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Li et al.

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(54) **METHOD FOR MANUFACTURING A LIGHT EMITTED DIODE DISPLAY**

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(73) Assignee: **SCT TECHNOLOGY, LTD.**, Grand Cayman (KY)

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(22) Filed: **Nov. 27, 2015**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01L 21/70 (2006.01)
H01L 25/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01L 25/50*** (2013.01); ***H01L 21/67144*** (2013.01); ***H01L 21/6831*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01L 2924/00; H01L 2924/00014; H01L 2924/0002; H01L 2224/13111; H01L 2224/131; H01L 2224/48091; H01L 2924/12042; H01L 2224/81815; H01L 2924/014; H01L 2224/81203; H01L 25/0753; H01L 2924/10
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0284190 A1* 12/2006 Zimmerman H01L 33/20 257/79
2010/0176705 A1* 7/2010 Van Herpen B32B 17/10036 313/46

(Continued)

Primary Examiner — Robert Bachner
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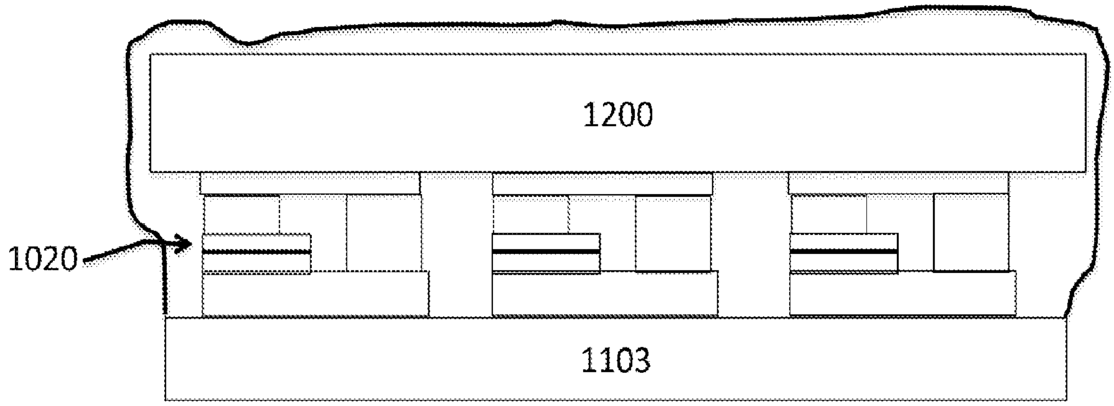
(57) **ABSTRACT**

A method for manufacturing a micro LED display is provided. The method includes providing a plurality of LED elements on a first substrate, transferring, using a magnetic holder or a vacuum holder, at least two of the plurality of LED elements of the same primary color from the first substrate to a second substrate, performing the steps of the providing and the transferring with respect to three primary colors, forming an array of RGB LED units on the second substrate, each of the array of RGB LED units including a red LED element, a green LED element, and a blue LED element, interposing the array of RGB LED units between the second substrate and an LED driver wafer, detaching the second substrate from the array of RGB LED units, and interposing the array of RGB LED units between the LED driver wafer and a cover.

5 Claims, 23 Drawing Sheets



Related U.S. Application Data

filed on Dec. 15, 2014, provisional application No. 62/110,672, filed on Feb. 2, 2015.

(51) **Int. Cl.**

H01L 23/00	(2006.01)
H01L 25/075	(2006.01)
H01L 21/67	(2006.01)
H01L 21/683	(2006.01)
H01L 21/66	(2006.01)
H01L 25/16	(2006.01)
H01L 25/18	(2006.01)
H01L 33/00	(2010.01)
H01L 33/62	(2010.01)
H01L 27/15	(2006.01)

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

CPC ***H01L 21/6838*** (2013.01); ***H01L 22/20*** (2013.01); ***H01L 24/00*** (2013.01); ***H01L 25/0753*** (2013.01); ***H01L 25/167*** (2013.01); ***H01L 25/18*** (2013.01); ***H01L 33/0079*** (2013.01); *H01L 27/156* (2013.01); *H01L 33/0095* (2013.01); *H01L 33/62* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0320581 A1* 12/2012 Rogers H01L 24/24 362/235

2013/0300984 A1* 11/2013 Lin H01L 25/0753 349/69

2014/0225136 A1* 8/2014 Kim H01L 33/62 257/89

* cited by examiner

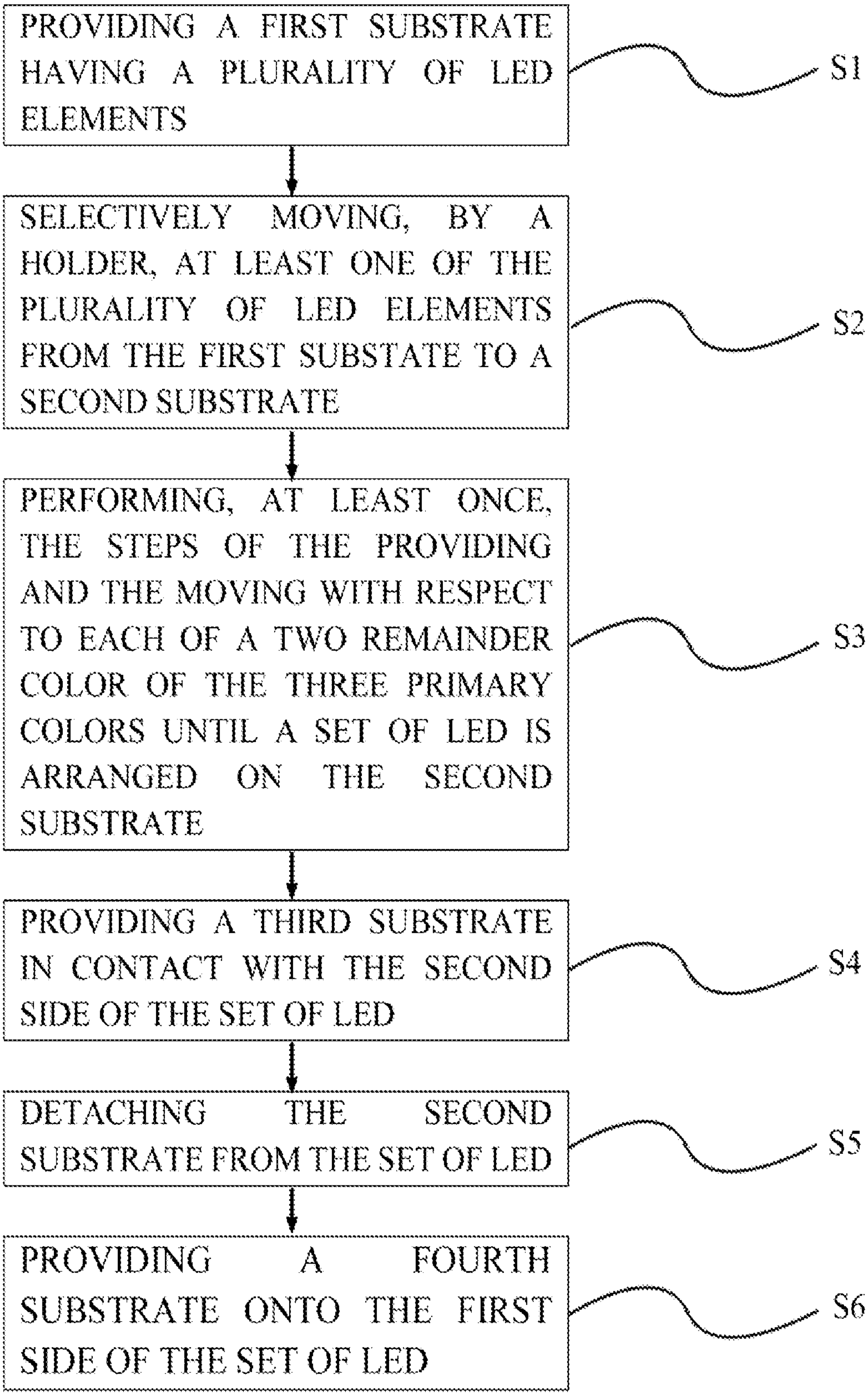

PROVIDING A FIRST SUBSTRATE HAVING A PLURALITY OF LED ELEMENTS
S1
SELECTIVELY MOVING, BY A HOLDER, AT LEAST ONE OF THE PLURALITY OF LED ELEMENTS FROM THE FIRST SUBSTATE TO A SECOND SUBSTRATE
S2
PERFORMING, AT LEAST ONCE, THE STEPS OF THE PROVIDING AND THE MOVING WITH RESPECT TO EACH OF A TWO REMAINDER COLOR OF THE THREE PRIMARY COLORS UNTIL A SET OF LED IS ARRANGED ON THE SECOND SUBSTRATE
S3
PROVIDING A THIRD SUBSTRATE IN CONTACT WITH THE SECOND SIDE OF THE SET OF LED
S4
DETACHING THE SECOND SUBSTRATE FROM THE SET OF LED
S5
PROVIDING A FOURTH SUBSTRATE ONTO THE FIRST SIDE OF THE SET OF LED
S6

