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(54) **METHOD OF TRANSFERRING MICRO DEVICE**

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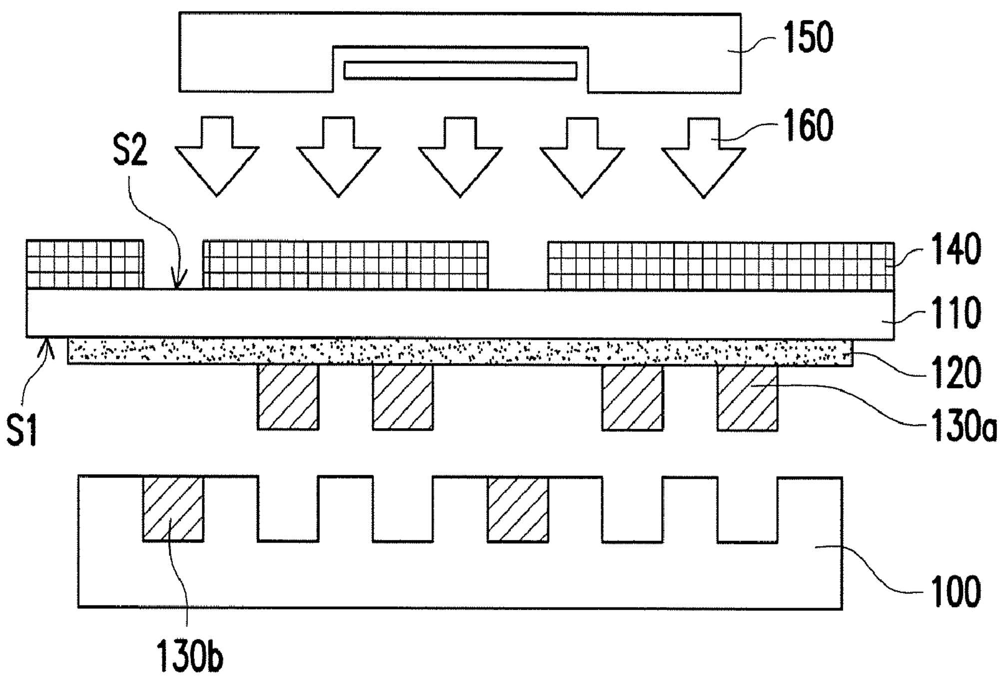
(57) **ABSTRACT**

A method of transferring micro devices is provided. A carrier substrate having a first surface and a second surface opposite to each other is provided, wherein a plurality of micro devices is disposed on the first surface, and each micro device binds to the first surface through laser debonding gel. Next, a receiving substrate is subjected to be relatively closer to the first surface, and a mask is provided on the second surface. Afterwards, the second surface with the mask is irradiated with a laser light, so as to keep the micro devices without laser irradiation binding on the first surface, and the micro devices irradiated with the laser light lose adhesive force and transfer to the receiving substrate.



