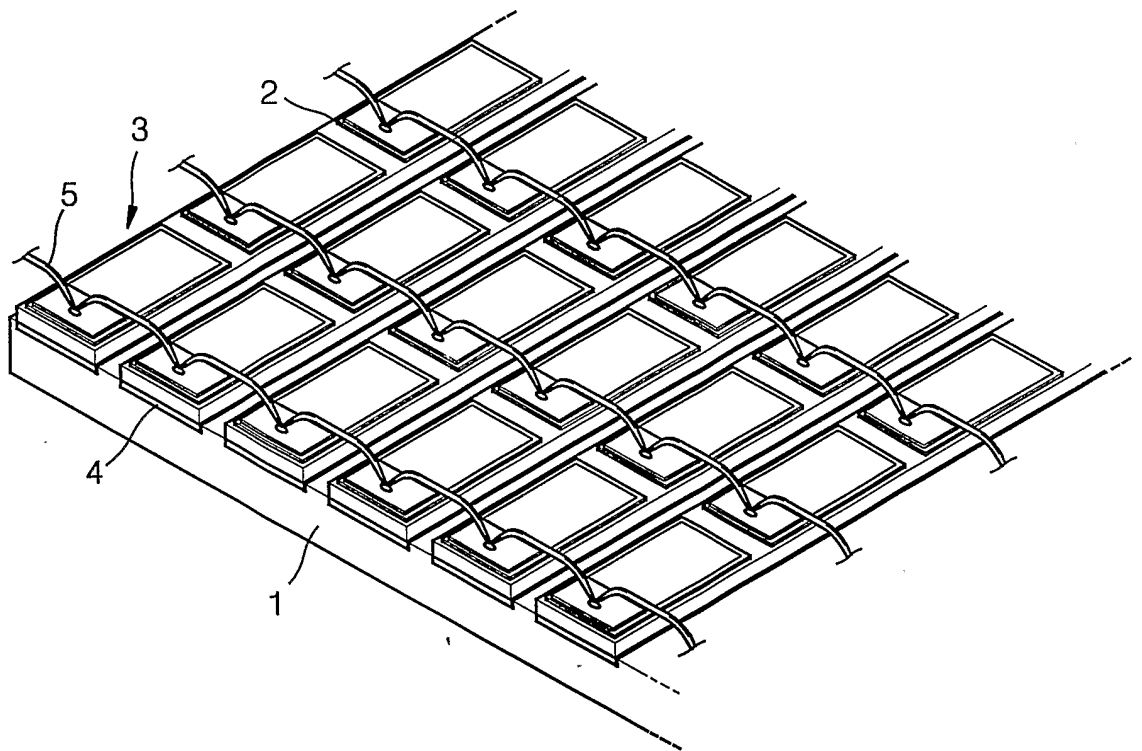
59. The method of claim 57, further comprising forming a graded layer on the surface of the first electrode unit after forming the first electrode unit.

5 60. The method of claim 57, further comprising forming a barrier to define a light emitting area of each pixel composed of at least one light emitting diode part and forming a protective layer of a transparent resin layer, after forming second electrode unit.

10 61. A display system comprising a plurality of display systems, which are manufactured as unit modules according to the method of claim 58 and connected to one another, thereby forming a large screen.