Fig. 1

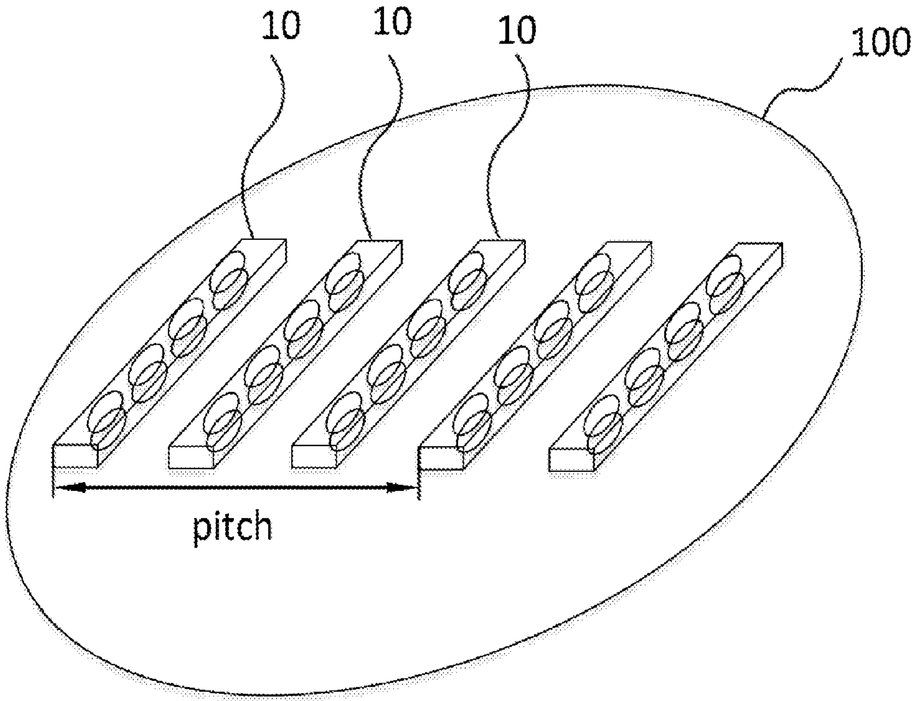


Fig. 2

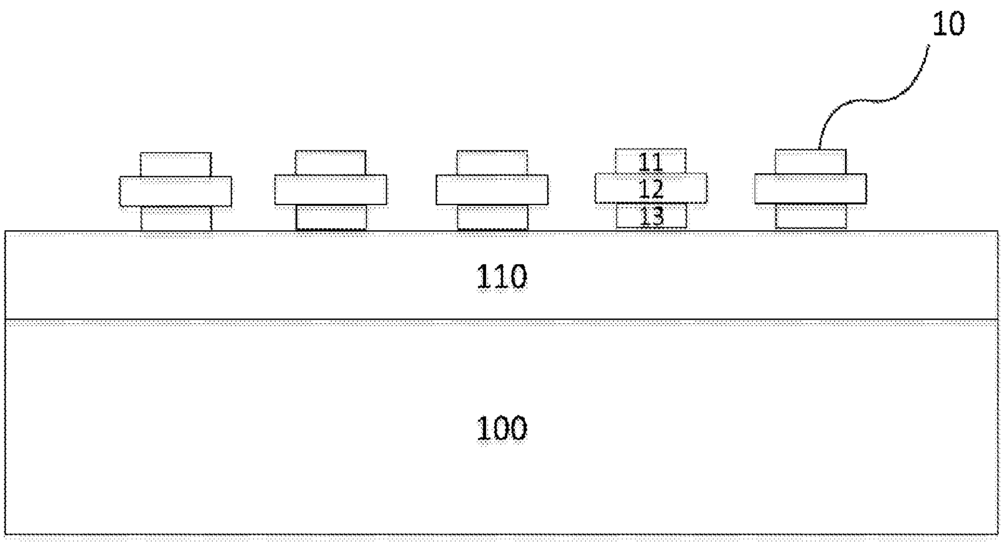


Fig. 3

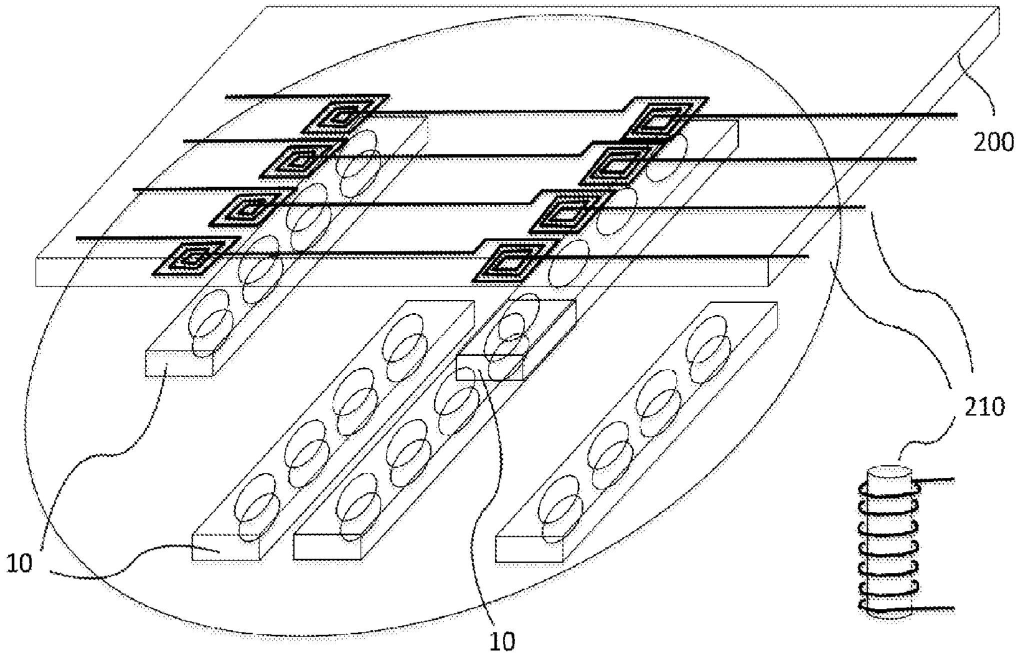


Fig. 4

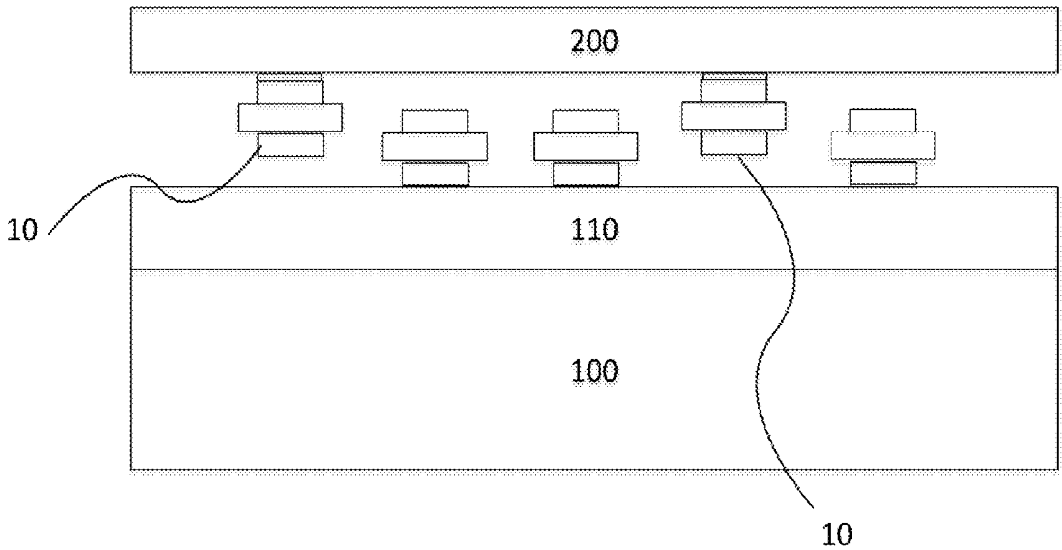


Fig. 5

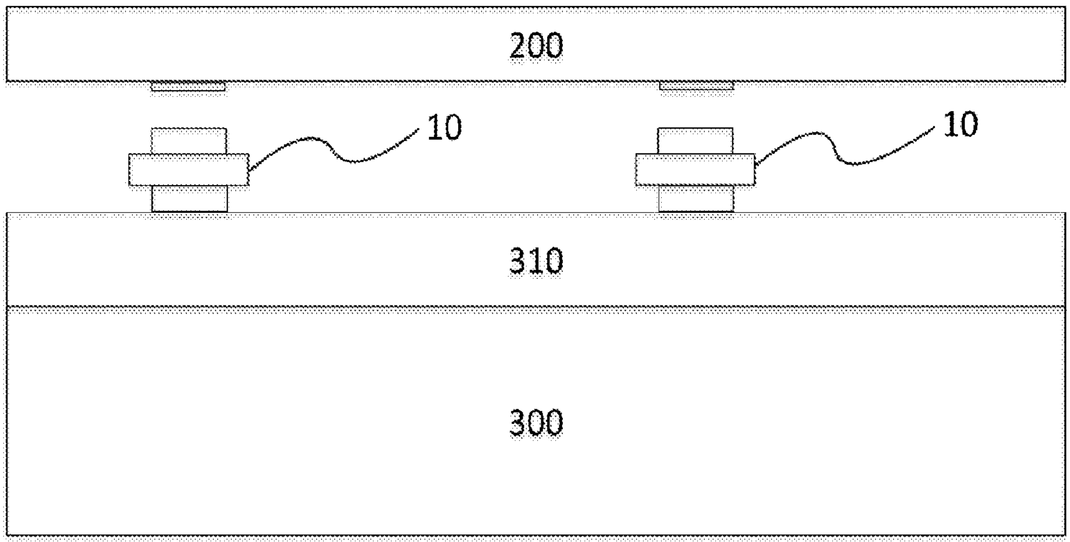


Fig. 6

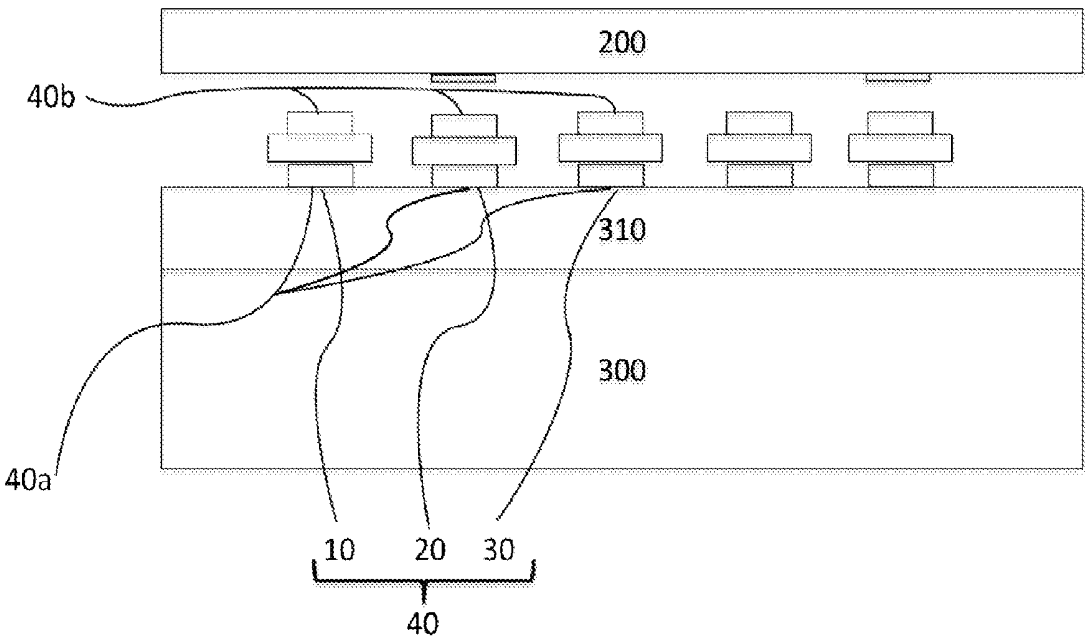


Fig. 7

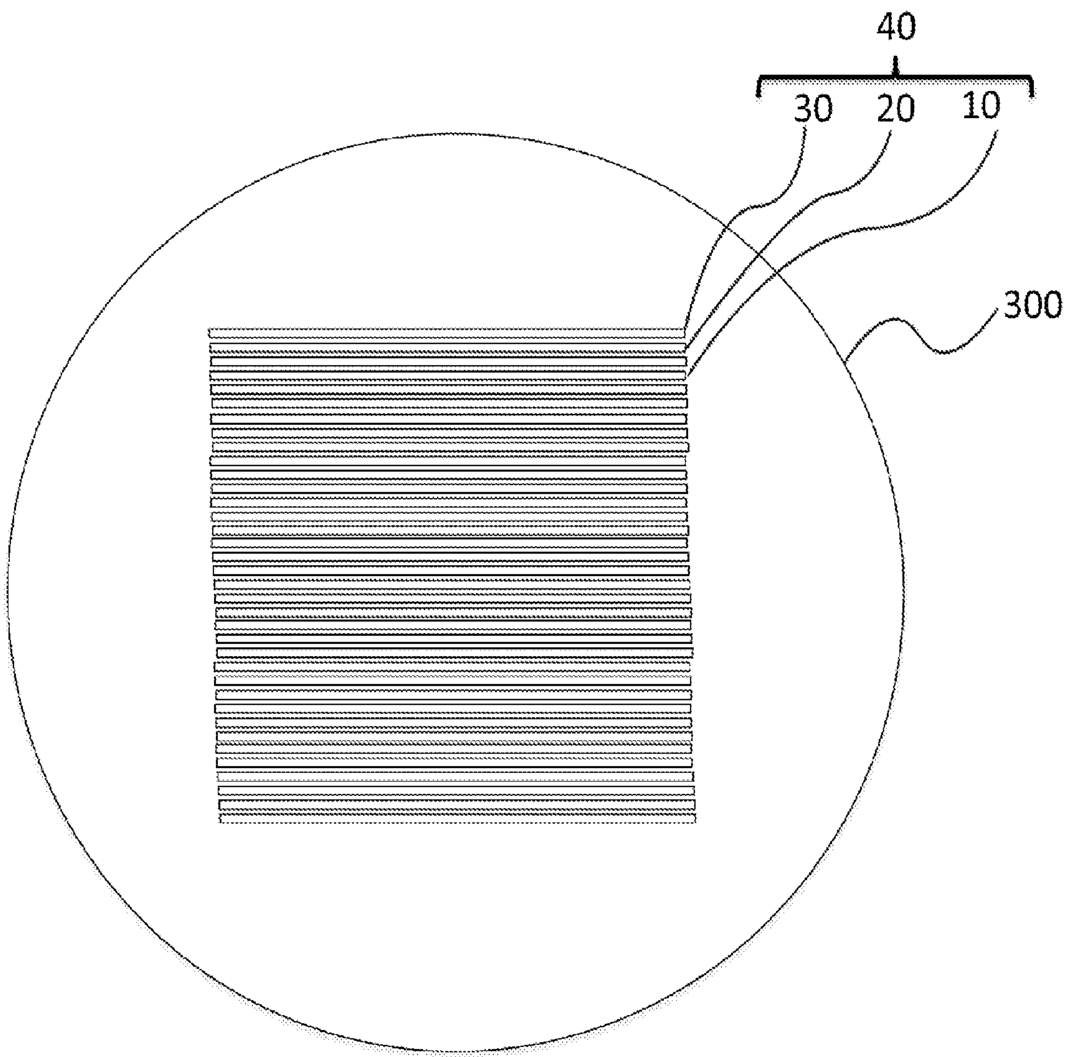


Fig. 8

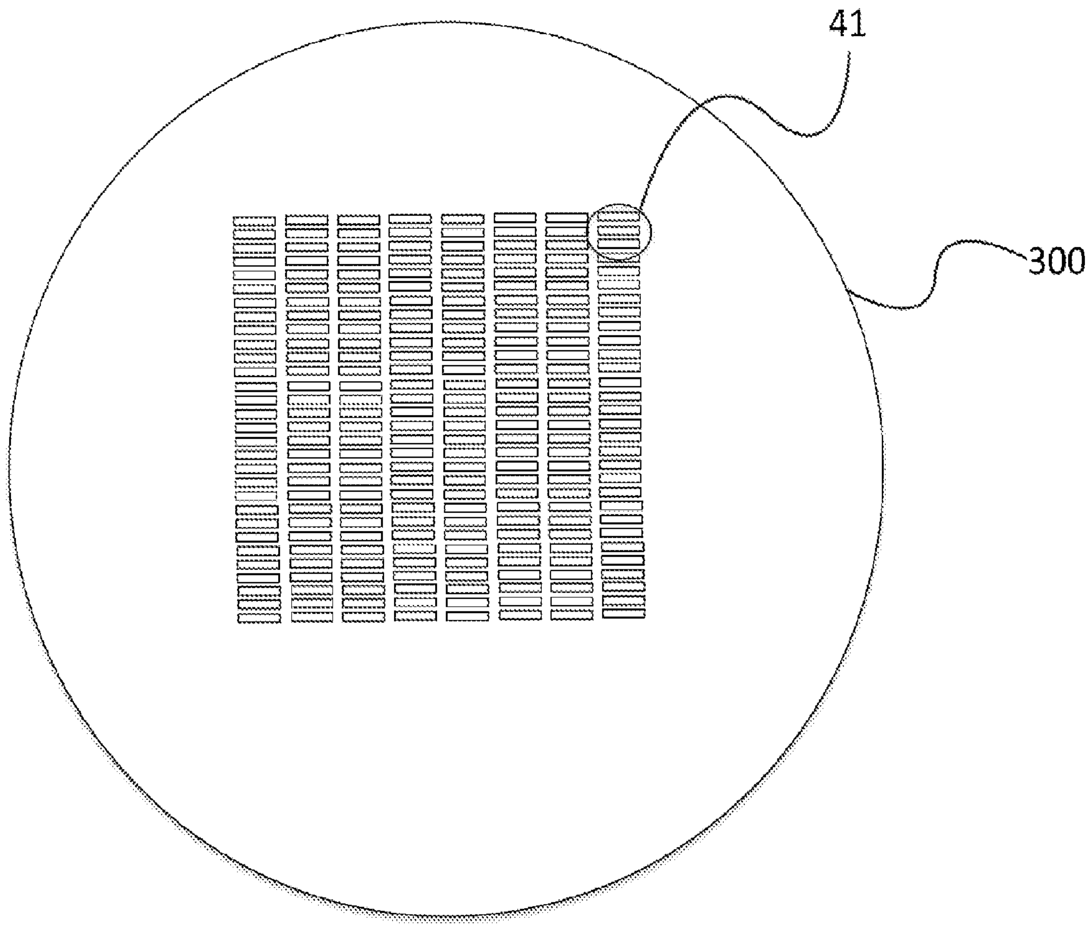


Fig. 9

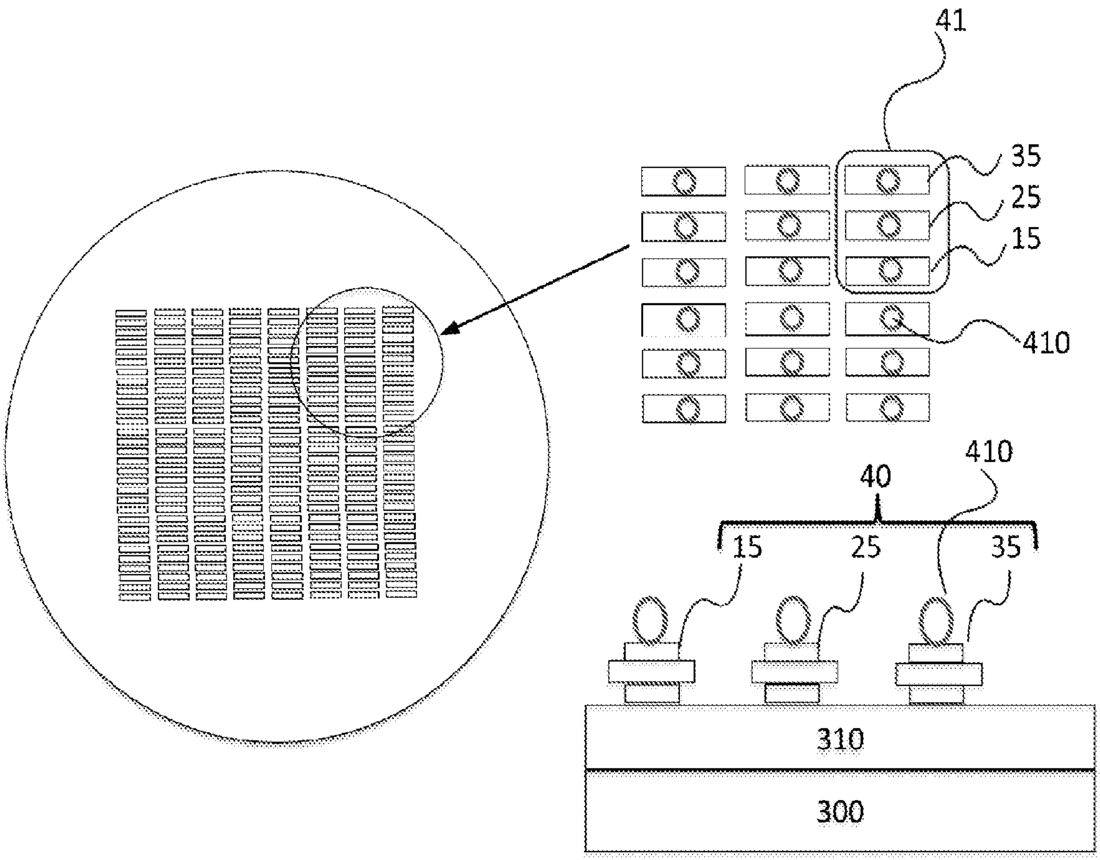