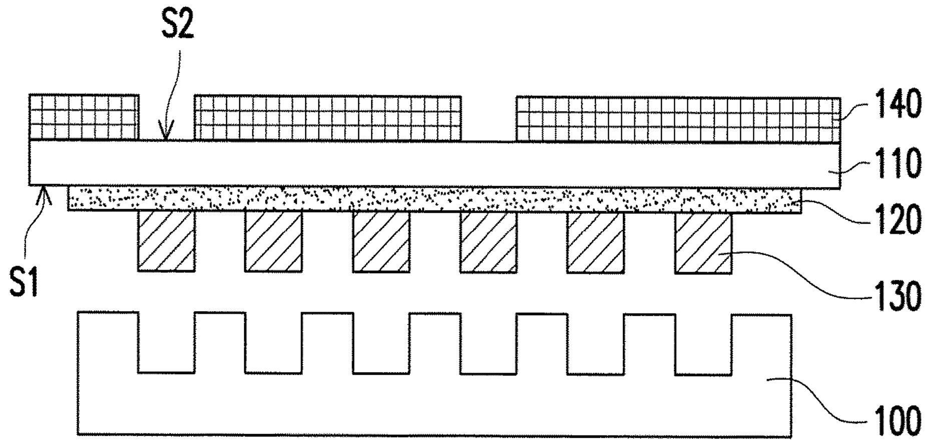


FIG. 1A

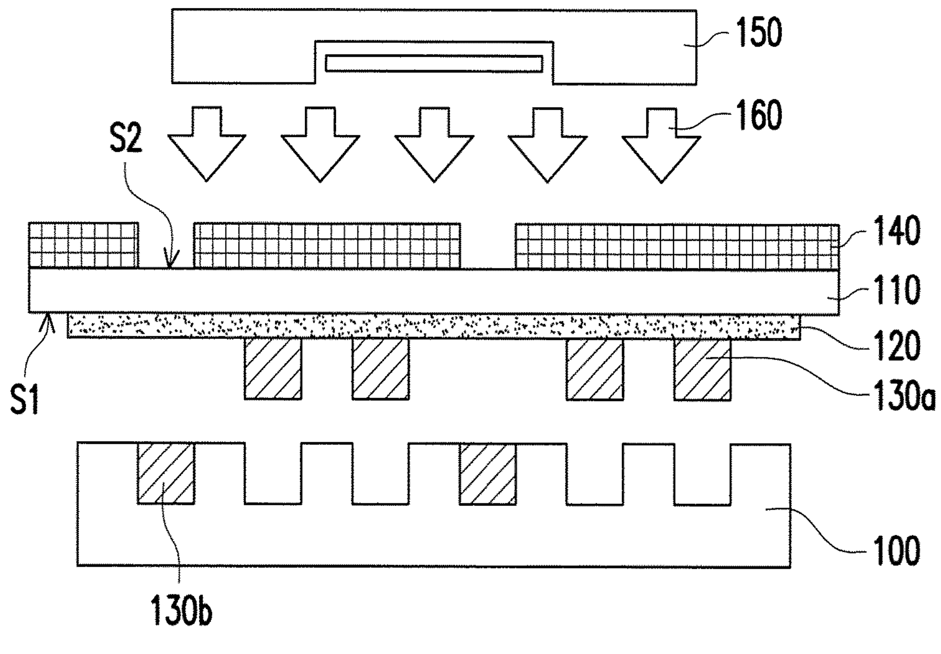


FIG. 1B

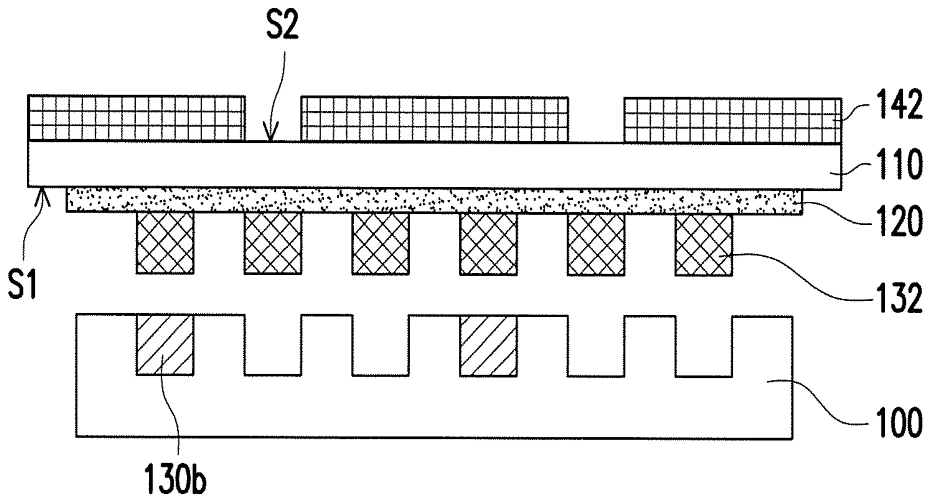

S2
142
110
120
S1
132
100
130b

FIG. 1C

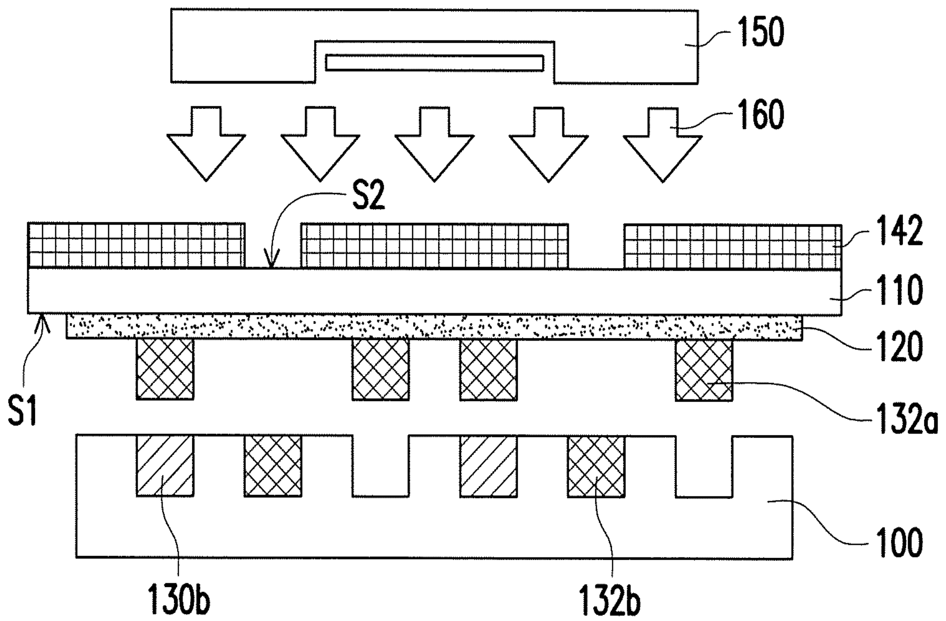

150
160
S2
142
110
120
S1
132a
100
130b
132b

FIG. 1D

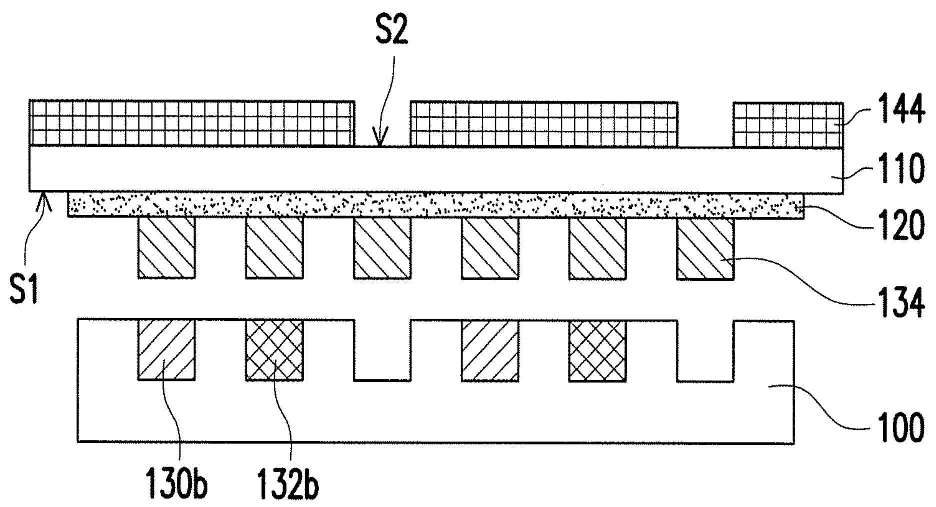

S2
144
110
120
S1
134
100
130b
132b

FIG. 1E

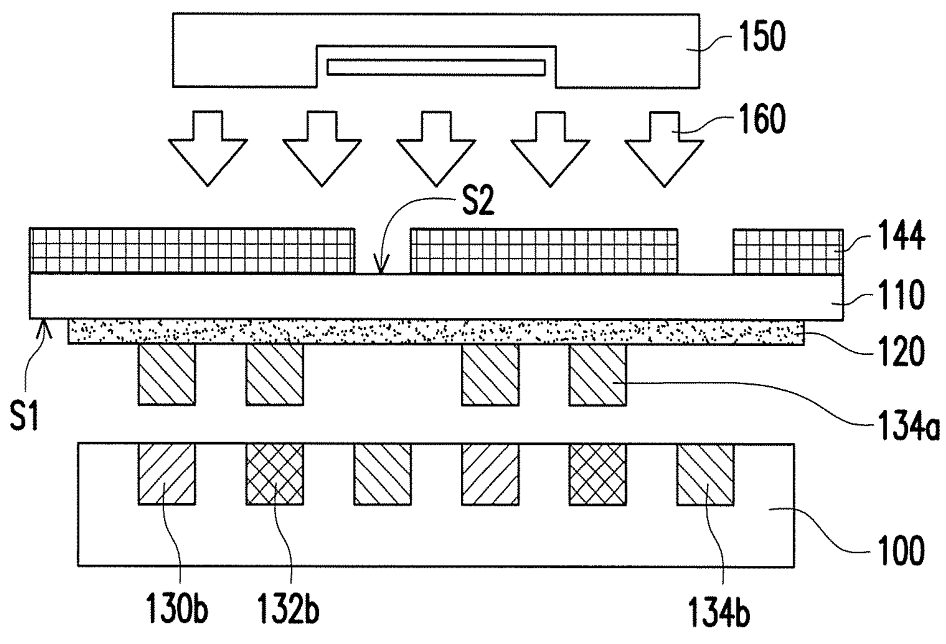

150
160
S2
144
110
120
S1
134a
100
130b
132b
134b

FIG. 1F

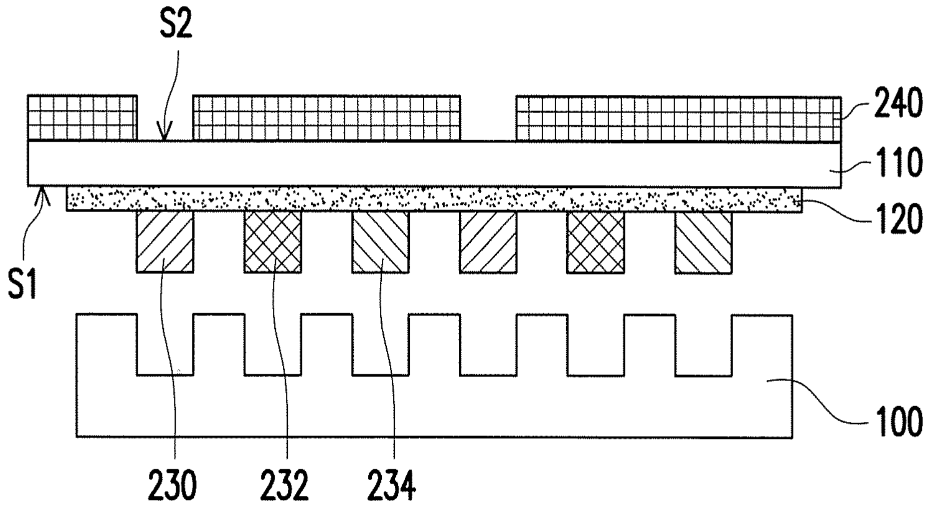

S2
240
110
120
S1
100
230
232
234

FIG. 2A

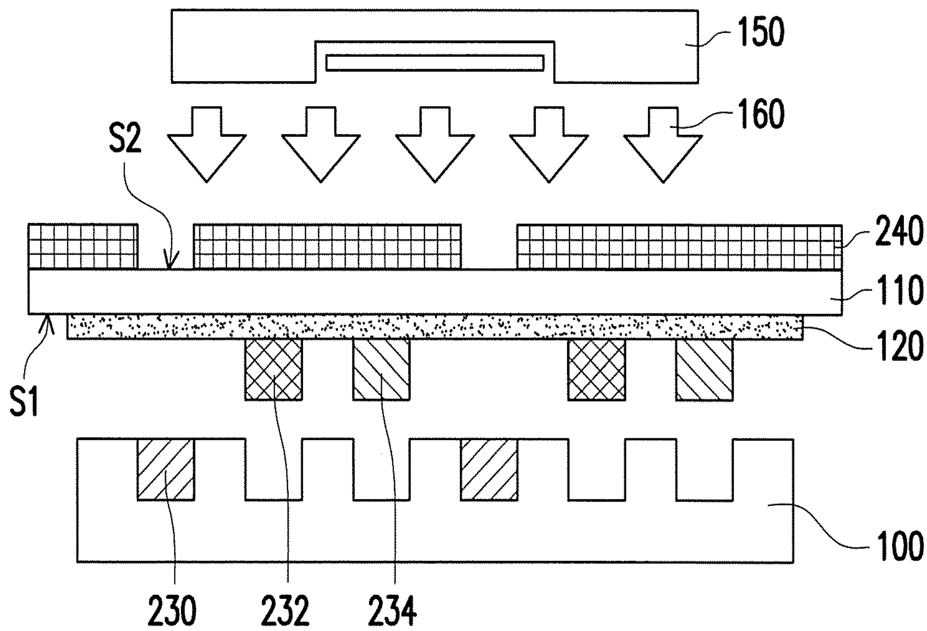

150
160
S2
240
110
120
S1
100
230
232
234

FIG. 2B

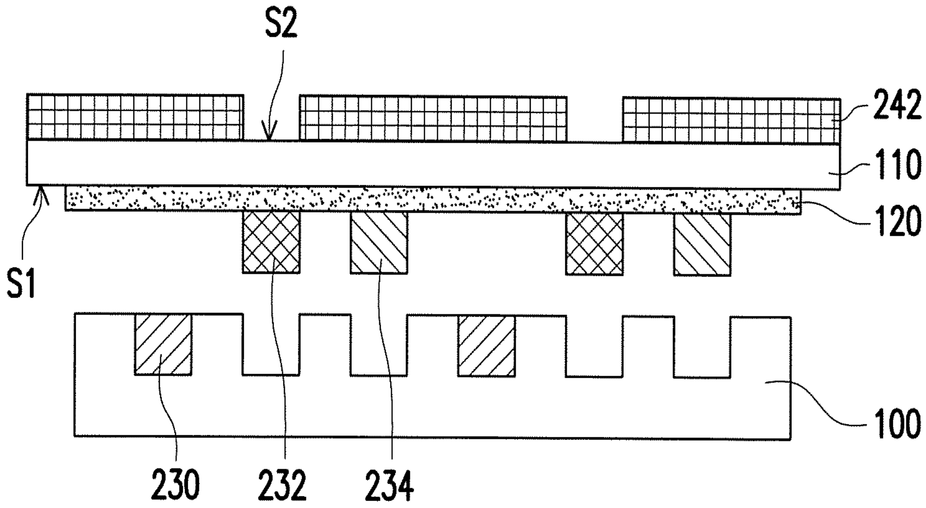

S2
242
110
120
S1
100
230
232
234

FIG. 2C

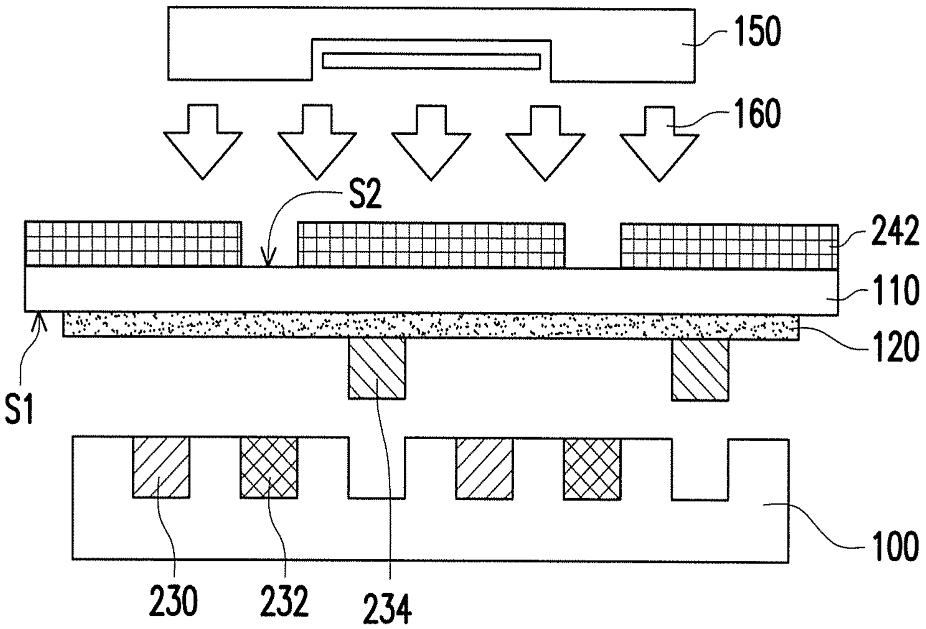

150
160
S2
242
110
120
S1
100
230
232
234

FIG. 2D

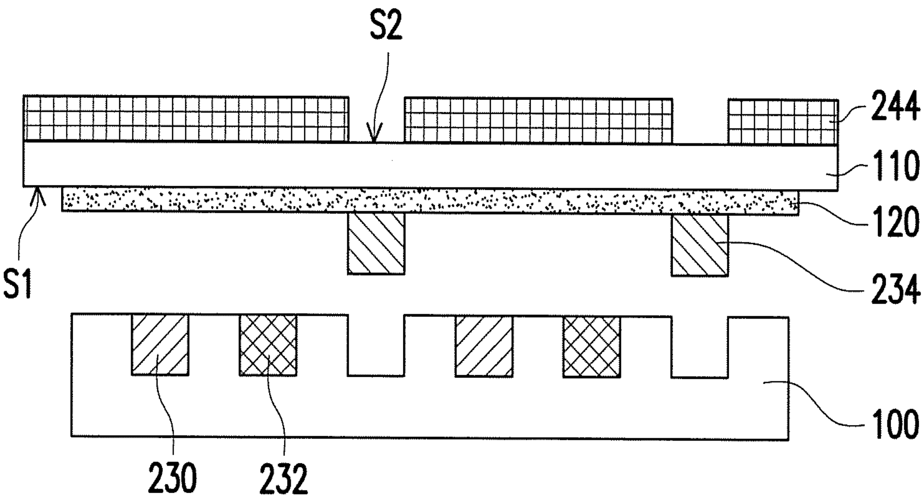

S2
244
110
120
S1
234
100
230
232

FIG. 2E

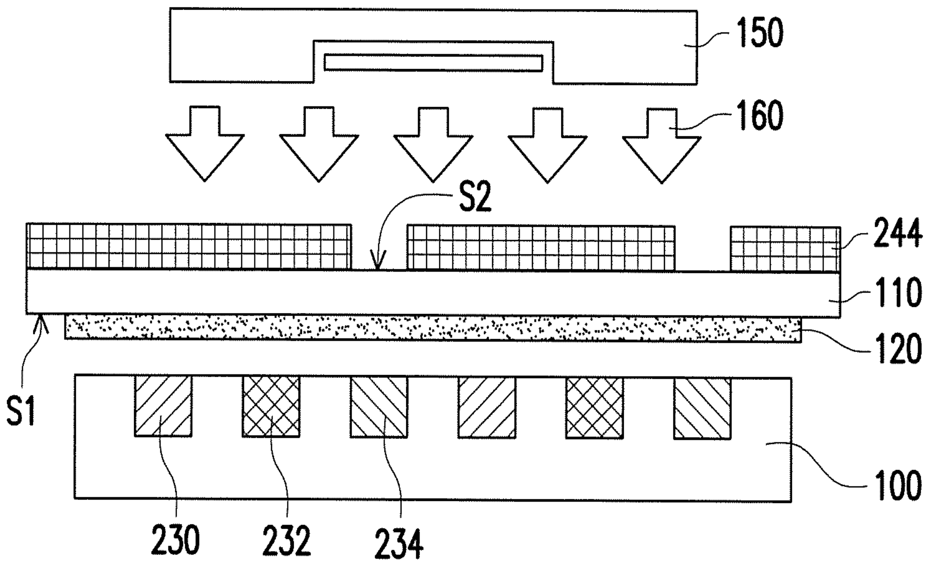

150
160
S2
244
110
120
S1
100
230
232
234

FIG. 2F