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FIG. 1



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FIG. 2

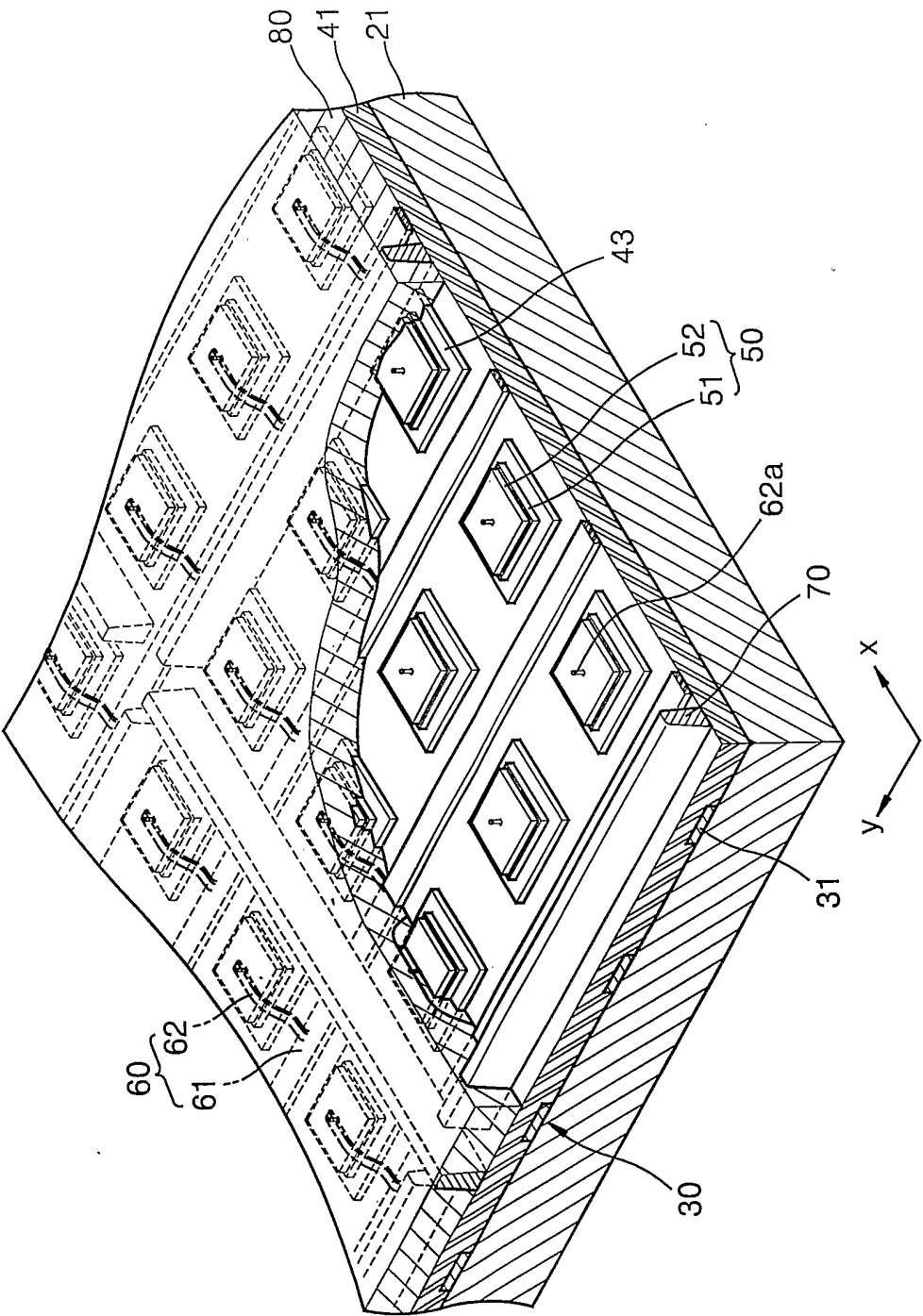


FIG. 5

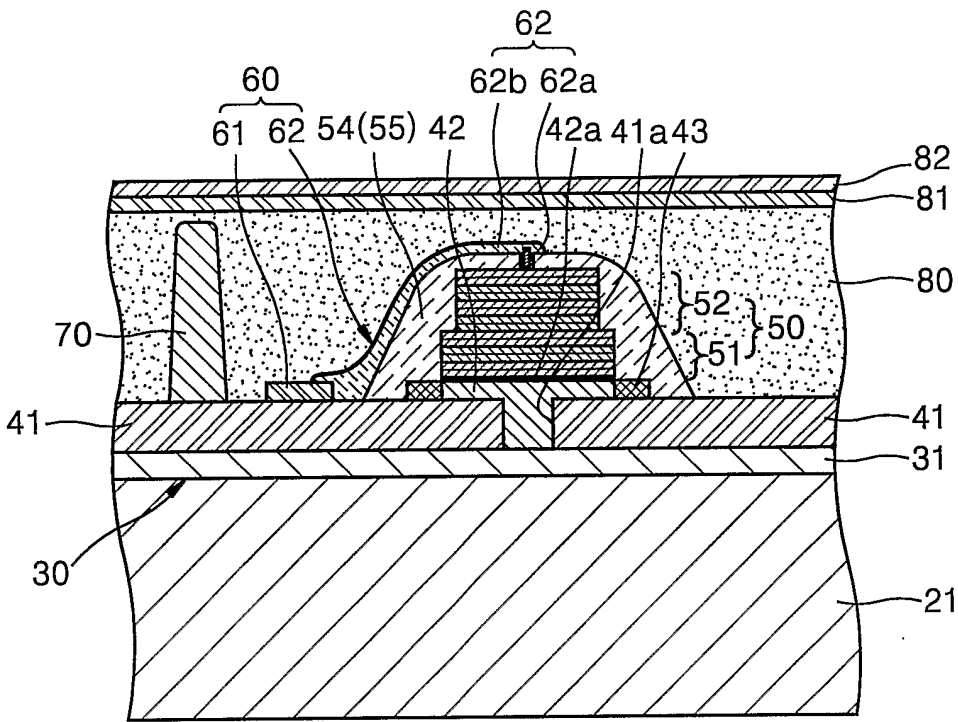
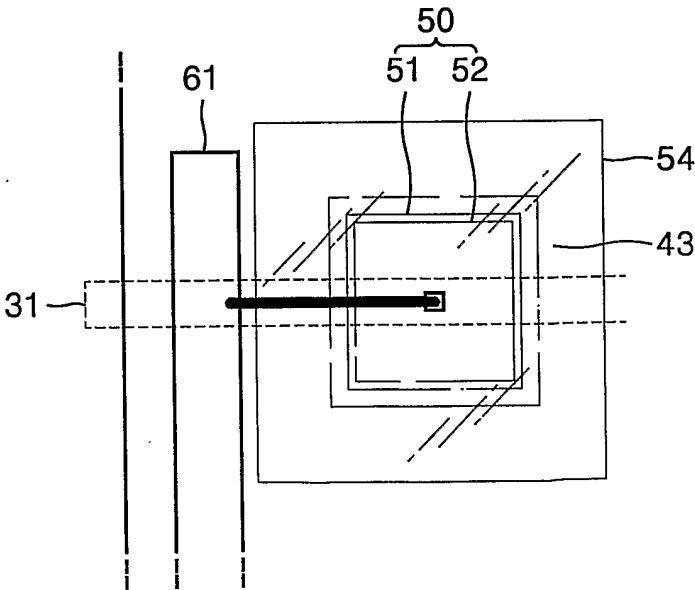