Fig. 10

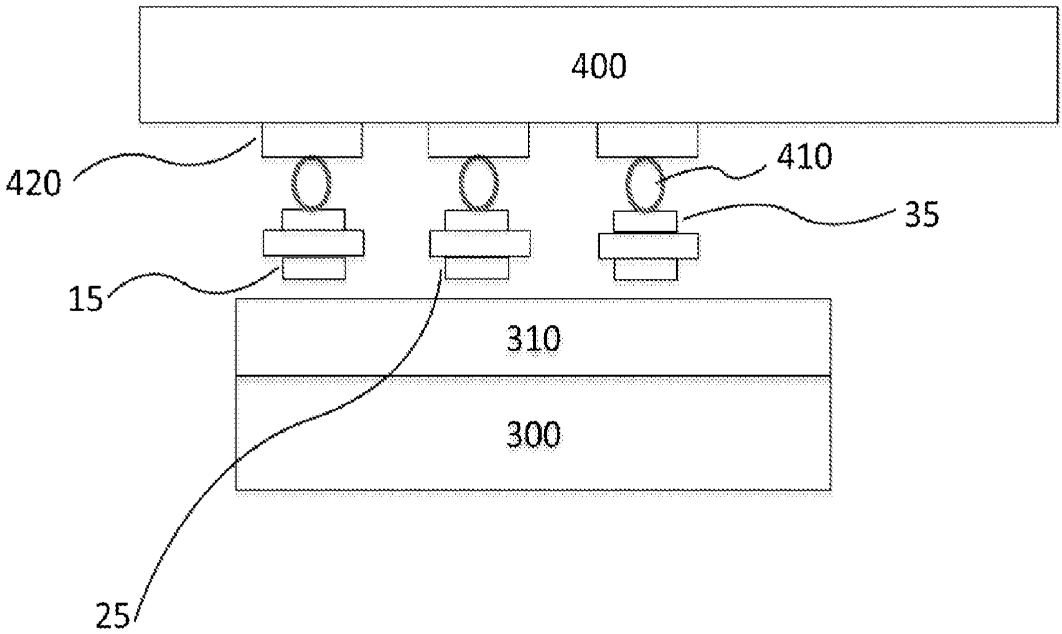


Fig. 11

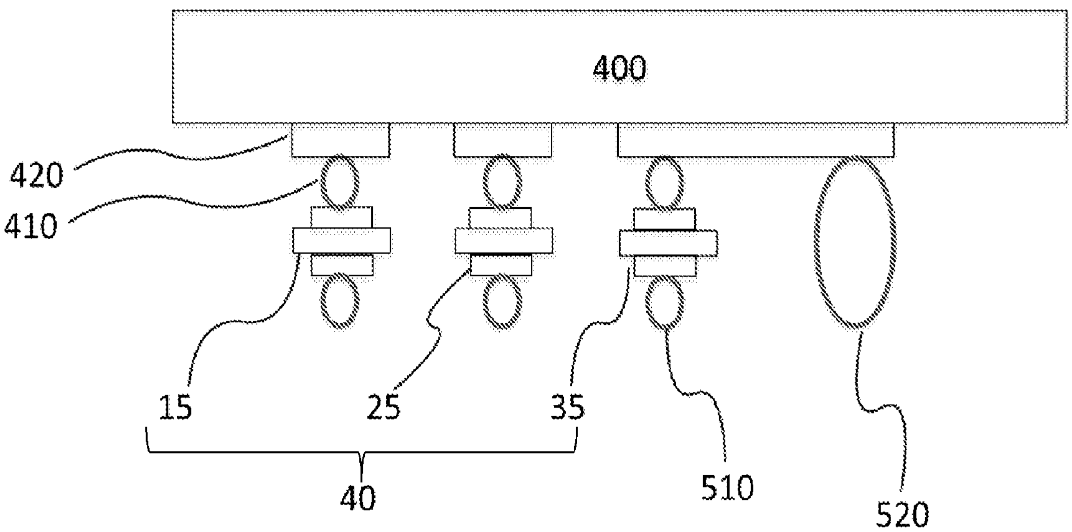


Fig. 12

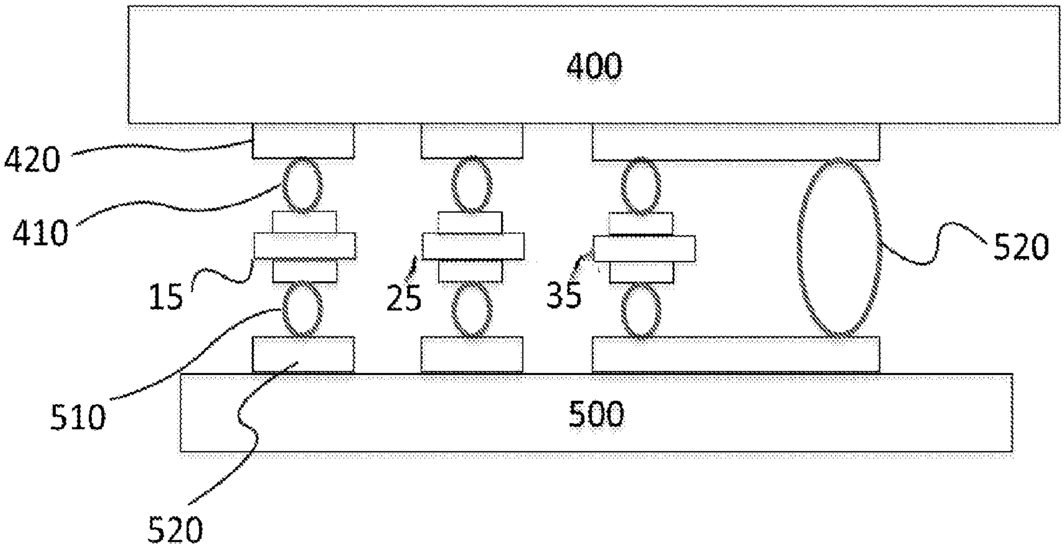


Fig. 13

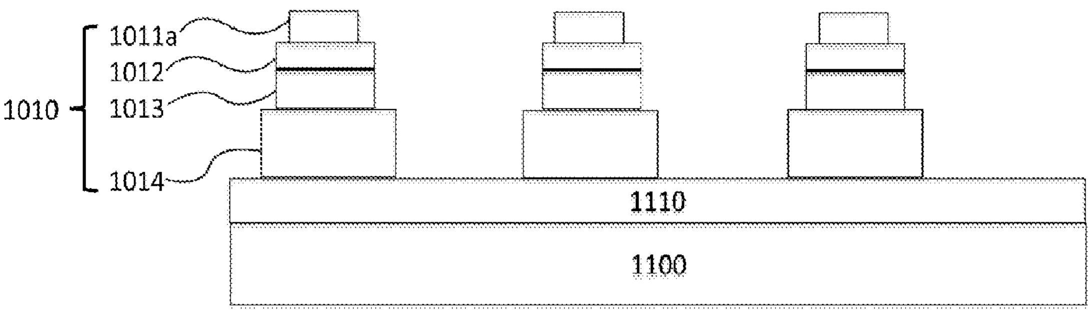


Fig. 14a

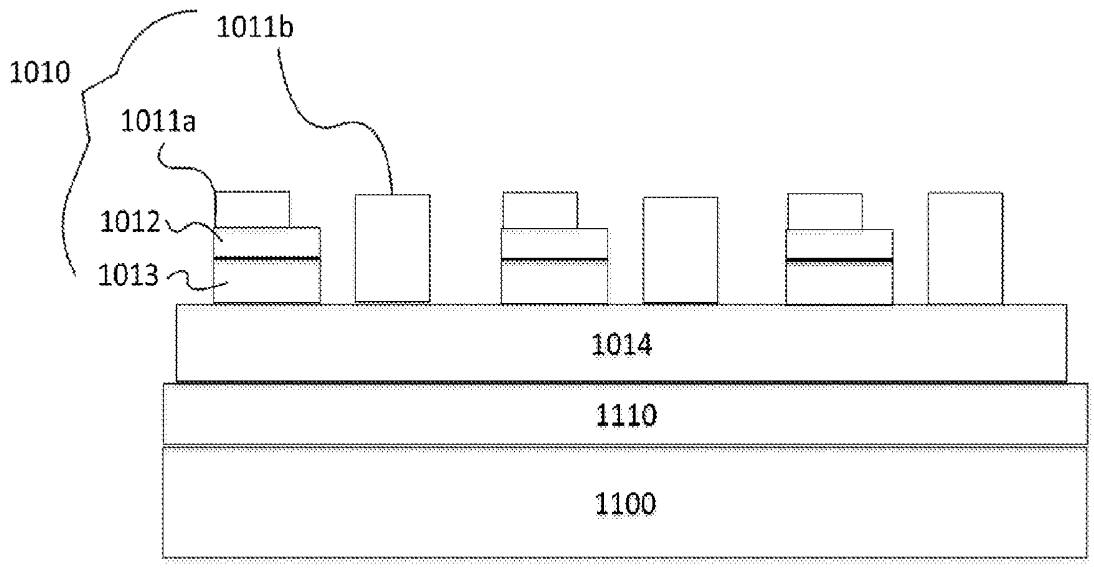


Fig. 14b

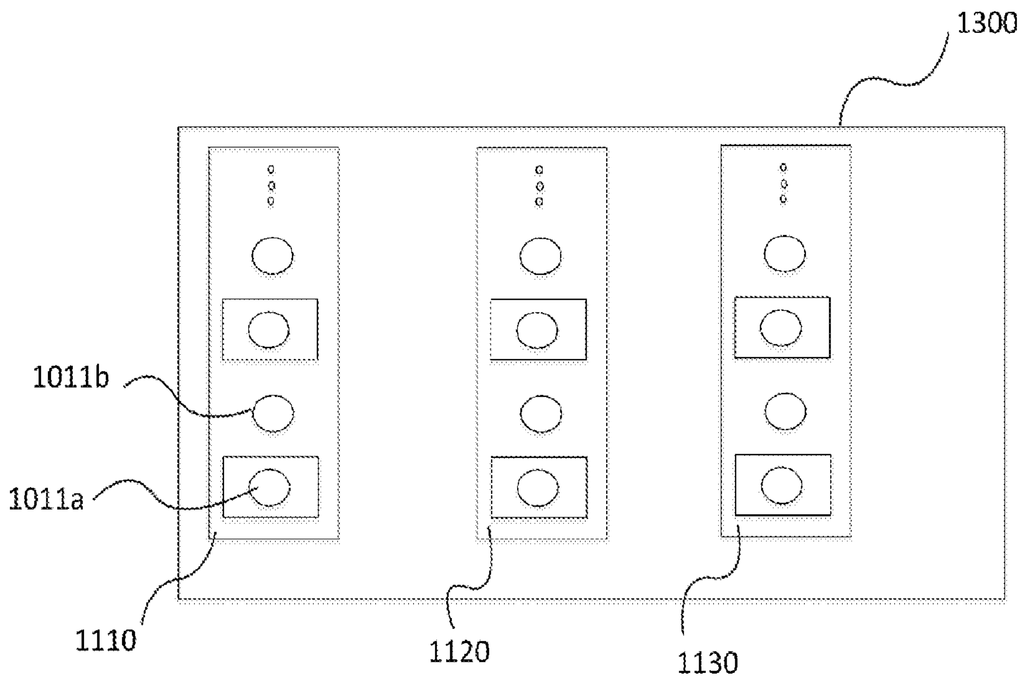


Fig. 14c

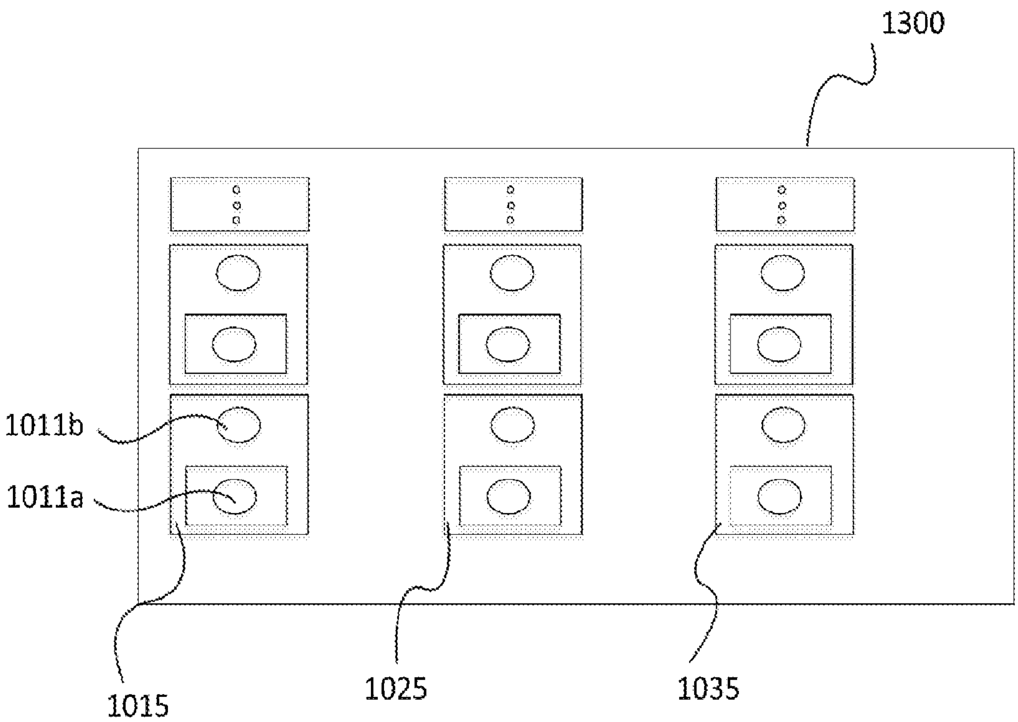


Fig. 14d

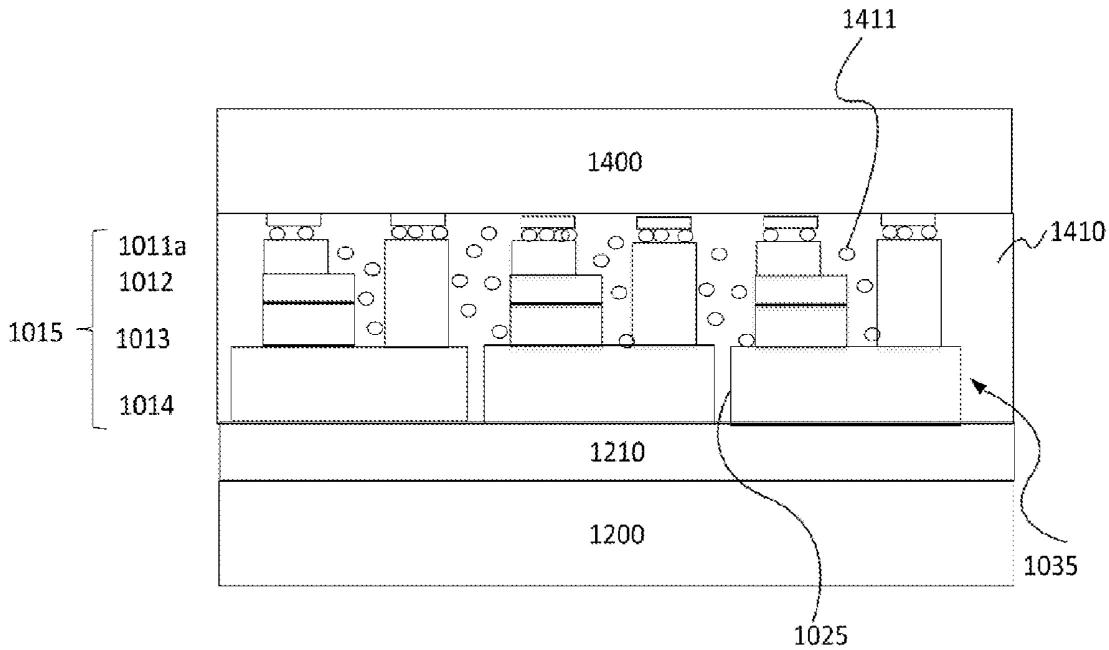
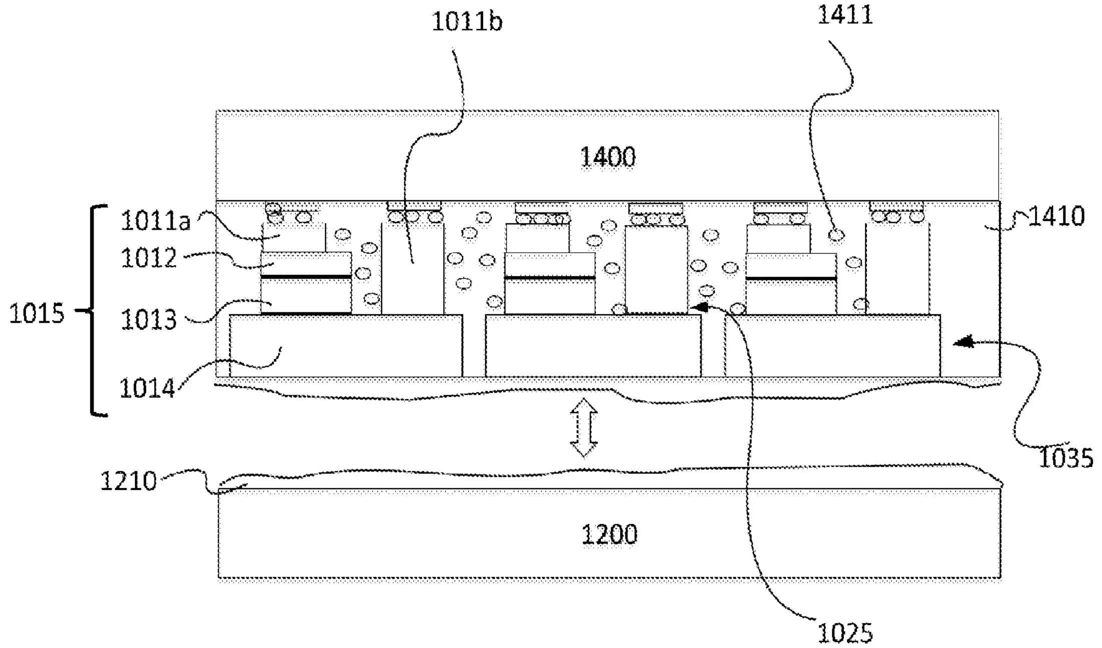