METHOD OF TRANSFERRING MICRO DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of Taiwan application serial no. 106133598, filed on Sep. 29, 2017. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The invention is related to a method of transferring, and more particularly, to a method of transferring micro devices.

Description of Related Art

[0003] Having advantages such as high brightness, high contrast, wide view angle, long service life and low power consumption, micro light-emitting diode display (micro LED display) has become the key of the future development of the display technology. The technology of directly moving micro light-emitting diode (micro LED) crystals to the driver backplane is called the mass transfer process, and the mass transfer process has the following technical obstacles. First, micro LEDs have an extremely tiny size (about 5 μm to 10 μm) and require more meticulous operative skills. Besides, as hundreds of thousands or millions of micro LEDs constitute only one panel, micro LEDs in a massive number of tens to hundreds of thousands are moved in one single transfer process.

[0004] In the prior art, methods of mechanical electrostatic attraction or adhesion by adhesive tape are often used to perform mass transfer process. The attractor and robot arms of the mechanical electrostatic attraction method are rather large, and thus are incapable of attracting micro LEDs smaller than 10 μm and transferring in a massive number. The method of adhesion by adhesive tape has the shortcoming of uneven adhesive force. When removing the adhesive force, the adhesive force decreases unstably and causes yield loss. Also, as the tape has a large area, it is incapable of selecting a micro LED at a particular location.

[0005] Based on the above, it is an important research topic to develop a method of transferring a mass of micro LEDs at one time, which is also adaptable for micro LEDs of tiny sizes (10 μm or smaller) and capable of selecting a micro LED at a particular location.

SUMMARY OF THE INVENTION

[0006] The invention provides a method of transferring micro devices which mainly uses a mask and a laser debonding gel, so as to transfer a mass of micro LEDs at one time. In addition, the method is adaptable for micro LEDs of tiny sizes (10 μm or smaller), and is further capable of selecting a micro LED at a particular location during the transfer process.

[0007] The method of transferring micro devices of the invention includes the following steps. A carrier substrate having a first surface and a second surface opposite to each other is provided, wherein a plurality of micro devices is disposed on the first surface, and each of the plurality of micro devices binds to the first surface through a laser debonding gel. Next, a receiving substrate is subjected to be relatively closer to the first surface, and a mask is provided on the second surface. Afterwards, the second surface with the mask is irradiated with a laser light, so as to keep the micro devices without laser irradiation binding on the first surface, and the micro devices irradiated with the laser light lose adhesive force and transfer to the receiving substrate.