FIG. 6



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FIG. 7

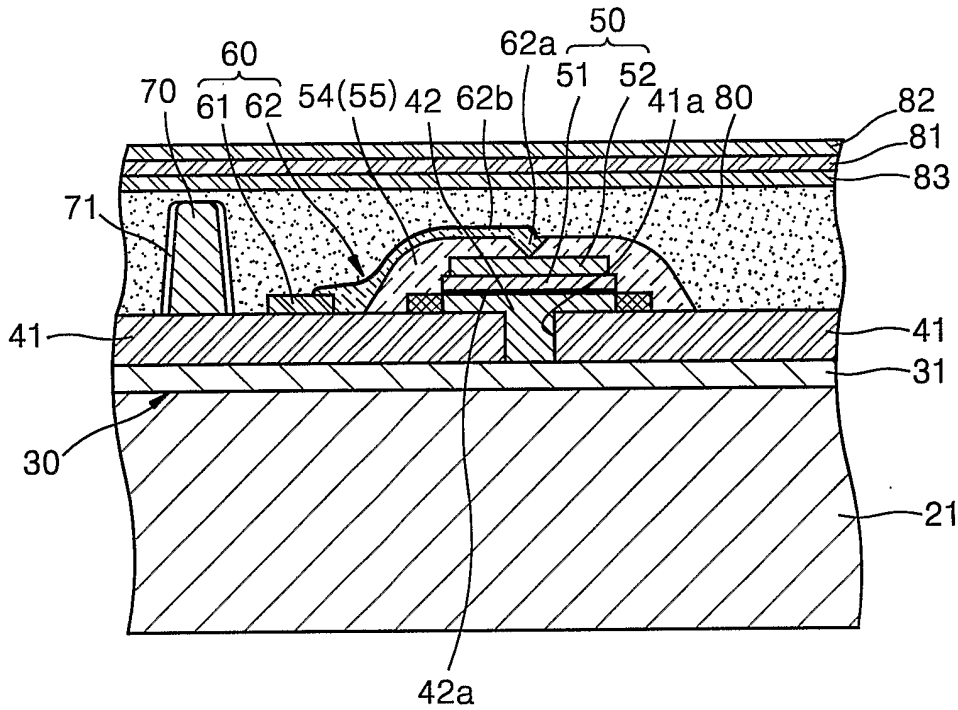
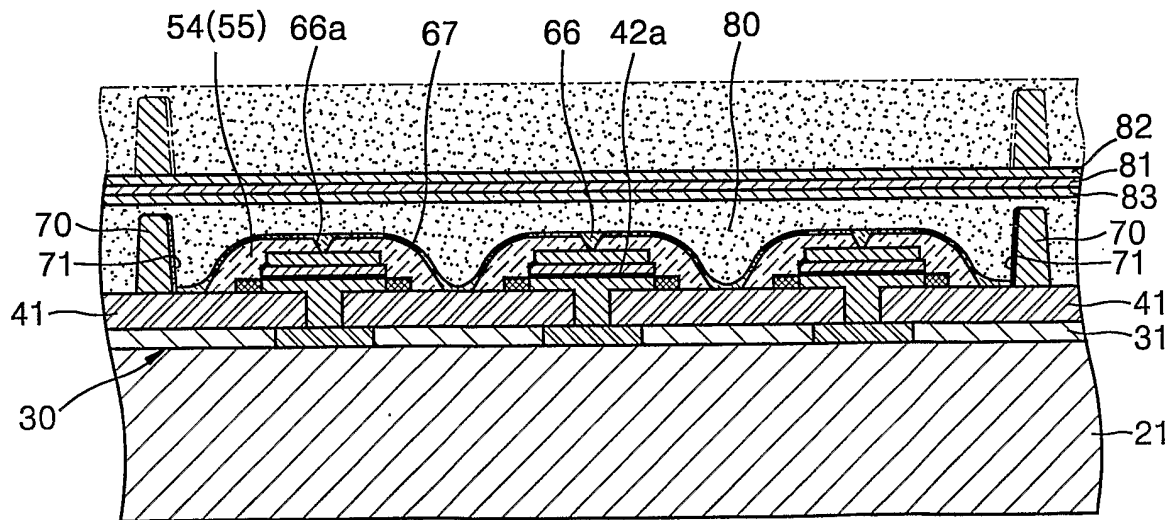


FIG. 8A



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FIG. 8B

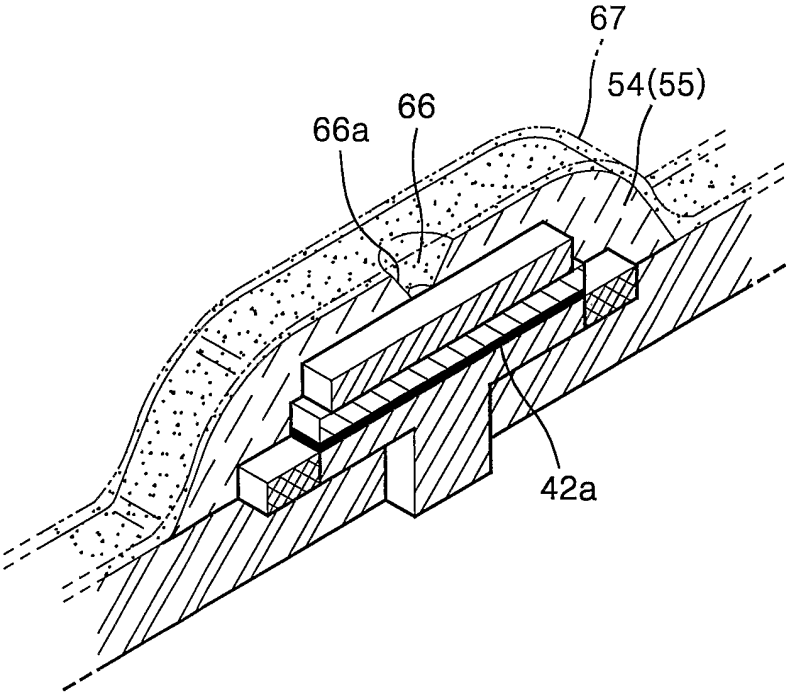
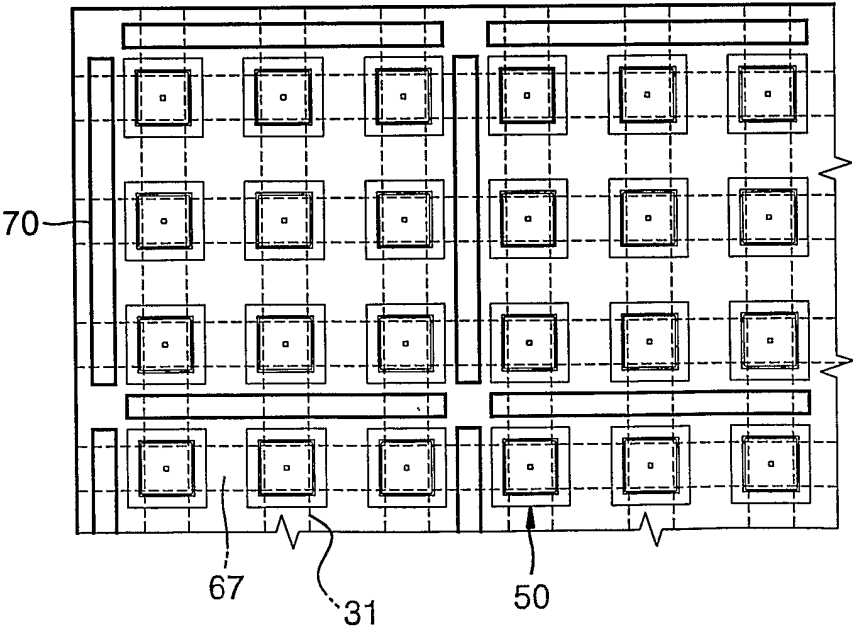