1411
1400
1410
1011a
1012
1015
1013
1014
1210
1200
1035
1025

Fig. 15


1011b
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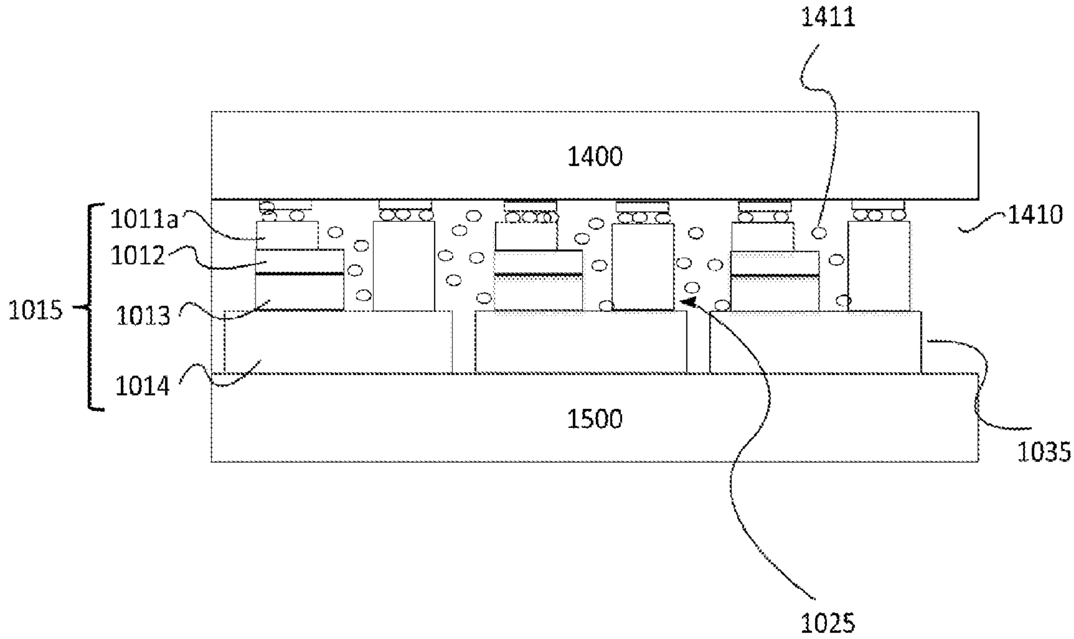
1014
1035
1210
1200
1025

Fig. 16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1400
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1500
1035
1025

Fig. 17

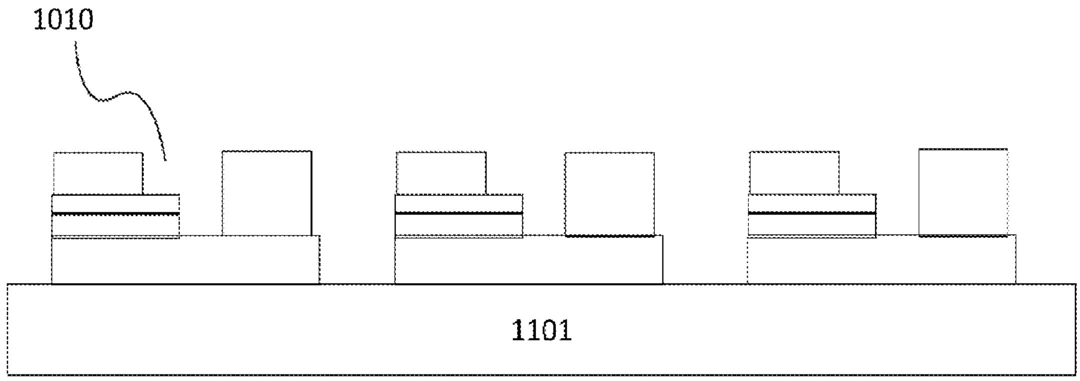
1010
1101

Fig. 18

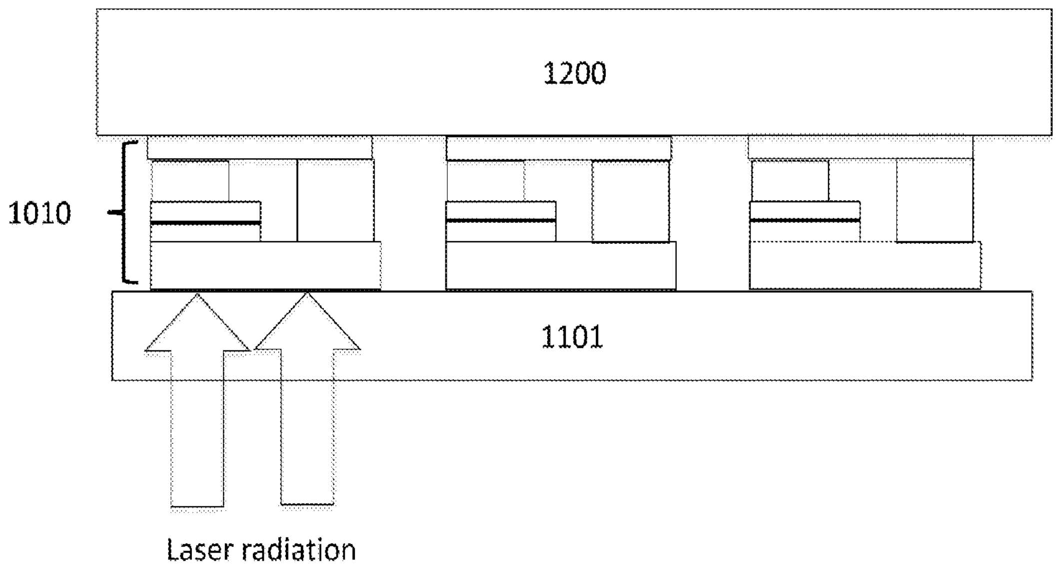
1200
1010
1101
Laser radiation

Fig. 19

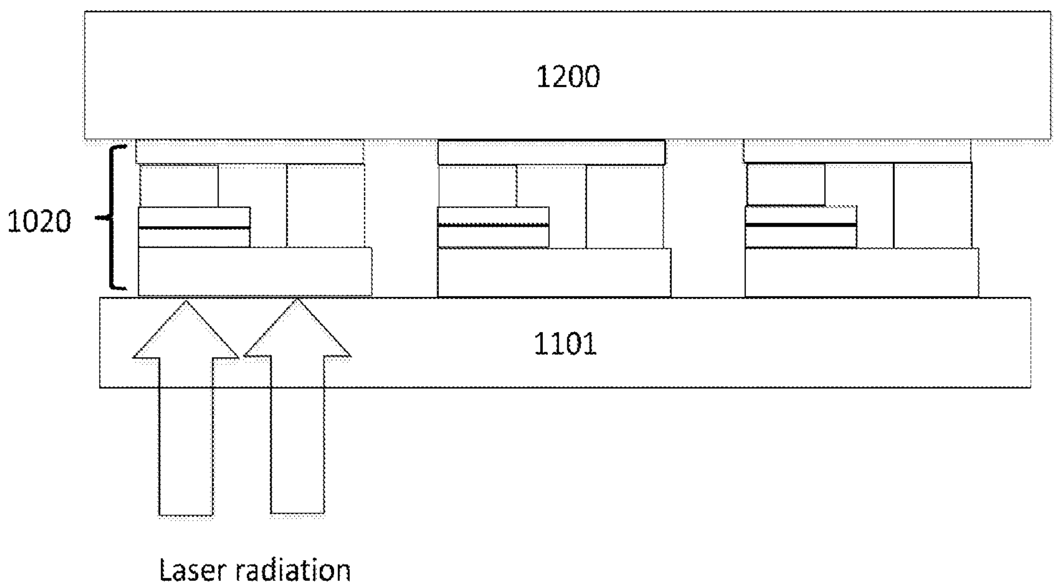
1200
1020
1101
Laser radiation

Fig. 20

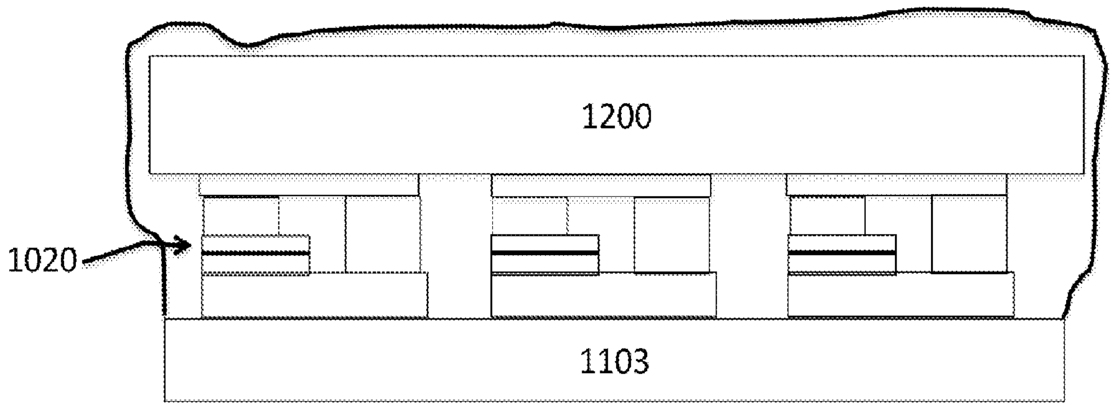

Fig. 21

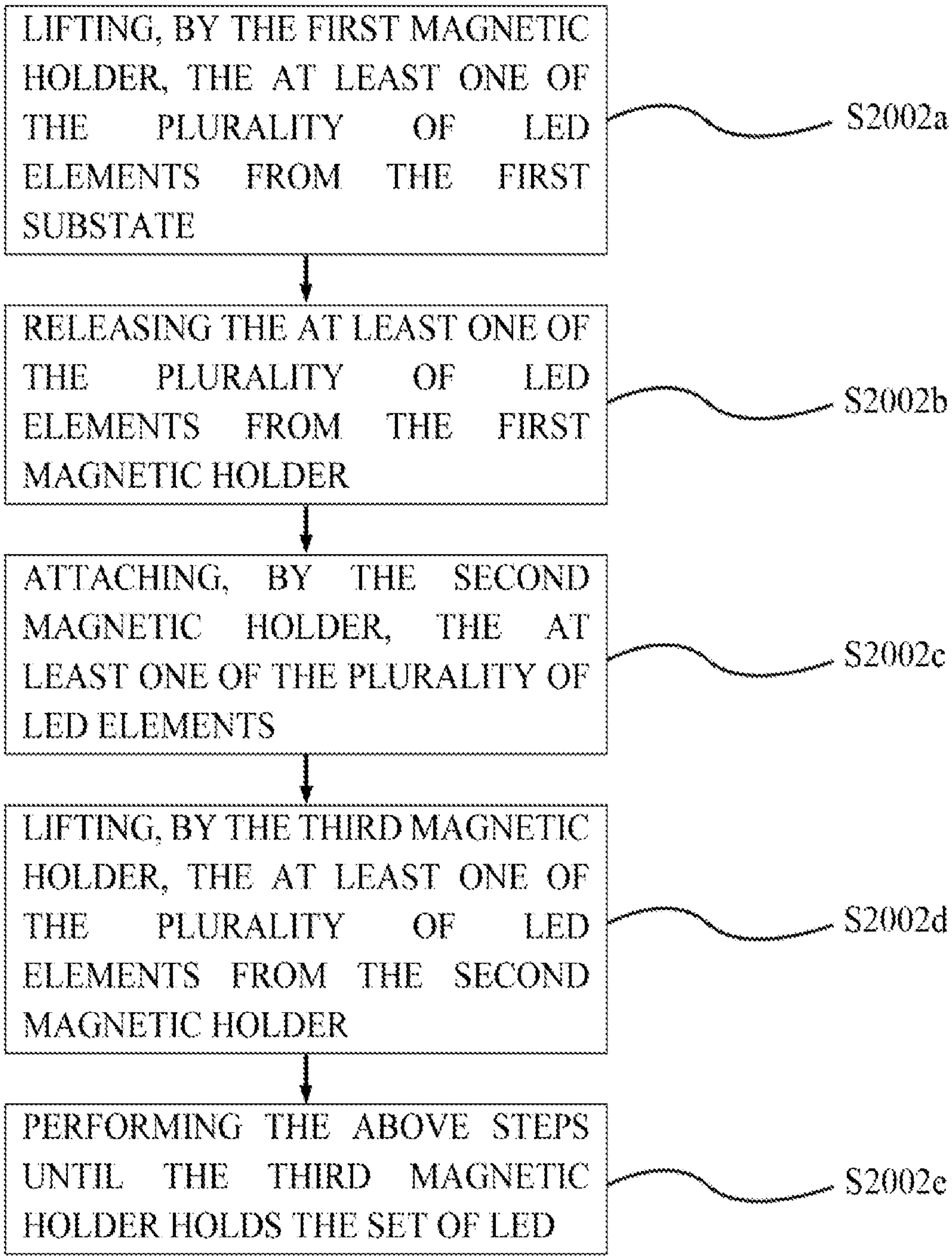
LIFTING, BY THE FIRST MAGNETIC HOLDER, THE AT LEAST ONE OF THE PLURALITY OF LED ELEMENTS FROM THE FIRST SUBSTATE
S2002a
RELEASING THE AT LEAST ONE OF THE PLURALITY OF LED ELEMENTS FROM THE FIRST MAGNETIC HOLDER
S2002b
ATTACHING, BY THE SECOND MAGNETIC HOLDER, THE AT LEAST ONE OF THE PLURALITY OF LED ELEMENTS
S2002c
LIFTING, BY THE THIRD MAGNETIC HOLDER, THE AT LEAST ONE OF THE PLURALITY OF LED ELEMENTS FROM THE SECOND MAGNETIC HOLDER
S2002d
PERFORMING THE ABOVE STEPS UNTIL THE THIRD MAGNETIC HOLDER HOLDS THE SET OF LED
S2002e