[0008] In an embodiment of the invention, the method of transferring micro devices further includes coating the laser debonding gel on the first surface, so that each of the plurality of micro devices binds to the first surface through the laser debonding gel.

[0009] In an embodiment of the invention, the method of transferring micro devices further includes coating the laser debonding gel on each of the plurality of micro devices so that each of the plurality of micro devices binds to the first surface through the laser debonding gel in between.

[0010] In an embodiment of the invention, the plurality of micro devices disposed on the first surface is a plurality of micro LEDs emitting lights in a same color.

[0011] In an embodiment of the invention, the plurality of micro devices disposed on the first surface is a plurality of micro LEDs emitting lights in different colors.

[0012] In an embodiment of the invention, the carrier substrate is a glass substrate, and the receiving substrate is a driver integrated circuit (IC) on glass substrate.

[0013] In an embodiment of the invention, a material of the laser debonding gel includes polyimide.

[0014] In an embodiment of the invention, the laser debonding gel loses adhesive force when irradiated with a laser light having a wave length in a range from 200 mn to 1064 nm.

[0015] Based on the above, the invention provides a method of transferring micro devices includes binding the plurality of micro LEDs to a glass with the laser debonding gel and, along with the mask, keeping the plurality of micro LEDs without laser irradiation binding on the glass, and the plurality of micro LEDs irradiated with the laser light loses adhesive force and transfers to a driver backplane. As such, the method of transferring micro devices of the invention is capable of transferring a mass of micro LEDs at one time, is adaptable for micro LEDs of tiny sizes (10 μm or smaller), and is further capable of selecting a micro LED at a particular location during the transfer process.

[0016] To make the aforementioned and other features and advantages of the invention more comprehensible, several embodiments accompanied with figures are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a portion of this specification. The drawings illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure.

[0018] FIG. **1**A to FIG. **1**F are schematic cross-sectional views of a method of transferring micro devices according to the first embodiment of the invention.

[0019] FIG. **2**A to FIG. **2**F are schematic cross-sectional views of a method of transferring micro devices according to the second embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

[0020] In order to clearly illustrate the invention, the sizes and the ratios of the layers and regions may be exaggerated in the figures of the specification. In addition, the number of the devices (such as the micro devices) as illustrated is merely an example and should not be construed as a limitation to the invention. The number of the device may be adjusted according to practical operations.

[0021] FIG. **1** A to FIG. **1**F are schematic cross-sectional views of a method of transferring micro devices according to the first embodiment of the invention.

[0022] First, referring to FIG. **1**A, a carrier substrate **110** having a first surface S1 and a second surface S2 opposite to each other is provided, wherein a plurality of micro devices **130** is disposed on the first surface S1, and each of the plurality of micro devices **130** binds to the first surface S1 through a laser debonding gel **120**. It should be noted that, although FIG. **1**A illustrates coating the laser debonding gel **120** on the first surface S1, so that each of the plurality of micro devices **130** binds to the first surface S1 through the laser debonding gel **120**, the invention is not limited thereto. The laser debonding gel may be coated only on each of the plurality of micro devices **130**, so that each of the plurality of micro devices **130** binds to the first surface S1 through the laser debonding gel. Also, the descriptions herein related to binding micro devices to the first surface S1 through a laser debonding gel **120** are not only adapted for the plurality of micro devices **130** but also adapted for the plurality of micro devices **132** and **134** to be mentioned in the following.

[0023] More specifically, the carrier substrate **110** is, for example, a glass substrate. A material of the laser debonding gel **120** may include polyimide, and the laser debonding gel **120** loses adhesive force when irradiated with a laser light that, for example, has a wave length in a range from 200 nm to 1064 nm, but the present invention is not limited thereto. Other laser debonding gel losing adhesive force when irradiated with a laser light may also be used. In this embodiment, the plurality of micro devices **130** disposed on the first surface S1 is a plurality of micro LEDs emitting lights in a same color, for example, red LEDs, but the invention is not limited thereto. Green or blue LEDs may also be selected according to the operation requirements.

[0024] Next, still referring to FIG. **1**A, a receiving substrate **100** and the first surface S1 are subjected to be relatively closer to each other, and a mask **140** is provided on the second surface S2. More specifically, the receiving substrate **100** is, for example, a driver IC on glass substrate, and a material of the mask **140** is, for example, quartz glass or plastic. In FIG. **1**A, the mask **140** is directly disposed on the second surface S2 of the carrier substrate **110** and contacts the second surface S2, but the invention is not limited thereto. The mask **140** may also be in a distance from the second surface S2 of the carrier substrate **110** and does not contact the second surface S2. Also, the descriptions herein related to providing a mask are not only adapted for the mask **140** but also adapted for the mask **142**, **144**, **240**, **242** and **244** to be mentioned in the following.