FIG. 9



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FIG. 10

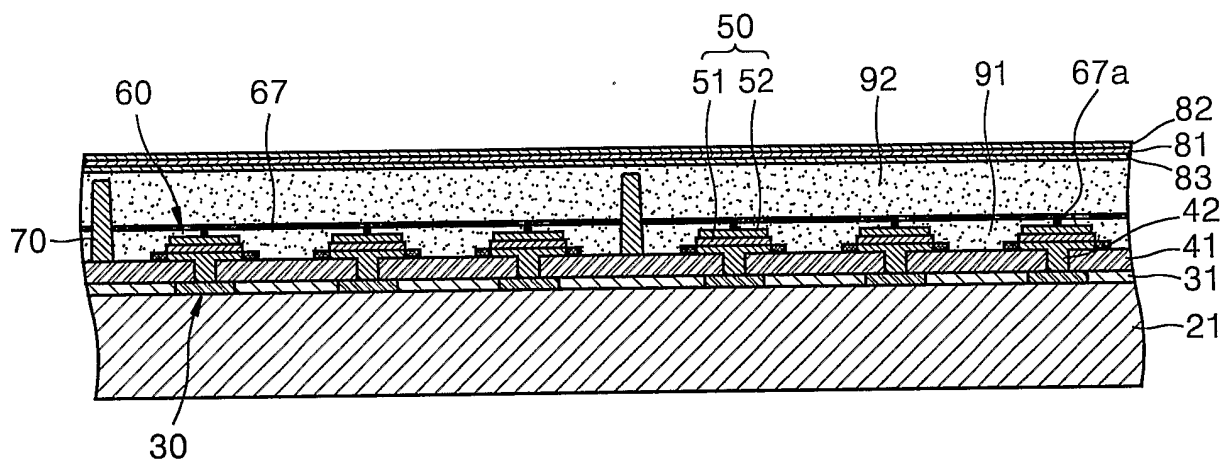


FIG. 11