Fig. 22

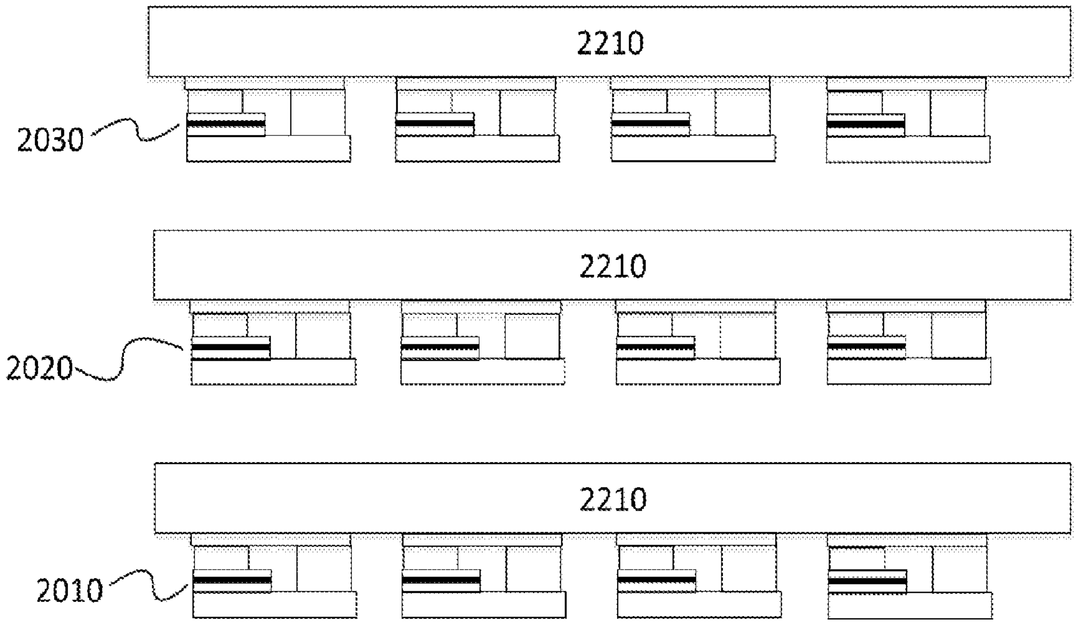

Fig. 23

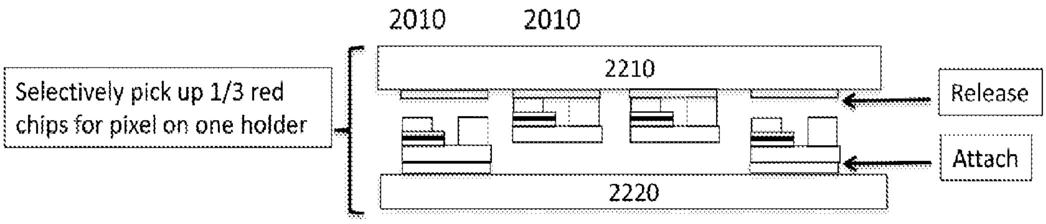

Fig. 24a

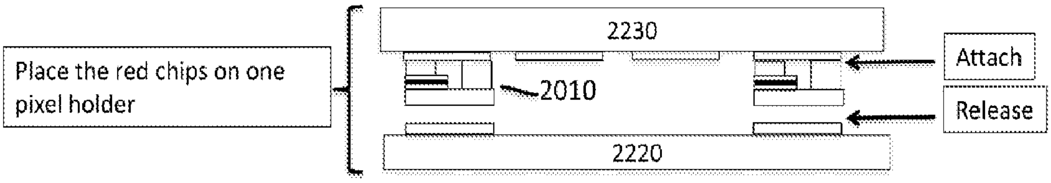

Fig. 24b

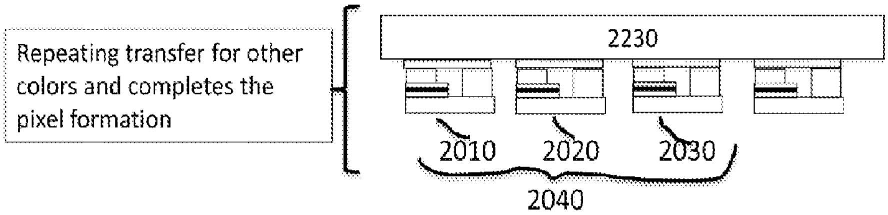

Fig. 24c

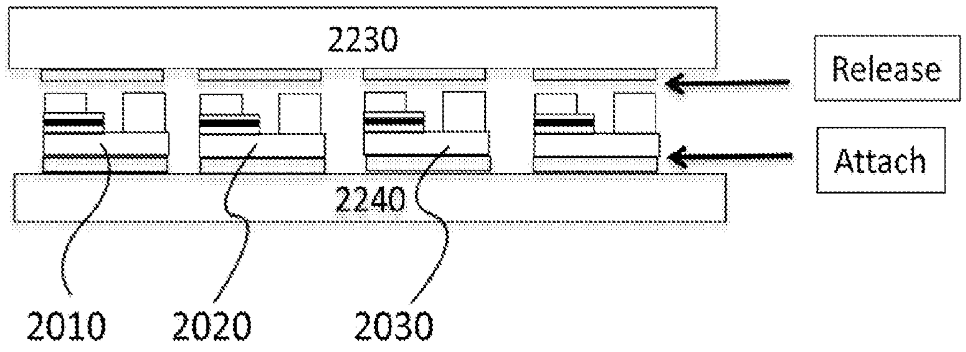

Fig. 25

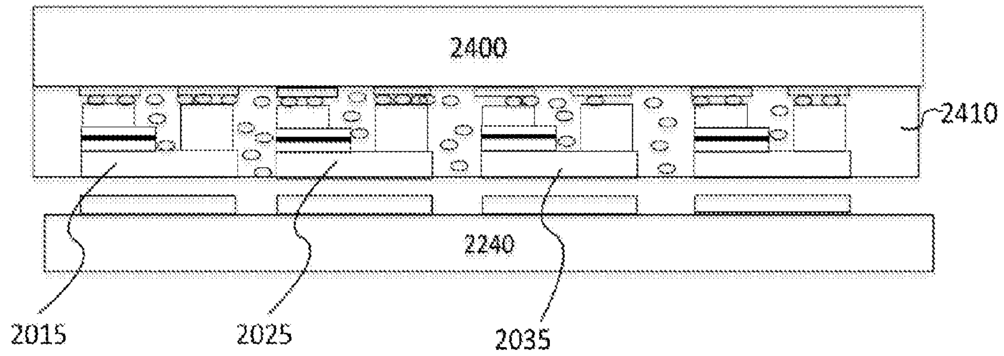

Fig. 26

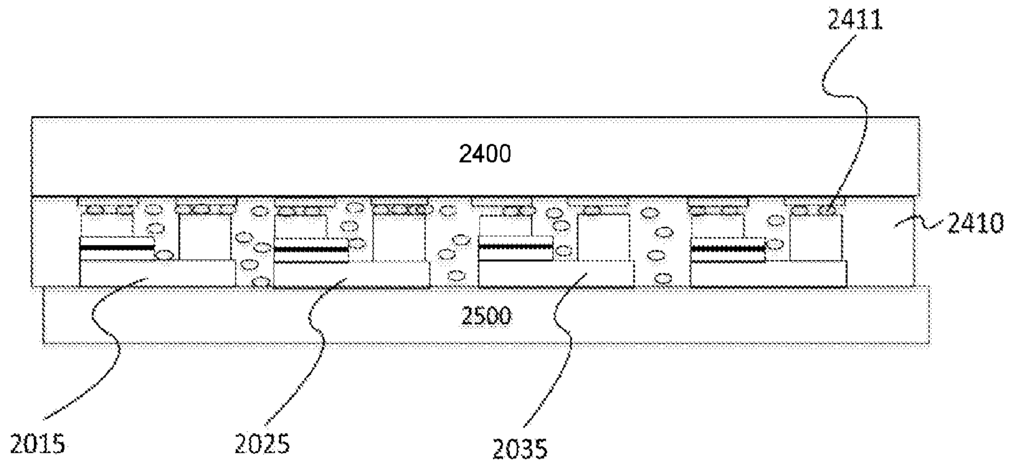

Fig. 27

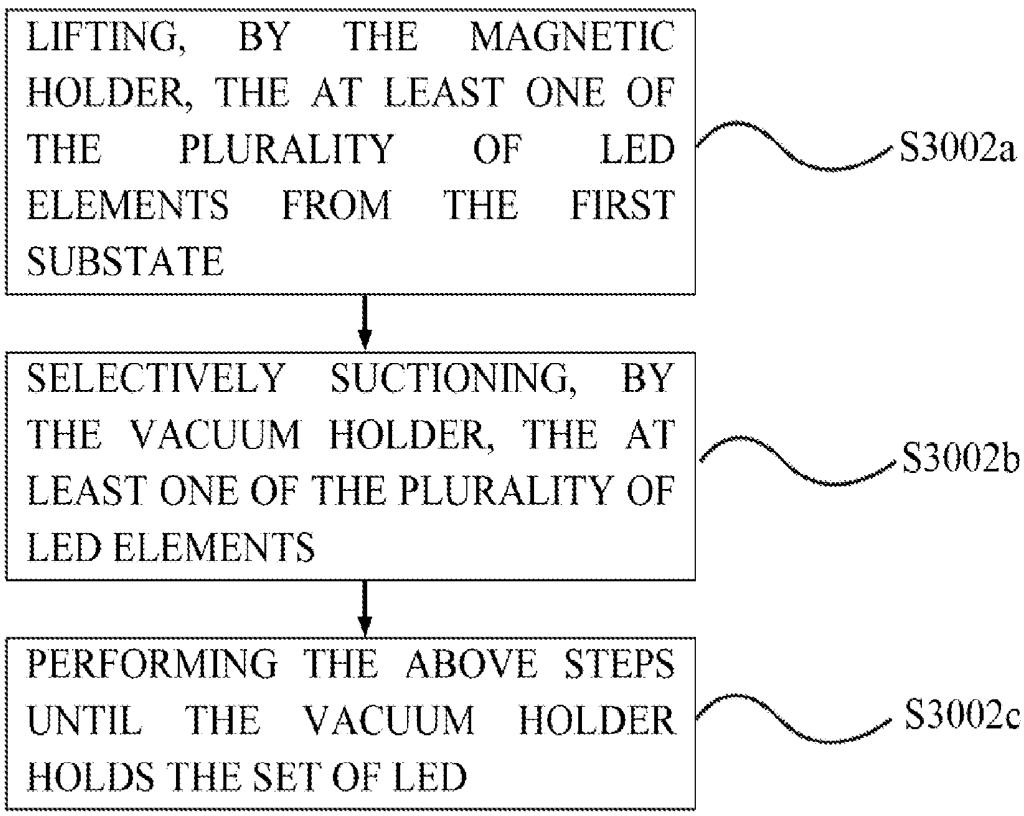
LIFTING, BY THE MAGNETIC HOLDER, THE AT LEAST ONE OF THE PLURALITY OF LED ELEMENTS FROM THE FIRST SUBSTATE
S3002a
SELECTIVELY SUCTIONING, BY THE VACUUM HOLDER, THE AT LEAST ONE OF THE PLURALITY OF LED ELEMENTS
S3002b
PERFORMING THE ABOVE STEPS UNTIL THE VACUUM HOLDER HOLDS THE SET OF LED
S3002c

Fig. 28

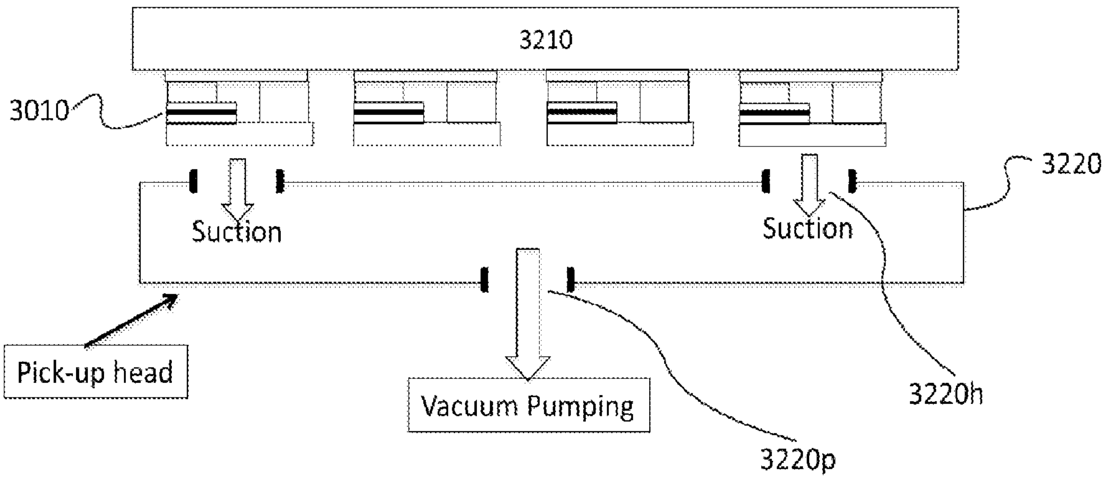
3210
3010
3220
Suction
Suction
Pick-up head
Vacuum Pumping
3220h
3220p

Fig. 29

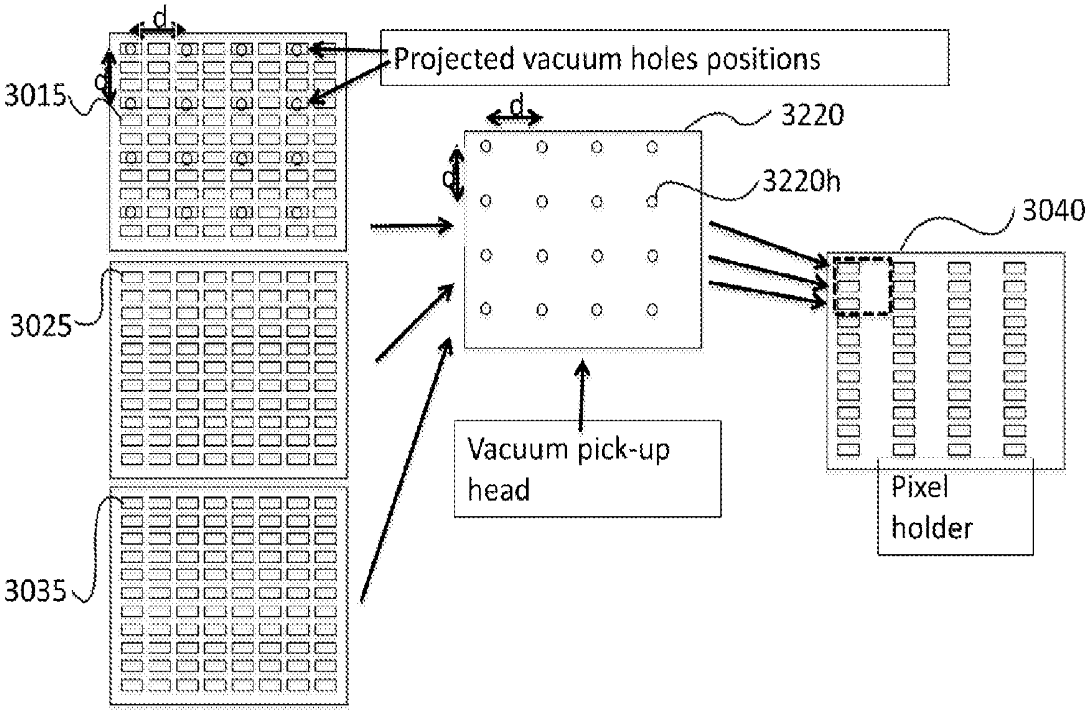
d
d
3015
Projected vacuum holes positions
d
3220
d
3220h
3040
3025
Vacuum pick-up head
Pixel holder
3035