[0025] Afterwards, referring to FIG. **1**B, the second surface S2 with the mask **140** is irradiated with a laser light **160** introduced by a laser apparatus **150**, so as to keep a plurality of micro devices **130***a* without laser irradiation binding on the first surface S1, and a plurality of micro devices **130***b* irradiated with the laser light **160** loses adhesive force and transfers to the receiving substrate **100**. In detail, the laser light **160** has a wavelength of, for example, 355 nm, and the laser debonding gel may lose adhesive force when irradiated with a laser light that, for example, has a wave length of 355 nm. When the second surface S2 with the mask **140** is irradiated with the laser light **160**, a space corresponding to an opening of the mask **140**, where the plurality of micro devices **130***b* is located, is left uncovered and irradiated with the laser light **160**. Thus, a portion of the laser debonding gel **120** between the plurality of micro devices **130***b* and the first surface S1 loses adhesive force, resulting the plurality of micro devices **130***b* to fall and transfer to the receiving substrate **100**. On the other hand, a space covered by the mask **140**, where the plurality of micro devices **130***a* is located, is not irradiated with the laser light **160**. Thus, the adhesive force of a portion of the laser debonding gel **120** between the plurality of micro devices **130***a* and the first surface S1 is not influenced, and the plurality of micro devices **130***a* keeps binding on the first surface S1.

[0026] As such, the method of transferring micro devices of the invention is not only adaptable for micro LEDs of tiny sizes (10 μm or smaller), but also capable of selecting a micro LED at a particular location during the transfer process by the mask design corresponding to the micro devices intended to be debonded and transferred, so as to solve the problem of removing a malfunctioned LED.

[0027] Afterwards, referring to FIG. **1**C, a plurality of micro devices **132** is disposed on the first surface S1, and each of the micro devices **132** binds to the first surface S1 through the laser debonding gel **120**. In this embodiment, the plurality of micro devices **132** disposed on the first surface S1 is a plurality of micro LEDs emitting lights in a same color, for example, green LEDs, but the present invention is not limited thereto. Other LEDs emitting lights in a color different from the plurality of micro devices **130** may also be selected according to the operation requirements.

[0028] Still referring to FIG. **1**C, the receiving substrate **100** having the plurality of micro devices **130***b* transferred thereto and the first surface S1 are subjected to be relatively closer to each other, and a mask **142** is provided on the second surface S2. A material of the mask **142** may be the same as that of the mask **140**.

[0029] Afterwards, referring to FIG. **1**D, the second surface S2 with the mask **142** is irradiated with a laser light **160** introduced by a laser apparatus **150**, so as to keep a plurality of micro devices **132***a* without laser irradiation binding on the first surface S1, and a plurality of micro devices **132***b* irradiated with the laser light **160** loses adhesive force and transfers to the receiving substrate **100**. In FIG. **1**D, a technical mechanism similar to which described in the above FIG. **1**B is used. By designing the location of the opening of the mask **142**, a space corresponding to an opening, where the plurality of micro devices **132***b* is located, is left uncovered and irradiated with the laser light **160**. Thus, a portion of the laser debonding gel **120** between the plurality of micro devices **132***b* and the first surface S1 loses adhesive force, resulting the plurality of micro devices **132***b* to fall and transfer to the receiving substrate **100**. On the other hand, a space covered by the mask **142**, where the plurality of micro devices **132***a* is located, is not irradiated with the laser light **160**. Thus, the adhesive force of a portion of the laser debonding gel **120** between the plurality of micro devices **132***a* and the first surface S1 is not influenced, and the plurality of micro devices **132***a* keeps binding on the first surface S1.

[0030] Next, referring to FIG. **1**E, a plurality of micro devices **134** is disposed on the first surface S**1**, and each of the micro devices **134** binds to the first surface S**1** through the laser debonding gel **120**. In this embodiment, the plurality of micro devices **134** disposed on the first surface S**1** is a plurality of micro LEDs emitting lights in a same color, for example, blue LEDs, but the invention is not limited thereto. Other LEDs emitting lights in a color different from the plurality of micro devices **130** and **132** may also be selected according to the operation requirements.

[0031] Still referring to FIG. **1**E, the receiving substrate **100** having the plurality of micro devices **130***b* and **132***b* transferred thereto and the first surface S**1** are subjected to be relatively closer to each other, and a mask **144** is provided on the second surface S**2**. A material of the mask **144** may be the same as that of the mask **140** and **142**.

[0032] Afterwards, referring to FIG. **1**F, the second surface S**2** with the mask **144** is irradiated with a laser light **160** introduced by a laser apparatus **150**, so as to keep a plurality of micro devices **134***a* without irradiation of the laser light **160** binding on the first surface S**1**, and a plurality of micro devices **134***b* irradiated with the laser light **160** loses adhesive force and transfers to the receiving substrate **100**. In FIG. **1**F, a technical mechanism similar to which described in the above FIG. **1**B is used. By designing the location of the opening of the mask **144**, a space corresponding to an opening, where the plurality of micro devices **134***b* is located, is left uncovered and irradiated with the laser light **160**. Thus, a portion of the laser debonding gel **120** between the plurality of micro devices **134***b* and the first surface S**1** loses adhesive force, resulting the plurality of micro devices **134***b* to fall and transfer to the receiving substrate **100**. On the other hand, a space covered by the mask **144**, where the plurality of micro devices **134***a* is located, is not irradiated with the laser light **160**. Thus, the adhesive force of a portion of the laser debonding gel **120** between the plurality of micro devices **134***a* and the first surface S**1** is not influenced, and the plurality of micro devices **134***a* keeps binding on the first surface S**1**. As such, the transfer of micro LEDs emitting lights in different colors (red LEDs, green LEDs and blue LEDs) is accomplished.