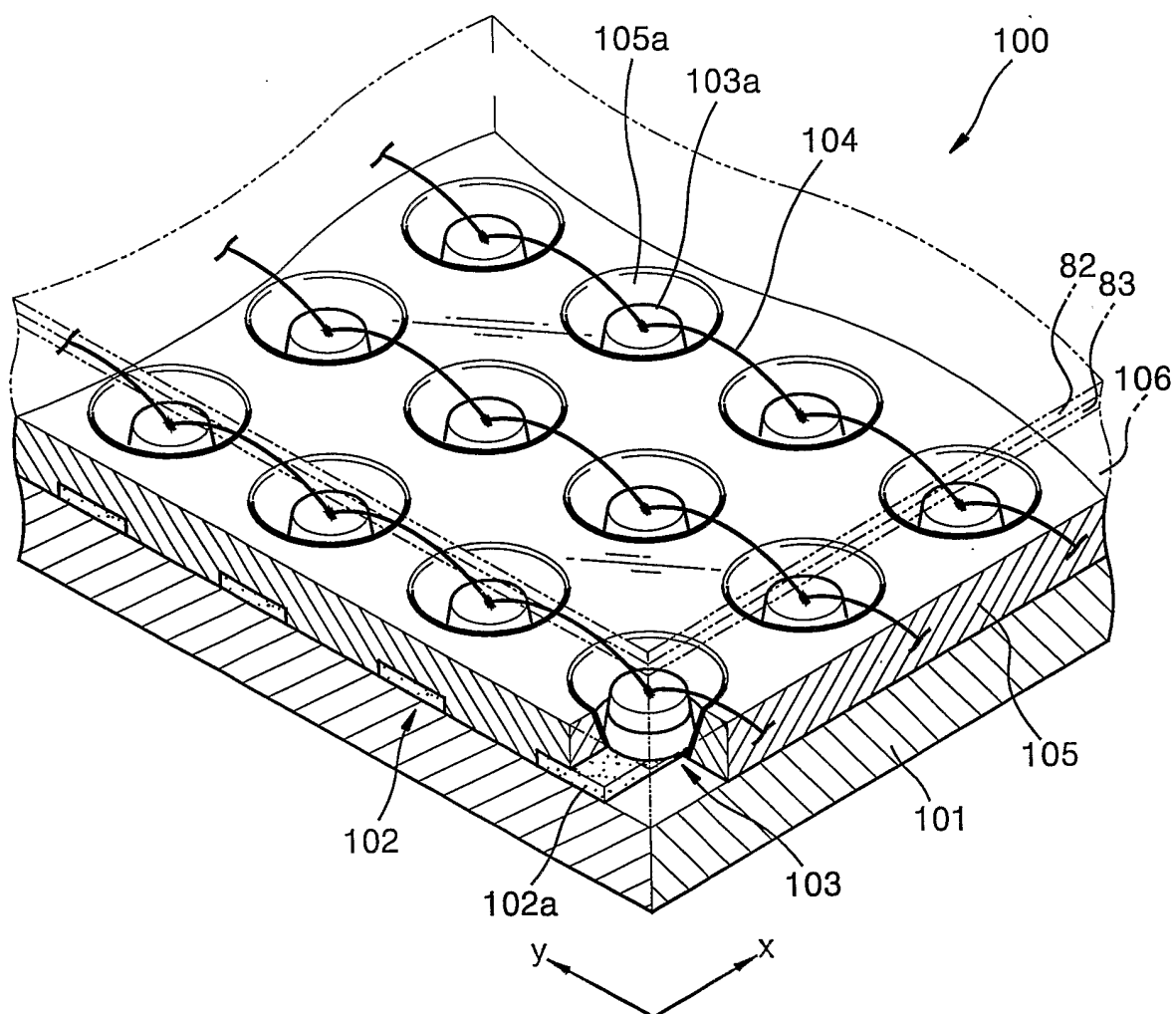


FIG. 12

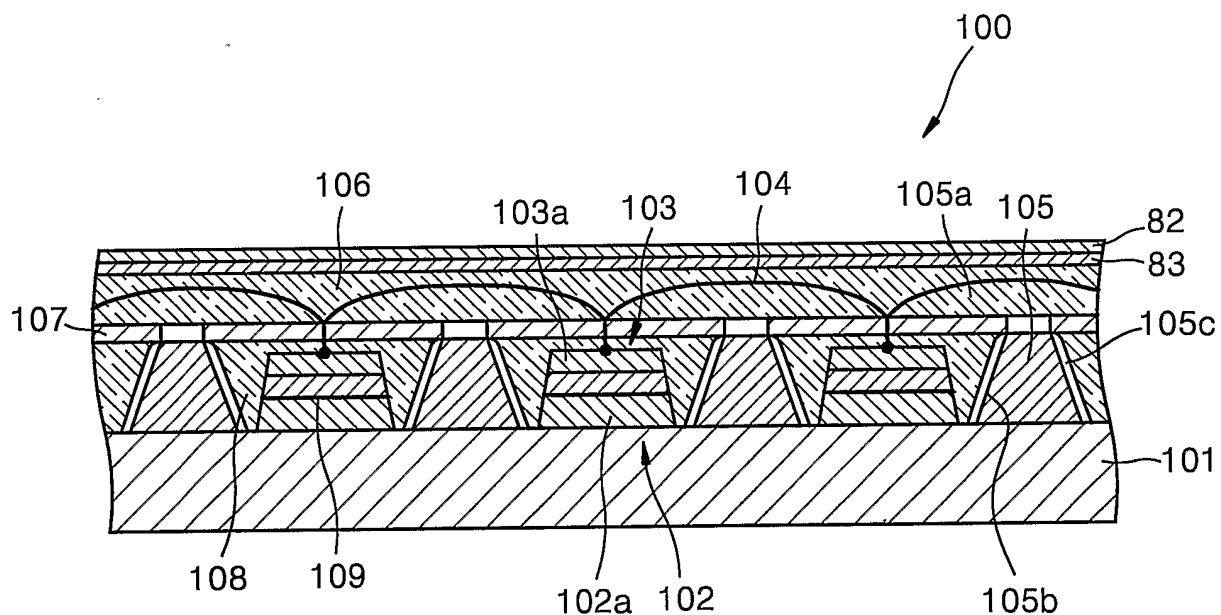
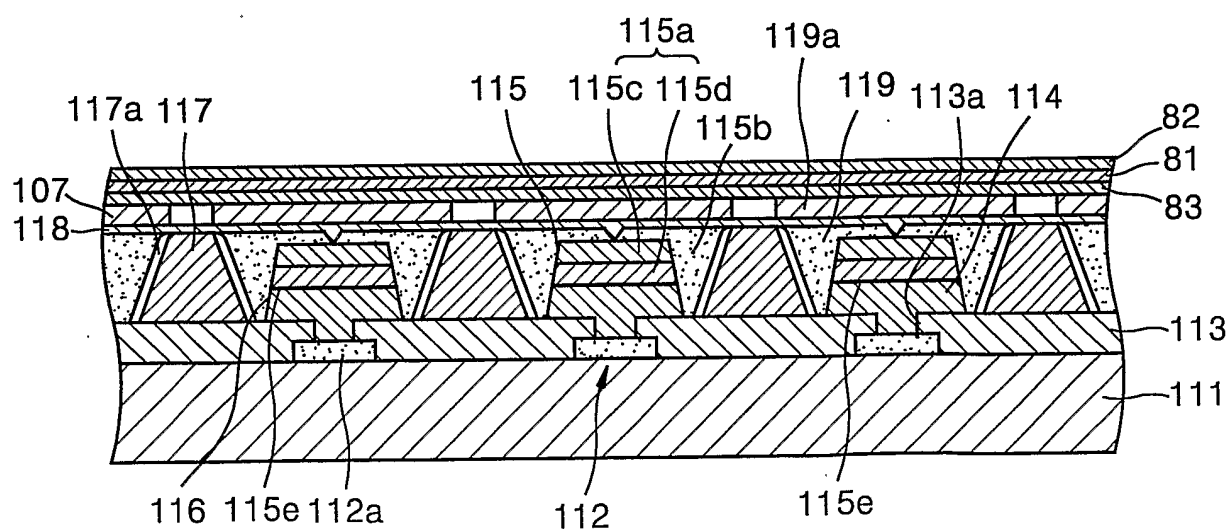