Fig. 30

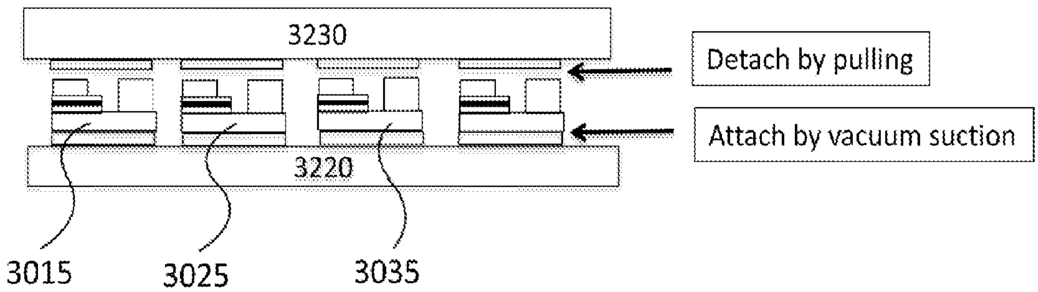

Fig. 31

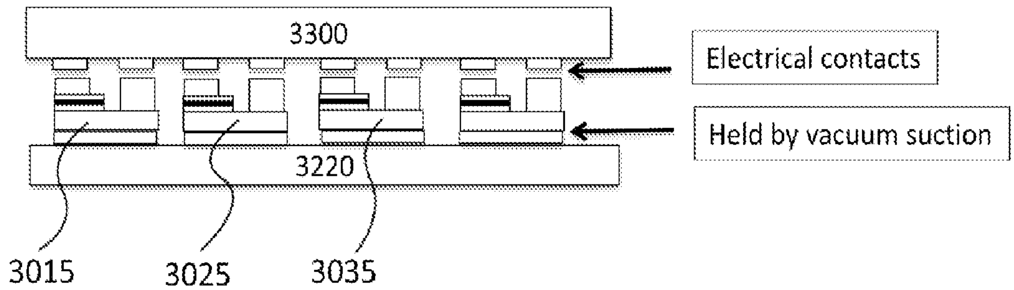

Fig. 32

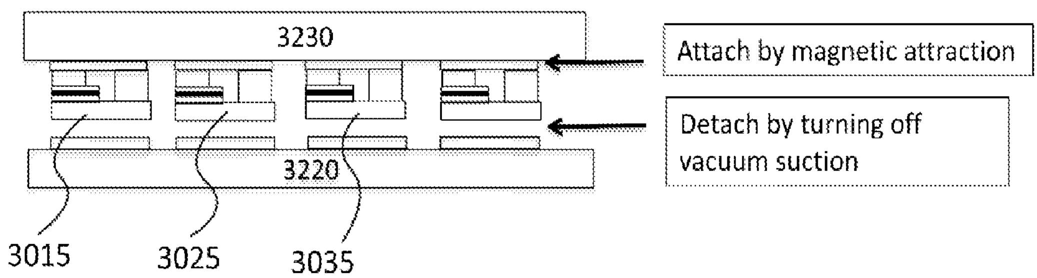

Fig. 33

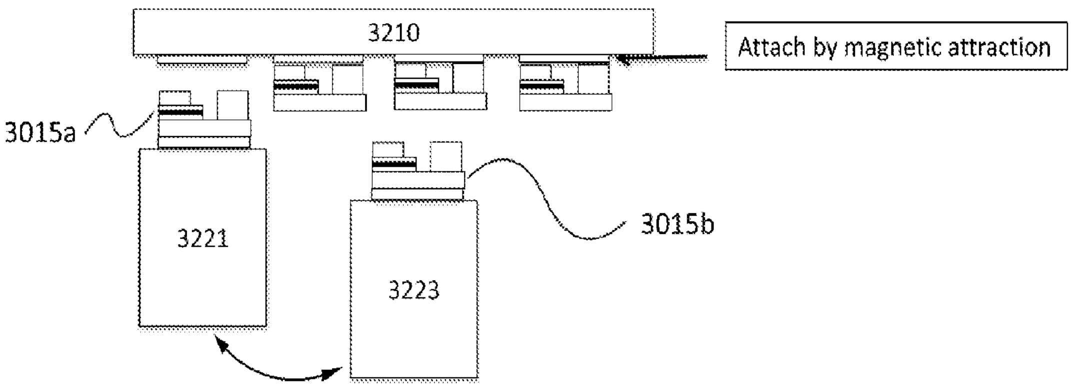
3210
Attach by magnetic attraction
3015a
3221
3223
3015b

Fig. 34

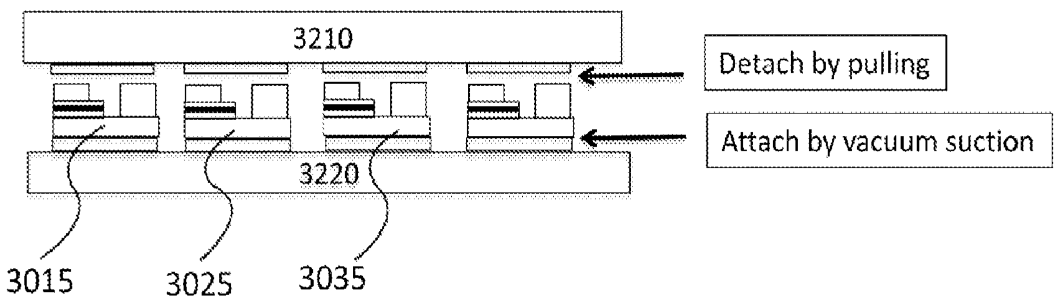
3210
Detach by pulling
Attach by vacuum suction
3220
3015
3025
3035

Fig. 35

METHOD FOR MANUFACTURING A LIGHT EMITTED DIODE DISPLAY

UTILITY PATENT APPLICATION

This application is a non-provisional application and claims benefit from U.S. provisional application Ser. No. 62/085,299, filed Nov. 27, 2014, U.S. provisional application Ser. No. 62/092,114, filed Dec. 15, 2014, and U.S. provisional application Ser. No. 62/110,672, filed Feb. 2, 2015, the disclosures of which are hereby incorporated by reference.

FIELD OF THE DISCLOSURE

This disclosure relates generally to a light emitting diode (LED) display and a method for manufacturing the same, in particular to a micro LED display.

BACKGROUND OF THE DISCLOSURE

Light emitting diodes (LEDs) are well-known semiconductor devices that convert current into light. The color of the light (wavelength) emitted by an LED depends on the semiconductor materials used. Gallium-Nitride (GaN) has gained much attention, because it is found that GaN can be combined with indium to produce InGaN/GaN semiconductor layers that can emit green, blue, and ultraviolet light. This wavelength controllability enables an LED semiconductor designer to tailor material characteristics to achieve beneficial device characteristics. Accordingly, GaN-based optoelectronic device technology has rapidly evolved since their commercial introduction in 1994.

Light emitting diodes (LEDs) based upon gallium nitride (GaN) are expected to be used in future high-efficiency lighting applications, replacing incandescent and fluorescent lighting lamps. Current GaN-based LED devices are prepared by heteroepitaxial growth techniques on foreign substrate materials. A typical wafer level LED device structure may include a lower n-doped GaN layer formed over a sapphire growth substrate, a single quantum well (SQW) or multiple quantum well (MWQ), and an upper p-doped GaN layer.

Micro-LED, also known as microLED, mLED or μLED, is an emerging flat panel display technology. Micro-LED displays have arrays of microscopic LEDs forming the individual pixel elements. Compared to the widespread LCD technology, micro-LED displays offer far greater contrast, much faster response times, and would use less energy

Conventionally, during the in micro-LED manufacture, RGB pixel is provided and manufactured one by one. Since this process takes longer time, for mass production, more efficient and faster manufacturing method is required.

SUMMARY OF THE DISCLOSURE

In view of the aforementioned needs, the present disclosure provides a method for manufacturing an LED display. According to one embodiment of the present disclosure, a method for manufacturing a light emitting diode (LED) display is provided. The method includes providing a plurality of LED elements on a first substrate, each of the plurality of LED elements being of a same primary color of three primary colors, transferring, using a magnetic holder or a vacuum holder, at least two of the plurality of LED elements of the same primary color from the first substrate to a second substrate, performing the steps of the providing

and the transferring with respect to LED elements for each of two remaining primary colors, forming an array of RGB LED units on the second substrate, each of the array of RGB LED units including a red LED element, a green LED element, and a blue LED element, interposing the array of RGB LED units between the second substrate and an LED driver wafer, detaching the second substrate from the array of RGB LED units, and interposing the array of RGB LED units between the LED driver wafer and a cover.

A size of each of the array of RGB LED units is equal to or smaller than 100 μm.

The forming step further employs a lithographic etching process to divide the red LED element, the green LED element, and the blue LED element of the array of RGB LED units into a red LED pixel, a green LED pixel, and a blue LED pixel.

Each of the array of RGB LED units includes the red LED pixel, the green LED pixel, and the blue LED pixel in a row. The magnetic holder includes a first magnetic holder, a second magnetic holder, and a third magnetic holder. The transferring step includes lifting, by the first magnetic holder, the at least two of the plurality of LED elements from the first substrate, releasing the at least two of the plurality of LED elements from the first magnetic holder to the second magnetic holder, attaching the at least two of the plurality of LED elements to the second magnetic holder, and lifting, by the third magnetic holder the at least two of the plurality of LED elements from the second magnetic holder. The performing step includes performing the above steps until the third magnetic holder holds the array of RGB LED units and placing the array of RGB LED units onto the second substrate. The second substrates is a fourth magnetic holder. The detaching the second substrate includes turning off magnetic field of the fourth magnetic holder. The holder includes both of the magnetic holder and the vacuum holder.

The transferring step includes lifting, by the magnetic holder, the at least two of the plurality of LED elements from the first substrate, suctioning, by the vacuum holder, the at least two of the plurality of LED elements, and performing the above steps until the vacuum holder holds the array of RGB LED units.

The method further includes detaching the magnetic holder from the array of RGB LED units on the vacuum holder, testing the array of RGB LED units on the vacuum holder with an LED probe card, attaching the magnetic holder to the array of RGB LED units, detaching the vacuum holder by turning off vacuum suction, and replacing an out-of-specification (OOS) LED element with a single vacuum head.

Each of the array of RGB LED units includes a first electrode and a second electrode disposed on a same surface of the array of RGB LED units.

According to another embodiment, each of the array of RGB LED units includes a first electrode and a second electrode, and the first electrode and the second electrode are respectively disposed on two opposite surfaces of the array of RGB LED units.

At least one of the first substrate, the second substrate, and the LED driver wafer includes an adhesive layer for holding the LED elements or the array of RGB LED units.

The adhesive layer is heated to release the LED elements or the array of RGB LED units.

The interposing step includes forming an anisotropic conductive film (ACF) layer between the LED driver wafer and the second substrate. The cover is either a glass panel or a touch sensitive panel.

The first substrate is either a sapphire substrate or a transparent substrate, and wherein the transferring step further comprises a lazier lift off (LLO) method to separate the at least two of the plurality of LED elements from the first substrate.

The first substrate is a GaAs substrate and wherein the transferring step further includes etching the first substrate using ammonia hydroxide to separate the at least two of the plurality of LED elements from the first substrate.

According to another embodiment of the present disclosure, a method for manufacturing a micro-light emitting diode (LED) display is provided. The method includes providing a first substrate having a plurality of red LED elements, providing a second substrate having a plurality of green LED elements, providing a third substrate having a plurality of blue LED elements, transferring, using a magnetic holder or a vacuum holder, at least two of the plurality of red LED elements from the first substrate to a fourth substrate, transferring, using the magnetic holder or the vacuum holder, at least two of the plurality of green LED elements from the second substrate to a fourth substrate, transferring, using the magnetic holder or the vacuum holder, at least two of the plurality of blue LED elements from the third substrate to a fourth substrate, forming a plurality of patterns, each of the plurality of patterns having a red LED element, a green LED element, and a blue LED element in a row, dividing the red LED element, the blue LED element, and the green LED element into a red LED pixel, a green LED pixel, and a blue LED pixel, respectively so as to form an array of RGB LED units on the fourth substrate, interposing the array of RGB LED units between the fourth substrate and an LED driver wafer, detaching the fourth substrate from the array of RGB LED units, and interposing the array of RGB LED units between the LED driver wafer and a cover.

A size of each of the array of RGB LED units is equal to or smaller than 100 μm. The interposing step comprising forming an anisotropic conductive film (ACF) layer between the LED driver wafer and the fourth substrate. The magnetic holder comprises a first magnetic holder, a second magnetic holder, and a third magnetic holder. The transferring step includes lifting, by the first magnetic holder, the at least two of the plurality of LED elements from the first substrate, releasing the at least two of the plurality of LED elements from the first magnetic holder to the second magnetic holder, attaching the at least two of the plurality of LED elements to the second magnetic holder, and lifting, by the third magnetic holder the at least two of the plurality of LED elements from the second magnetic holder. The performing step comprises performing the above steps until the third magnetic holder holds the array of RGB LED units and placing the array of RGB LED units onto the fourth substrate, wherein the fourth substrates is a fourth magnetic holder. The detaching the fourth substrate comprises turning off magnetic field of the fourth magnetic holder.

The transferring step includes lifting, by the magnetic holder, the at least two of the plurality of LED elements from the first substrate, suctioning, by the vacuum holder, the at least two of the plurality of LED elements, and performing the above steps until the vacuum holder holds the array of RGB LED units.

The method further includes detaching the magnetic holder from the array of RGB LED units on the vacuum holder, testing the array of RGB LED units on the vacuum holder with an LED probe card, attaching the magnetic holder to the array of RGB LED units, detaching the vacuum holder by turning off vacuum suction, and replacing an out-of-spec (OOS) LED element with a single vacuum head.

According to the other embodiment of the present disclosure, a micro-light emitting diode (LED) display is provided. The micro-LED display includes a first substrate, a red LED pixel, a green LED pixel, and a blue LED pixel disposed on the first substrate and having a pitch smaller than a predetermined size, a second substrate having a first electrode, a second electrode, and a third electrode electrically coupled to the red LED pixel, the green LED pixel, and the blue LED pixel, respectively, and an anisotropic conductive films (ACF) layer interposed between the first substrate and the second substrate, wherein the ACF layer comprises a conductive particle.

Each of the array of RGB LED units includes the red LED pixel, the green LED pixel, and the blue LED pixel in a row.

The pitch is smaller than 100 μm. The conductive particle is nano-sized metal particle.

The first substrate is cover glass or touch sensitive panel.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a brief flow chart for manufacturing a light emitting diode (LED) display according to the present disclosure.

FIG. **2** is a perspective view illustrating a plurality of first LED strips on first substrate.

FIG. **3** is a section view illustrating a plurality of first LED strips s disposed on an adhesive layer and first substrate.

FIG. **4** is a schematic diagram illustrating a holder transferring at least two of the first LED strips from first substrate to second substrate.

FIG. **5** is a section view of FIG. **4**.

FIG. **6** is a section view illustrating the transferring operation of first LED strips onto a second substrate using a holder.

FIG. **7** is a section view illustrating an array of LED strips disposed on a second substrate.

FIG. **8** is a plane view of FIG. **7**.

FIG. **9** illustrates an array of LED units on second substrate after LED strips in FIG. **8** are divided into LED pixels using techniques such as lithographic etching.

FIG. **10** shows that a third adhesive member is placed onto each of the LED pixels for bonding.

FIG. **11** shows one method for attaching array of LED units onto a third substrate.

FIG. **12** shows that a fourth adhesive member is placed onto array of LED units for bonding.

FIG. **13** shows one method for attaching array of LED units onto a fourth substrate.

FIG. **14***a* is a section view of first LED strips on first substrate.

FIG. **14***b* is another section view taken from a view normal to the one for FIG. **14***a*.

FIG. **14***c* shows first LED strip, second LED strip, and third LED strip disposed on third substrate.

FIG. **14***d* shows the pattern of LED strips on third substrate after an etching process.

FIG. **15** illustrates third substrate bond to the LED strips via anisotropic conductive film (ACF).

FIG. **16** shows that second substrate is detached by melting second adhesive layer.

FIG. **17** shows a fourth substrate being attached to the LED strips.

FIG. **18** is a section view of LED strips attached on first substrate according to another embodiment of the present disclosure.

FIG. **19** shows a method for detaching green and blue LED strips from GaN by a Laser Lift-Off (LLO) method.

FIG. **20** shows a method for detaching red LED strips from first substrate by the LLO method.

FIG. **21** is a section view of LED strips interposed between first substrate and second substrate according to another embodiment of the present disclosure.

FIG. **22** is a flow chart of the transferring step (S**2**).

FIG. **23** is a section view of LED strips attached to first magnetic holder.

FIGS. **24***a*-**24***c* are schematic diagrams illustrating the transferring method according to another embodiment of the present disclosure.

FIG. **25** is a section view of LED strips disposed on fourth magnetic holder.

FIGS. **26** and **27** are brief section views of LED strips filled with anisotropic conductive film (ACF) layer.

FIGS. **28**-**35** illustrate methods for testing and replacing LED strips with a vacuum holder according to the other embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout the several views. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. Terms used herein are for descriptive purposes only and are not intended to limit the scope of the disclosure. The terms "comprises" and/or "comprising" are used to specify the presence of stated elements, steps, operations, and/or components, but do not preclude the presence or addition of one or more other elements, steps, operations, and/or components. The terms "first," "second," and the like may be used to describe various elements, but do not limit the elements. Such terms are only used to distinguish one element from another.