FIG. 13



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FIG. 14

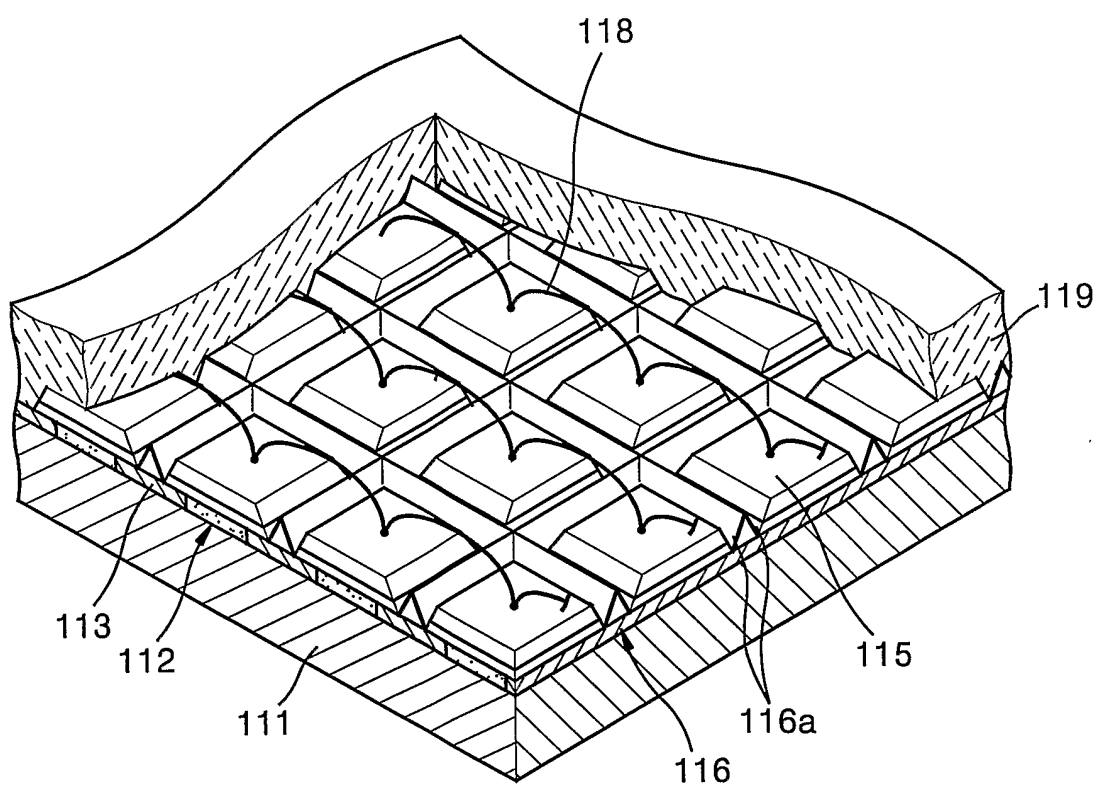


FIG. 15

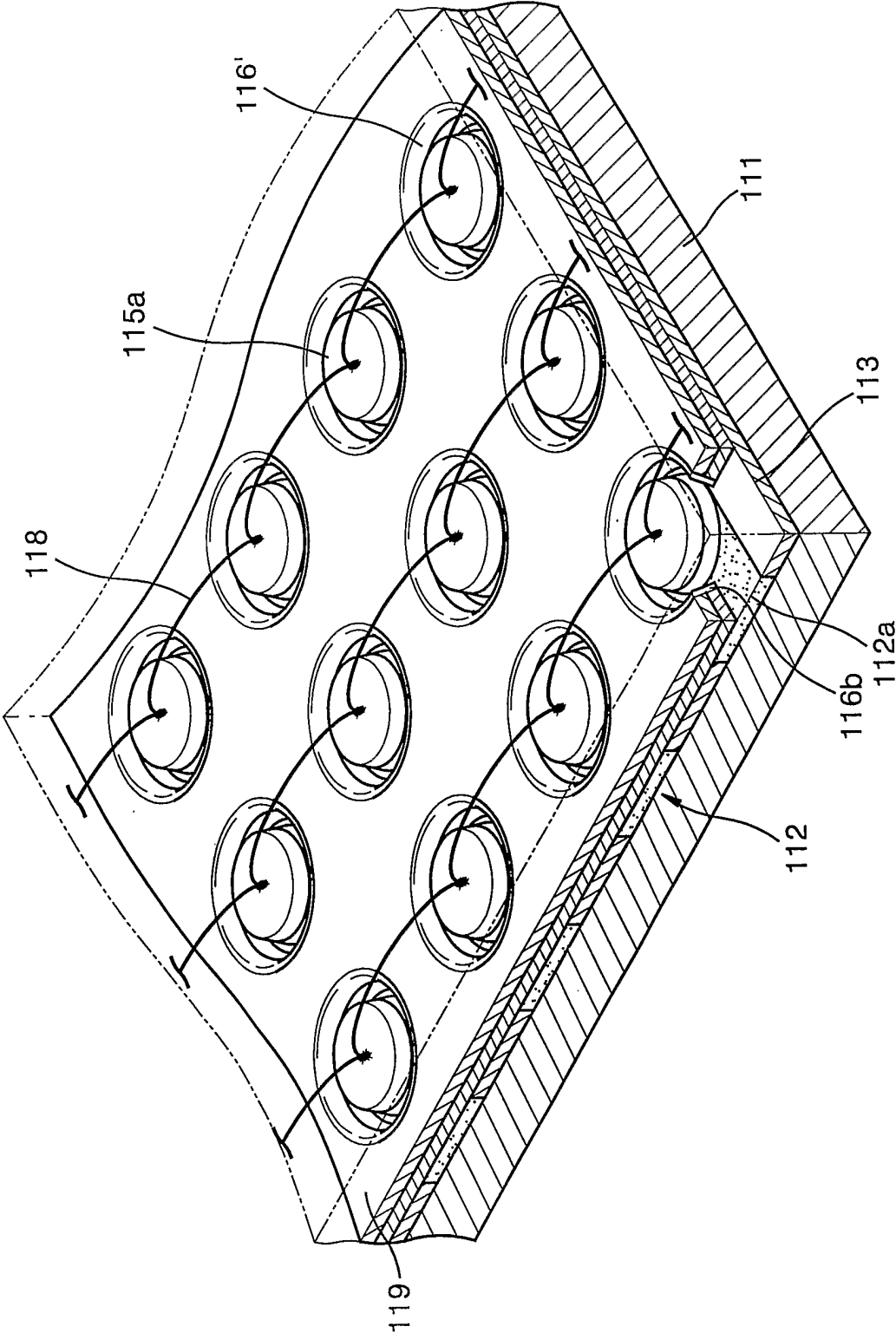


FIG. 16

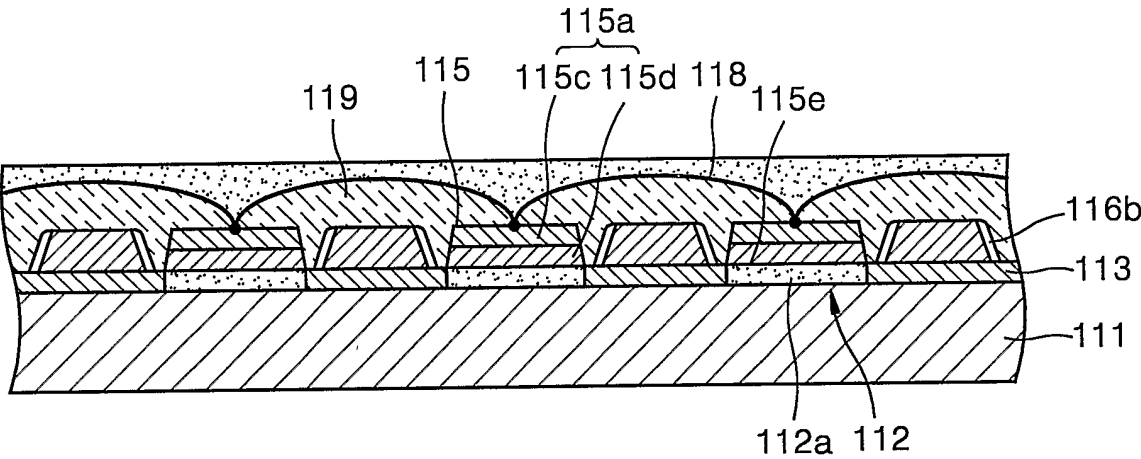


FIG. 17

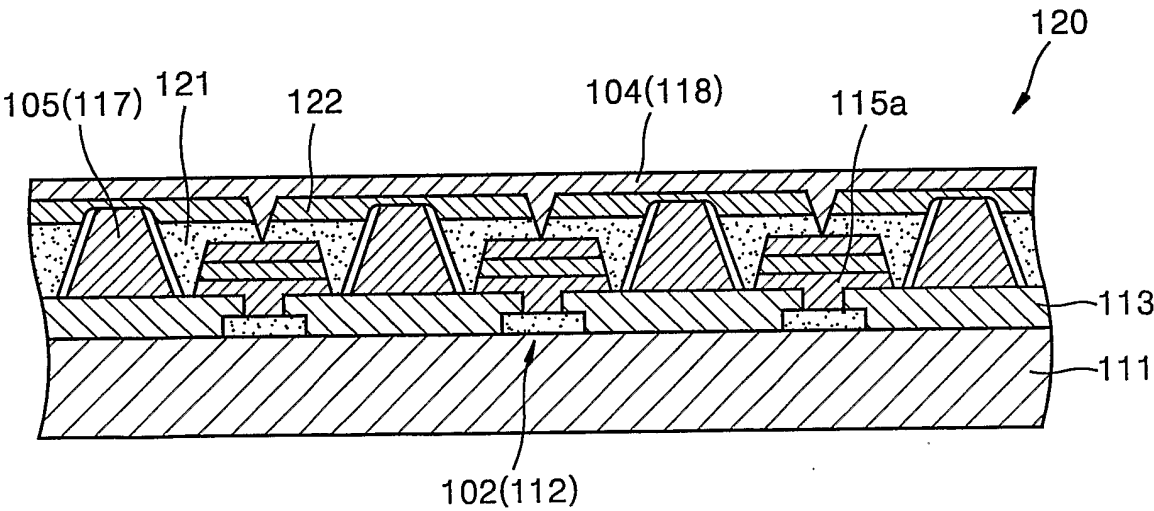


FIG. 18

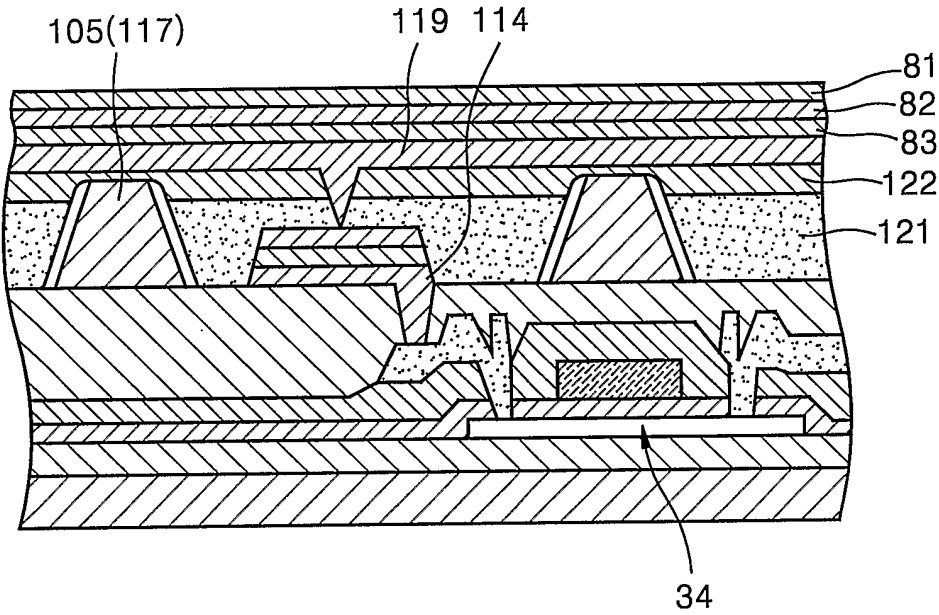


FIG. 19

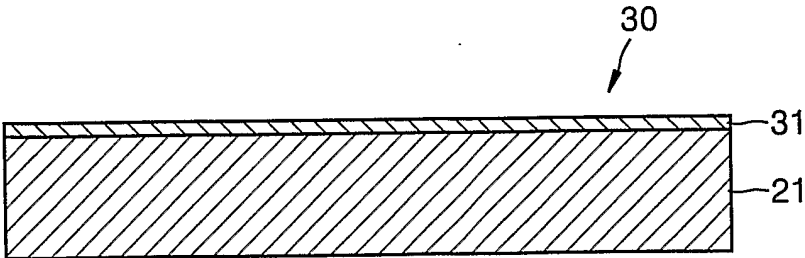


FIG. 20

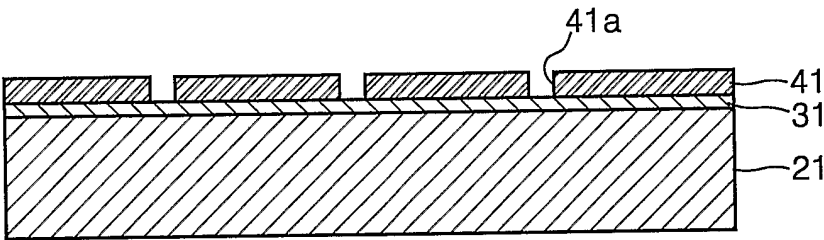


FIG. 21

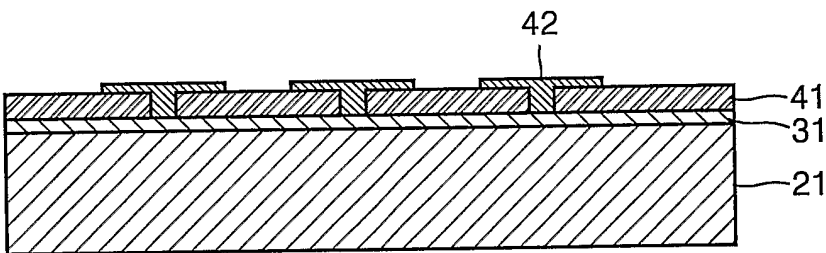


FIG. 22

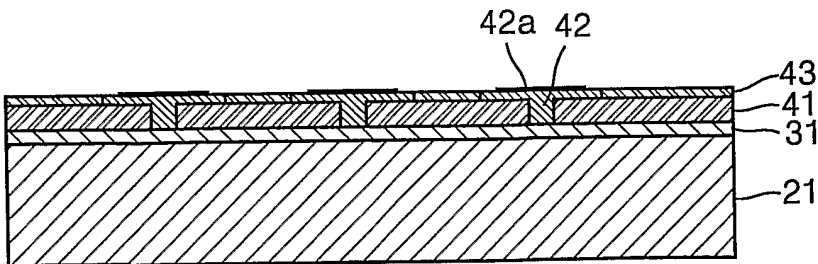


FIG. 23

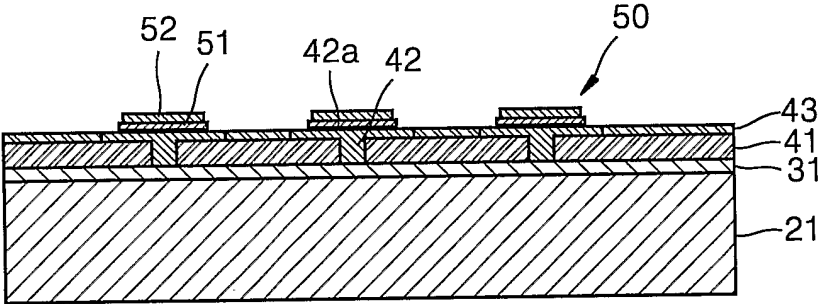


FIG. 24

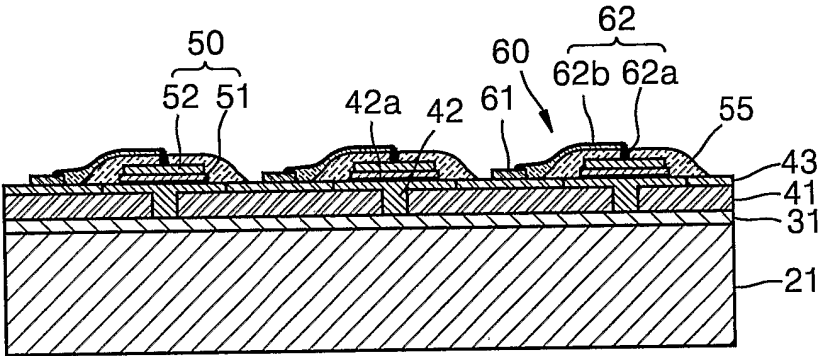