In the following description, all numbers disclosed herein are approximate values, regardless whether the word "about" or "approximate" is used in connection therewith. The value of each number may differ by 1%, 2%, 5%, 7%, 8%, 10%, 15% or 20%. Therefore, whenever a number having a value N is disclosed, any number having the value N+/−1%, N+/−2%, N+/−3%, N+/−5%, N+/−7%, N+/−8%, N+/−10%, N+/−15% or N+/−20% is specifically disclosed, wherein "+/−" refers to plus or minus. Whenever a numerical range with a lower limit, RL, and an upper limit, RU, is disclosed, any number falling within the range is specifically disclosed. In particular, the following numbers within the range are specifically disclosed: $R=RL+k*(RU-RL)$, wherein k is a variable ranging from 1% to 100% with a 1% increment, i.e., k is 1%, 2%, 3%, 4%, 5%, . . . , 50%, 51%, 52%, . . . , 95%, 96%, 97%, 98%, 99%, or 100%. Moreover, any numerical range defined by two R numbers as defined above is also specifically disclosed.

These and/or other aspects become apparent and are more readily appreciated by those of ordinary skill in the art from the following description of embodiments of the present disclosure, taken in conjunction with the accompanying drawings. The figures depict embodiments of the present disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the disclosure described herein.

The current disclosure provides a method for making high resolution (HD) and ultra-high resolution (UHD) micro-LED displays, e.g., those for smart phone uses. Micro-LED display is a direct emissive type display. According to micro-LED technology, LED is not merely used for back-light purpose but RGB lights are emitted directly from the micro-LED pixel, without any color filter. Micro LED display usually has a less than 100 μm-size pixel.

FIG. **1** is a flow chart for manufacturing a micro-light emitting diode (LED) display according to the present disclosure. The method includes the following six (6) steps: providing a a plurality of LED elements **10**, **20**, and **30** on a first substrate **100** (S**1**), selectively transferring, by a holder **200**, at least two of the plurality of LED elements **10**, **20**, and **30** from the first substrate **100** to a second substrate **300** (S**2**), performing, at least once, the steps of the providing (S**1**) and the transferring (S**2**) with respect to each of two remaining primary colors until an array of LED units **40** is arranged on second substrate **300** (S**3**), providing a third substrate **400** in contact with a second surface **10***b* of the array of LED units **40** (S**4**), detaching second substrate **300** form the array of LED units **40** (S**5**), and providing a fourth substrate **500** onto a first surface **10***a* of the array of LED units **40** (S**6**). The third substrate can be an LED driver wafer while the fourth substrate serves as a cover of the micro-LED display.

Each step of the first embodiment of the present disclosure would be further described below in conjunction with FIGS. **2**-**13**.

FIG. **2** is a perspective view illustrating a plurality of first LED elements **10** on first substrate **100**. FIG. **3** is a section view illustrating a plurality of first LED elements **10** disposed on an adhesive layer **110** and first substrate **100**. In the providing step (S**1**), a first substrate **100** having a plurality of LED elements **10** is provided. The plurality of first LED elements **10** forms first LED strip **10**. Hereinafter, the plurality of first LED elements are also generally referred to as first LED element, first LED strip **10**, first LED strips **10**, or collectively LED strips **10**. Each of first LED strips **10** has a first color. In a similar manner, a plurality of second LED elements **20** can form a second LED strip **20** with a second color, and a plurality of third LED elements **30** can form a third LED strip **30** with a third color. Each of the first color, the second color, and the third color is one of primary colors, including but not limited to red, green, or blue, respectively. For the purpose of example, only first LED strip **10** is described below in detail but second LED strip **20** and third LED strip **30** can be provided in a similar manner.

A pixel pitch is defined by a width of three (3) first LED strips **10**. For instance, if the pitch is 70 μm, then the width of the first LED strip is 70/3 minus space between the first LED strip **10**. Furthermore, although the term "LED strip" as well as its illustrations suggest a long strip of LED material, the length of the LED strip in the longitudinal direction can be large or small. For example, the LED strip may be in a substantially square shape. In this sense, "LED strip," "LED chip," "LED element," and "LED pixel" are used interchangeably.

Each of the plurality of first LED elements **10** has a first surface **10***a* and a second surface **10***b*. The second surface **10***b* is disposed to face an opposite direction of first surface **10***a*. Since each of the plurality of first LED elements **10** would be arranged to face a same direction, hereinafter, the plurality of first LED elements **10** would be generally referred to as having the first surface **10***a* and the second surface **10***b*.

Each of the plurality of first LED elements also includes N-electrode **11**, active material **12**, and P-electrode **13**. Each of N-electrode **11** and P-electrode **13** is made of metal materials, i.e. Ni or F and may include magnetic materials that can be attracted by a magnet or interact with a magnetic field. Since each of N-electrode **11** and P-electrode **13** is responsive to a magnet field, a magnetic field may lift first LED strip **10** from first substrate **100**. The active material **12** includes n-GaN layer (not shown), active layer (not shown), and p-GaN layer (not shown), and one of ordinary skill in the art would appreciate how to make the active material **12**. The plurality of LED elements **10** (LED strip) are affixed on first substrate **100** using a first adhesive layer **110**. First substrate **100** is in contact with first surface **10***a* of the plurality of LED elements **10**. First adhesive layer **110** can include, i.e. a wax layer. Any suitable wax may be used as long as the plurality of LED elements **10** may be satisfactorily affixed to first substrate **100**. Examples of the wax layer may include a paraffin-based wax.

Referring to FIG. **3**, N-electrode **11** and P-electrode **13** are disposed on the opposite surface of the plurality of LED elements **10**. Hereinafter, N-electrode **11** and P-electrode **13** are also generally referred to as electrodes or metal contacts. Although FIG. **2** illustrates that P-electrode **13** is in contact with first adhesive layer **110**, the configuration of N-electrode **11** and P-electrode **13** are not limited thereto. For instance, N-electrode **11** can be in contact with first adhesive layer **110** and P-electrode **13** can be disposed opposite surface of N-electrode **11**. In another embodiment of the present disclosure, N-electrode **11** and P-electrode **13** can be disposed on the same surface as well.

If N and P electrodes **11** and **13** reside on the same surface of LED strip **10**, it is referred to as lateral LED strip. If N and P electrodes **11** and **13** reside on the opposite surfaces of LED strip **10**, it is referred to as vertical LED strip.

FIG. **4** is a schematic diagram illustrating a holder **200** transferring at least two of the first LED strips **10** from first substrate **100** to second substrate **300**. In the transferring step (S**2**), holder **200** selectively moves at least two of the plurality of first LED elements **10** from first substrate **100** to second substrate **300**.

Holder **200** can be any suitable means that can pick up LED elements from a substrate and hold them during transfer (S**2**) in accordance with embodiments of the present disclosure. For example, holder **200** may lift the micro LED structure using vacuum (i.e., suction), magnetic, adhesive, or electrostatic forces to pick up the first LED strip **10**. As an example, holder **200** may be, but is not limited thereto, a magnetic pick up device. Holder **200** may be comprised of permanent magnet or electromagnet. Holder **200** can selectively pick up and move at least two of first LED strip **10** using by magnetic force generated by an array of magnetic inductors **210**. Holder **200** can, for instance, pick up every other three first LED strips **10** from first substrate **100**. A plurality of first LED strips **10** disposed on first substrate **100** can have same color and need to be selectively moved to second substrate **200** so as to arrange all of three primary colors, i.e. red, green, and blue on second substrate **300**. An inductor can be used to generate the magnetic field. During the moving process, holder **200** is in contact with second surface **10***b* of the at least two of first LED strips **10**.

FIG. **5** is a section view of FIG. **4**. First substrate **100** may be heated to soften or melt first adhesive layer **110** so that first LED strip **10** can be easily detached from first substrate **100**. The current to the magnetic inductors (not shown) is turned on to generate a magnetic field from holder **200**. As explained with respect to FIG. **4**, one in every three first LED strips **10** is lifted up from first substrate **100**. The current to the inductors (not shown) can be adjusted so that holder **200** may be used to selectively pick only one in three first LED strips **10**. A control unit (not shown) can be provided to program the selection of first LED strips **10** and control the magnetic inductors. The control unit (not shown) can be a software computer application or a hardware associated with the software computer application.

FIG. **6** is a section view illustrating the transferring operation of first LED strips **10** by the holder onto a second substrate **300**. Holder **200** can release first LED strips **10**, which are lifted from first substrate **100** and placed onto second substrate **300**, which can be a Si substrate. In this case, the first LED strips **10** can be affixed to second substrate **300** via a second adhesive layer **310**. Second adhesive layer **310** includes, i.e. a wax layer. As illustrated in FIG. **6**, two (2) first LED strips **10** are placed to have a distanced from one another so that other colors of second LED strip **20** and third LED strip **30** can be placed therebetween.

FIG. **7** is a section view illustrating an array of LED units **40** disposed on a second substrate **300**. FIG. **8** is a plan view of FIG. **7**. In the performing step (S**3**), the steps of providing (S**1**) and transferring (S**2**) are performed at least once with respect to each of second LED strip **20** and third LED strip **30** until an array of LED units **40** is arranged on second substrate **300**. Array of LED units **40** is comprised of at least one unit having the three primary colors, i.e. red, green, and blue.

Array of LED units **40** is comprised of a part of the at least one of first LED strip **10**, second LED strip **20**, and third LED strip **30**. First surface **10***a* and second surface **10***b* of the plurality of LED elements **10**, **20**, and **30** are disposed to face in same direction of a first surface **40***a* and a second surface **40***b* of array of LED units **40**. Here, array of LED units **40** includes first LED strip **10**, second LED strip **20**, and third LED strip **30**. Second substrate **300** is in contact with first surface **40***a* of array of LED units **40**. As illustrated, first LED strip **10**, second LED strip **20**, and third LED strip **30** are placed in parallel to each other in a repeating RGB/RGB/RGB pattern. The pitch of each of the LED unit **40** is equal to or smaller than 100 μm. In particular, the pitch the LED unit **40** is equal to or smaller than 50 μm.

FIG. **9** illustrates the pattern of array of LED units **41** on second substrate **300** after a procedure such as lithographic etching. The method according to the embodiment of the present disclosure can further include a forming step. The forming step forms pixels from array of LED units **40** on second substrate **300** by a lithographic etching method. If array of LED units **40** is comprised of single unit pixels instead of strip, the lithographic etching process can be omitted. For instance, after etching process, a strip generally divided into a plurality of pixels as shown in FIG. **9**. However, if a strip is provided with a plurality of pixels or with a singular pixel, lithographic etching process is not necessary. In such case, the pattern of array of LED units **41** can have same meaning with array of LED units **40**. Hereinafter, array of LED units **40** is interchangeably used with the pattern of array of LED units **41**. The pitch of each of the LED unit **41** is equal to or smaller than 100 μm. In particular, the size the LED unit **41** is equal to or smaller than 50 μm.

FIG. **10** shows that a third adhesive member **410** is placed onto each of the LED pixels **15**, **25**, and **35** for bonding. FIG. **11** shows one method for attaching array of LED units **40** onto a third substrate **400**. In the providing the third substrate step (S4), a third adhesive member **410** is provided between array of LED units **40** and third substrate **400**. Third adhesive member **410** can be any material suitable for bump bonding. For instance, the adhesive member **410** can be indium bumps. First LED strip **10**, second LED strip **20**, and third LED strip **30** are divided into a plurality of first LED pixels **15**, second LED pixels **25**, and third LED pixels **35** after the lithographic etching method. If each of first LED strip **10**, second LED strip **20**, and third LED strip **30** is provided as a single unit pixel, each of first LED strip **10**, second LED strip **20**, and third LED strip **30** is same with each of first LED pixels **15**, second LED pixels **25**, and third LED pixels **35**, respectively. Each of array of RGB LED units **40** includes a first LED pixel **15**, a second LED pixel **25**, and a third LED pixel **35**. If each of first LED strip **10**, second LED strip **20**, and third LED strip **30** includes a singular pixel or LED element, each of first LED strip **10**, second LED strip **20**, and third LED strip **30** would be same with the first LED pixel **15**, the second LED pixel **25**, and the third LED pixel **35**, respectively.

Referring to FIG. **11**, in the detaching step (S5), second substrate **300** is detached from the first LED pixels **15**, second LED pixels **25**, and third LED pixels **35** or array of LED units **40**.

Third substrate **400** is heated so that its heat melts the third adhesive member **410**, i.e. indium bumps on each of first LED pixel **15**, second LED pixel **25**, and third LED pixel **35**. Third substrate **400** is then cooled down so that third adhesive member **410**, i.e. indium bumps bonds third substrate **400** with first LED pixel **15**, second LED pixel **25**, and third LED pixel **35**. Third substrate **400** is an LED driver IC wafer so that electronic components or circuitry can be coupled thereto. Second adhesive layer **310** is then heated so that second adhesive layer **310**, i.e. wax melts and releases first LED pixel **15**, second LED pixel **25**, and third LED pixel **35** to third substrate **400**.

FIG. **12** shows that a fourth adhesive member **510** is placed onto array of LED units **40** for bonding. FIG. **13** shows one method for attaching array of LED units **40** onto a fourth substrate **500**. In the providing the fourth substrate step (S6), fourth substrate **500** is provided onto first surface **40***a* of array of LED units **40**.

Referring to FIG. **12**, third adhesive member **410**, e.g. indium bump, is used to bond third substrate **400**, which comprises an LED driver circuitry. Interconnecting electrodes and traces **420** can be disposed between third adhesive member **410** and third substrate **400**. Fourth adhesive member **510** is provided first surface **40***a* of array of LED units **40**. Fifth adhesive member **520** can be provided to connect circuitry on third substrate **400** and circuitry on fourth substrate **500**. Fourth substrate **500** can be of any known material suitable for an LED display, such as a sheet of glass or a touchpad panel.

FIGS. **14***a-d* illustrate another embodiment of the present disclosure. FIG. **14***a* is a section view of first LED strips **1010** on first substrate **1100**. FIG. **14***b* is another section view taken from a view normal to the one for FIG. **14***a*. FIGS. **14***a* and **14***b* show first LED strips **1010** on first substrate **1100** via a first adhesive layer **1110**. FIGS. **14***a* and **14***b* illustrate lateral LED strips **1010**. As shown in FIG. **14***a*, the first LED strip **1010** include metal electrodes **1011** on P-type GaN or AlInGaP **1012**, which in turn resides on a layer of light emitting material **1013**. The light emitting material **1013** layer is disposed on N-type GaN or AlInGaP layer **1014**.

In another embodiment as shown in FIG. **14***b*, a first LED strip **1010** includes metal electrodes **1011***a* and **1011***b*, P-type GaN or AlInGaP layer **1012**, a light emitting material layer **1013**. The first LED strip **1010** is disposed on an N-type GaN or AllGaP layer.

FIG. **14***c* shows first LED strip **1010**, second LED strip **1020**, and third LED strip **1030** disposed on third substrate **1300**. Transferring each of first LED strip **1010**, second LED strip **1020**, and third LED strip **1030** onto the third substrate **1300** can be performed in the similar method explained with respect to FIGS. **4-7**.

FIG. **14***d* shows the pattern of array of RGB LED units **1015**, **1025**, and **1035** on third substrate **1300** after an etching process. FIG. **15** illustrates third substrate **1400** bond to the RGB LED pixels **1015**, **1025**, and **1035** using the anisotropic conductive film (ACF) technology. ACF technology can be used for higher signal densities and smaller overall packages. In an ACF process, an anisotropic material can be first deposited on a base substrate. This may be done using a lamination process for ACF, or either dispense or printing process for ACP. The device or secondary substrate can be then placed in position over the base substrate and the two surfaces can be pressed together to mount the secondary substrate or device to the base substrate. In many cases this mounting process is done with no heat or a minimal amount of heat that is just sufficient to cause the anisotropic material to become slightly tacky. For bonding, the amount of thermal energy required is higher due to the need to first flow the adhesive and allow the two surfaces to come together into electrical contact, and then to cure the adhesive and create a lasting reliable bond. The temperatures, times, and pressure required for these processes can vary. ACF can be used when electrical connection is made at smaller gap between the electrodes. In this case, pitch size can depends on particle size. Nano metal particles can be used for several micron size pitch. For lateral LED strips, since the electrodes are on the same surface of the LED strip, the ACF can be applied only once to attach both N- and P-type electrodes. In the case of vertical LED strips, the ACF can be applied twice, one application for attaching the electrodes on each surface. Between the two applications, insulating epoxy can also be employed to ensure no shorting between the two ACFs. Using ACF this way may significantly simplify the packaging process. For example, the providing the third substrate step (S4) can be performed via anisotropic conductive films (ACF) method.