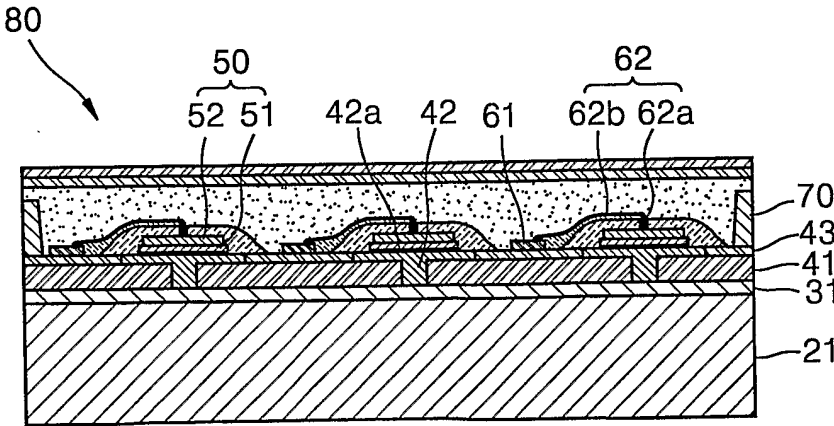


FIG. 25



INTERNATIONAL SEARCH REPORT

national application No.
PCT/KR02/01453**A. CLASSIFICATION OF SUBJECT MATTER****IPC7 H01L 33/00, G09F 9/30, H01L 27/15**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 H01L, G09F, G06F, H05B33

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions, since 1975

Korean Utility models and applications for Utility models, since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 5-53511 A2 (TOYODA GOSEI CO. LTD) 3 MAY 1993 see the whole documents	1-62
Y	US 4775645 A (VICTOR COMPANY OF JAPAN. LTD.) 4 OCT 1988 see the whole documents	1-62
Y	US 4445132 A (TOKYO SHIBAURA DENKI K K.) 24 APR 1984 see the abstract and the figures 1-11	2
Y	EP 932137 A1 (SEIKO EPSON CORPORATION) 28 JUL 1999 see the abstract and the figures 4-6	5
Y	JP 8-264840 A2 (SANYO ELECTRIC CO. LTD.) 11 OCT 1996 see the whole documents	13-15, 17-19, 28, 32, 37-38, 48-50, 56
Y	WO 01/33640 A1 (OSRAM OPTO SEMICONDUCTOR GMBH & CO. OHG) 10 MAY 2001 see the whole documents	9-10, 26-27, 39-40, 47, 52, 55
A, D	JP 2001-51623 A2 (SONY CORP) 23 FEB 2001 see the whole documents	1-62

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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