In the embodiment of FIG. **15**, RGB LED pixels **1015**, **1025**, and **1035** are placed between the third substrate **1400** (e.g., a driver wafer) and the second substrate. A second adhesive layer **1210** is interposed between ACF layer **1410** and second substrate **1200**. CF layer **1410** is an anisotropic adhesive film or paste, which contains nano-sized conductive particles.

FIG. **16** shows that second substrate **1200** is detached by melting second adhesive layer **1210**. Second adhesive layer **1210** can be heated and melt so that second substrate **1200** can be detached.

FIG. **17** shows a fourth substrate **1500** being attached to the RGB LED pixels **1015**, **1025**, and **1035**. Fourth substrate **1500** is can be a glass panel or a touchpad panel. According to this method, first LED pixel **1015** (or a red LED element), second LED pixel (or a green LED element) **1025**, and third LED pixel (or a blue LED element) **1035** are disposed on fourth substrate **1500** in a row with a pitch (P) smaller than a predetermined distance, e.g., 100 μm or 50 μm or smaller.

FIG. **18** is a section view of LED strips **1010** attached on first substrate **1101** according to another embodiment of the present disclosure. First substrate **1101** is either a sapphire substrate or a transparent substrate. Thus, LED strips **1010**, the light emitting layer, GaN, InGaN, or other structural elements can be grown on a sapphire substrate. Accordingly, LED strips **1010**, electrodes, and other necessary devices can be fabricated on the sapphire substrate as shown in FIG. **18**. This embodiment is particularly suitable for picking up and placing LED strips **1010** using a holder **200** being a magnetic pick up head because, for example, a lazier lift off (LLO) method can be used. The LLO method is described with reference to FIGS. **19** and **20**.

FIG. **19** shows a method for detaching green and blue LED strips from GaN by LLO method. Since first substrate **1101** is a sapphire substrate, which is transparent to laser while GaN is not, Laser Lift-Off (LLO) can be used to separate the devices from the sapphire substrate. Referring to FIG. **19**, the LED strips **1010** are attached to holder **200** being a magnetic pick up head while a laser beam passes through first substrate, i.e. sapphire substrate and targets GaN, which creates shockwaves that dissociates GaN from the sapphire substrate. Alternatively, UV Lift-Off may also be applied to separate the LED chips from the sapphire substrate. Thus, the transferring step (S**2**) can further include a LLO step to separate the at least two of the plurality of LED elements **10** from first substrate **100**.

FIG. **20** shows a method for detaching red LED strips from first substrate using Laser Lift-Off. In this case, AlInGaP red LED strips **1020** are attached to first substrate **1101**, i.e. sapphire substrate, by Van der Waals force. By selecting a laser that is absorbed at the interface of first substrate **1101**, i.e. the sapphire substrate, red LED strips **1020** can be detached from first substrate **1101**.

FIG. **21** is a section view of first LED strips **1010** interposed between first substrate **1103** and second substrate **1200** according to another embodiment of the present disclosure. First substrate **1103** is GaAs substrate and second LED strips **1020** are disposed thereon. Second LED strips **1020** can be separated from first substrate **1103**, i.e. GaAs substrate by an etching processing using ammonia hydroxide or other suitable means. With respect to the transferring step (S**2**), it can further include etching first substrate **1103** by using ammonia hydroxide to separate the at least two of the plurality of LED elements **1010**, **1020**, and **1030** from first substrate **1103**.

With reference to FIGS. **22-27**, the transferring step (S**2**) according to another embodiment of the present disclosure is described. FIG. **22** is a flow chart of the transferring step (S**2**).

Holder **200** may include a first magnetic holder **2210**, a second magnetic holder **2220**, and a third magnetic holder **2230**. First magnetic holder **2210** and second magnetic holder **2220** are the solid state magnetic pick up heads. Third magnetic holder **2230** is a RGB magnetic pixel holder. The transferring according to another embodiment of the present disclosure, includes the following five steps (S**2002***a*-S**2002***e*).

In a first lifting step (S**2002***a*), first magnetic holder **2210** lifts at least two of the plurality of LED elements **2010** (or first LED strip **2010**) from first substrate **100**. First magnetic holder **2210** is in contact with second surface **10***b* of at least two of the plurality of first LED elements **2010** (or first LED strip **2010**).

In a releasing step (S**2002***b*), first magnetic holder **2210** moves to a place which corresponds to second magnetic holder **2220** and selectively releases at least two of the plurality of first LED elements **2010** (or first LED strip **2010**) onto the second magnetic holder **2220**.

In an attaching step (S**2002***c*), second magnetic holder **2220** receives and attaches at least two of the plurality of first LED elements **2010** (or first LED strip **2010**) (S**2002***d*) from first magnetic holder **2210** thereto. First magnetic holder **2210** then moves away.

In a second lifting step (S**2002***d*), third magnetic holder **2230** is located that at least two of the plurality of first LED elements **2010** (or first LED strip **2010**) is interposed between second magnetic holder **2220** and third magnetic holder **2230**. Third magnetic holder **2230** lifts at least two of the plurality of first LED elements **2010** (or first LED strip **2010**) from second magnetic holder **2220**.

Last step (S**2002***e*) is to repeatedly perform the above steps (S**2002***a*-S**2002***d*) until the third magnetic holder holds the array of LED units.

FIG. **23** is a cross section view of LED strips **2010**, **2020**, and **2030** attached to first magnetic holder **2210**. FIG. **23** describes the first lifting step (S**2002***a*). First LED strips **2010**, second LED strips **2020**, and third LED strips **2030** are separated from their respective first substrates (not shown in FIGS. **23-27**) and are attached to respective first magnetic holders **2210**.

FIGS. **24***a*-**24***c* are cross section view illustrating the transferring method according to another embodiment of the present disclosure. FIG. **24***a* describes the releasing step (S**2002***b*) and the attaching step (S**2002***c*). FIG. **24***b* describes the second lifting step (S**2002***d*). FIG. **24***c* describes the last step (S**2002***e*).

Since LED strips **2010**, **2020**, and **2030** are attached to first, second and third magnetic holders **2210**, **2220**, and **2230** when solid state coils in first, second and third magnetic holders **2210**, **2220**, and **2230** are energized with electrical current (see, e.g., FIG. **4**), they can be selectively attached or released by energizing or shutting-off certain solid state coils in first, second and third magnetic holders **2210**, **2220**, and **2230**. In FIG. **24**, the pair of first magnetic holder **2210** holds a plurality of first LED strips **2010** while second magnetic holder picks up one third of the first LED strips from first magnetic holder **2210**. Second magnetic holder **2220** receives one third first LED strips **2010** from first magnetic holder **2210** and places first LED strips **2010** on third magnetic holder **2230**. The same process can be repeated to pick up second LED strips **2020** and third LED strips **2030** and place them on third magnetic holder **2230**. Once completed, all three types of first, second, and third LED strips are released to a fourth magnetic holder **2240**.

FIG. **25** is a brief section view of LED strips **2010**, **2020**, and **2030** disposed on fourth magnetic holder **2240**. FIG. **25** has similar section view with FIG. **11**. However, in FIG. **25**, LED strips **2010**, **2020**, **2030** are held to fourth magnetic holder **2240** by magnetic power, not by adhesive layer, i.e. wax. Third magnetic holder **2230** can then be detached from LED strips **2010**, **2020**, and **2030** by turning off the magnetic field therefrom.

FIG. **26** is a brief section view of LED RGB pixels **2015**, **2025**, and **2035** filled with anisotropic conductive film (ACF) layer **2410**. Fourth substrate **2400** is placed on a place where third magnetic holder **2230** is detached. LED strips can be filled with anisotropic conductive film (ACF). After ACF method is performed, fourth magnetic holder **2240** can be detached from LED pixels **2015**, **2025**, and **2035** by turning off the magnetic field therefrom. Here, differing from the process steps shown in FIGS. **16** and **17**, no adhesive layer is needed. Accordingly, it is not necessary to clean adhesive layer before attaching the fifth substrate **2500**, i.e. cover glass to RGB LED pixels **2015**, **2025**, and

2035, as shown in FIG. **27**. Conductive particle **2411** is nano-sized metal particles. ACF layer **2410** is an anisotropic adhesive film or paste.

FIGS. **28-35** illustrate methods for testing and replacing LED strips **3010**, **3020**, and **3030** with a vacuum holder **3220** according to the other embodiment of the present disclosure.

FIG. **28** is a flow chart for the transferring step according to the other embodiment of the present disclosure. Holder **200** includes a magnetic holder **3210** and a vacuum holder **3220**. Referring to FIG. **28**, the transferring step includes three (3) steps (**3002***a*-**3002***c*). In a lifting step (**3002***a*), magnetic holder **3210** lifts at least two of the plurality of first LED elements **3010** (or first LED strip **3010**) from first substrate **100**. Magnetic holder **3210** is in contact with second surface **10***b* of at least two of the plurality of LED elements **3010** (or first LED strip **3010**).

In a suctioning step (**3002***b*), vacuum holder **3220** holds at least two of the plurality of LED elements **3010** (or first LED strip **3010**). Vacuum holder **3220** is in contact with first surface **10***a* of at least two of the plurality of LED elements **3010** (or first LED strip **3010**).

In last step (**3002***c*), it is repeatedly performs the above steps (**3002***a* and **3002***b*) until vacuum holder **3220** holds array of LED units **3040**. LED strips **3010**, **3020**, and **3030** may be held and transported using vacuum holder **3220**.

FIGS. **26-33** show a schematic of vacuum holder **3220**. Vacuum holder **3220** may be a vacuum plate having a hollow inner chamber with suction orifices **3220***h* and vacuum pump **3220***p*. One surface of the vacuum plate has a plurality of suction orifices **3220***h* connected to the inner chamber while the other surface of the plate is connected to vacuum pump **3220***p*. When in use, vacuum orifices **3220***h* are aligned with RGB LED pixels **3015**, **3025**, and **3035** or patterns of LED strips (not shown) to be picked up. When the vacuum is on, the suction force pulls the RGB LED pixels **3015**, **3025**, and **3035** aligned with the vacuum orifices **3220***h* away from magnetic holder **3210**, as shown in FIG. **29**. The picked-up first LED pixel **3015** is attached to the vacuum holder **3220** for further manipulation.

FIG. **31**, third magnetic holder **3230** is placed on second surface **10***b* of RGB LED pixels **3015**, **3025**, and **3035**. Third magnetic holder **3230** can be detached by turning off the magnetic field therefrom.

In the illustration in FIG. **32**, third magnetic holder **3230** is detached and LED probe card **3300** is placed instead. The bonding pads of the RGB LED pixels **3015**, **3025**, and **3035** face outward when the RGB LED pixels **3015**, **3025**, and **3035** are attached to vacuum holder **3220**. The bonding pads can then connect to a power source for testing the RGB LED pixels **3015**, **3025**, and **3035**.

FIGS. **32-35** illustrate the process of testing and replacing RGB LED pixels **3015**, **3025**, and **3035**. As shown in FIG. **32**, LED probe card **3300** is used when testing RGB LED pixels **3015**, **3025**, and **3035**. LED probe card **3300** has a plurality of electrical contacts that are connected to a power source. While RGB LED pixels **3015**, **3025**, and **3035** are attached to vacuum holder **3220**, LED probe card **3300** is

applied to RGB LED pixels **3015**, **3025**, and **3035** so that the electrical contacts come into contact with the LED strips to light them up. RGB LED pixels **3015**, **3025**, and **3035** fail to light up or otherwise show irregularities are identified as out of specification and their locations indexed for replacement.

After testing, RGB LED pixels **3015**, **3025**, and **3035** are flipped back to third magnetic holder **3230** as shown in FIG. **33**. It can be accomplished by simply aligning vacuum holder **3220** and third magnetic holder **3230** properly then turning of the vacuum. Since the suction force is turned off, the magnetic force from third magnetic holder **3230** pull the LED chips back from vacuum holder **3220**. Once being transferred back to third magnetic holder **3230**, the out-of-spec LED strips can be replaced. FIG. **34** shows a method using single chip suction head to replace out-of-spec chips one by one. In another embodiment, a multiple out-of-spec chips can be replaced using a vacuum suction head having multiple vacuum orifices. The vacuum orifices can be open or shut automatically according to the indexed locations of the out-of-spec LEDs. FIG. **35** shows a section view of RGB LED pixels **3015**, **3025**, and **3035** after the replacement process.

It is to be understood that the exemplary embodiments described herein are that for presently preferred embodiments and thus should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

What is claimed is:

1. A micro-light emitting diode (LED) display comprising:

a first substrate;

a red LED pixel, a green LED pixel, and a blue LED pixel disposed on the first substrate and having a pitch smaller than a predetermined size;

a second substrate having disposed thereon a first electrode, a second electrode, and a third electrode configured to be electrically coupled to the red LED pixel, the green LED pixel, and the blue LED pixel, respectively; and

an anisotropic conductive film (ACF) layer filling a gap between the first substrate and the second substrate and simultaneously contacting the first substrate and the second substrate, wherein the ACF layer comprises conductive particles.

2. The method of claim **1**, wherein each of the array of RGB LED units comprises the red LED pixel, the green LED pixel, and the blue LED pixel arranged in a row.

3. The micro-LED display of claim **1**, wherein the pitch is smaller than 100 μm.

4. The micro-LED display of claim **1**, wherein the conductive particles are nano-sized metal particle.

5. The micro-LED display of claim **1**, wherein the first substrate is cover glass or touch sensitive panel.

* * * * *

patsnap

专利名称(译)	制造发光二极管显示器的方法
公开(公告)号	US9698134
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申请(专利权)人(译)	SCT科技有限公司.
当前申请(专利权)人(译)	SCT科技有限公司.
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IPC分类号	H01L21/70 H01L21/66 H01L25/16 H01L21/683 H01L21/67 H01L25/075 H01L25/18 H01L25/00 H01L23/00 H01L33/00 H01L27/15 H01L33/62
CPC分类号	H01L25/50 H01L21/67144 H01L21/6831 H01L21/6838 H01L22/20 H01L24/00 H01L25/0753 H01L25/167 H01L25/18 H01L33/0079 H01L27/156 H01L33/0095 H01L33/62 H01L21/82 H01L27/12 H01L21/6835 H01L24/81 H01L24/95 H01L24/97 H01L2221/68368 H01L2224/13109 H01L2224/16238 H01L2224/17181 H01L2224/81005 H01L2224/81815 H01L2224/81904 H01L2224/83851 H01L2224/95133 H01L2224/95136 H01L2224/97 H01L27/153 H01L2924/00014 H01L2224/81 H01L2224/83 H01L33/0093
优先权	62/085299 2014-11-27 US 62/092114 2014-12-15 US 62/110672 2015-02-02 US
其他公开文献	US20160155892A1
外部链接	Espacenet USPTO

摘要(译)

提供了一种用于制造微型LED显示器的方法。该方法包括在第一衬底上提供多个LED元件，使用磁性保持器或真空保持器将与第一衬底相同的原色的多个LED元件中的至少两个发送到第二衬底，执行提供和转移相对于三原色的步骤，在第二基板上形成RGB LED单元阵列，RGB LED单元阵列中的每一个包括红色LED元件，绿色LED元件和蓝色LED元件在第二基板和LED驱动器晶片之间插入RGB LED单元阵列，将第二基板与RGB LED单元的阵列分离，并将RGB LED单元阵列插入LED驱动器晶片和盖之间。