[0033] In the first embodiment as illustrated in the above FIG. **1**A to FIG. **1**F, the method of transferring micro devices disposes a plurality of micro LEDs emitting lights in a same color on the carrier substrate **110**, but the invention is not limited thereto. A plurality of micro LEDs emitting lights in different colors may be disposed on the carrier substrate **110** according to the operation requirements, as in the second embodiment illustrated in FIG. **2**A to FIG. **2**F.

[0034] FIG. **2**A to FIG. **2**F are schematic cross-sectional views of a method of transferring micro devices according to the second embodiment of the invention. It should be noted herein that the embodiment illustrated in FIG. **2**A to FIG. **2**F is similar to the embodiment illustrated in FIG. **1**A to FIG. **1**F. Therefore, portion of the reference numerals and contents of the previous embodiment are used to describe this embodiment, wherein the same reference numerals are used to represent identical or similar elements, and description of repeated technical contents are omitted. Please refer to the description of the previous embodiment for the omitted contents, which will not be repeated hereinafter.

[0035] First, referring to FIG. **2**A, a carrier substrate **110** having a first surface S**1** and a second surface S**2** opposite to each other is provided, wherein a plurality of micro devices **230**, **232** and **234** is disposed on the first surface S**1**, and each of the micro devices plurality of micro devices **230**, **232** and **234** binds to the first surface S**1** through a laser debonding gel **120**. It should be noted that, although FIG.**2**A illustrates coating the laser debonding gel **120** on the first surface S**1**, so that each of the plurality of micro devices **230**, **232** and **234** binds to the first surface S**1** through the laser debonding gel **120**, the invention is not limited thereto. The laser debonding gel may be coated only on each of the plurality of micro devices **230**, **232** and **234**, so that each of the plurality of micro devices **230**, **232** and **234** binds to the first surface S**1** through the laser debonding gel.

[0036] In an embodiment of the invention, the plurality of micro devices **230**, **232** and **234** disposed on the first surface S**1** are a plurality of micro LEDs emitting lights in different colors. For example, micro devices **230** may be red LEDs, micro devices **232** may be green LEDs, and micro devices **234** may be blue LEDs. However, the invention is not limited thereto and may be adjusted according to the operation requirements.

[0037] Next, still referring to FIG. **2**A, the receiving substrate **100** and the first surface S**1** are subjected to be relatively closer to each other, and a mask **240** is provided on the second surface S**2**. A material of the mask **240** may be the same as that of the mask **140** of the aforementioned embodiment.

[0038] Afterwards, referring to FIG. **2**B, the second surface S**2** with the mask **240** is irradiated with a laser light **160** introduced by a laser apparatus **150**, so as to keep micro devices **232** and **234** without irradiation of the laser light **160** binding on the first surface S**1**, and the plurality of micro devices **230** irradiated with the laser light **160** loses adhesive force and transfers to the receiving substrate **100**. In FIG. **2**B, a technical mechanism similar to which described in the FIG. **1**B of the above embodiment is used. By designing the location of the opening of the mask **240**, a space corresponding to an opening, where the plurality of micro devices **230** is located, is left uncovered and irradiated with the laser light **160**. Thus, a portion of the laser debonding gel **120** between the plurality of micro devices **230** and the first surface S**1** loses adhesive force, resulting micro devices **230** to fall and transfer to the receiving substrate **100**. On the other hand, a space covered by the mask **240**, where the micro devices **232** and **234** are located, is not irradiated with the laser light **160**. Thus, the adhesive force of a portion of the laser debonding gel **120** between the micro devices **232** and **234** and the first surface S**1** is not influenced, and the micro devices **232** and **234** keep binding on the first surface S**1**.

[0039] Next, referring to FIG. **2**C, the receiving substrate **100** having the micro devices **230** transferred thereto and the first surface S**1** are subjected to be relatively closer to each other, and a mask **242** is provided on the second surface S**2**. A material of the mask **242** may be the same as that of the mask **240**.

[0040] Afterwards, referring to FIG. **2**D, the second surface S**2** with the mask **142** is irradiated with a laser light **160** introduced by a laser apparatus **150**, so as to keep the micro devices **234** without irradiation of the laser light **160** binding on the first surface S**1**, and the plurality of micro devices **232** irradiated with the laser light **160** loses adhesive force and transfers to the receiving substrate **100**. In FIG. **2**D, a technical mechanism similar to which described in the above FIG. **2**B is used. By designing the location of the opening of the mask **242**, a space corresponding to an opening, where the plurality of micro devices **232** is located, is left uncovered and irradiated with the laser light **160**. Thus, a portion of the laser debonding gel **120** between the micro devices **232** and the first surface **S1** loses adhesive force, resulting the micro devices **232** to fall and transfer to the receiving substrate **100**. On the other hand, a space covered by the mask **142**, where the plurality of micro devices **234** is located, is not irradiated with the laser light **160**. Thus, the adhesive force of a portion of the laser debonding gel **120** between the micro devices **234** and the first surface **S1** is not influenced, and the plurality of micro devices **234** keeps binding on the first surface **S1**.

[0041] Then, referring to FIG. **2**E, the receiving substrate **100** having the micro devices **230** and **232** transferred thereto and the first surface **S1** are subjected to be relatively closer to each other, and a mask **244** is provided on the second surface **S2**. A material of the mask **244** may be the same as that of the mask **240** and **242**.

[0042] Afterwards, referring to FIG. **2**F the second surface **S2** with the mask **244** is irradiated with the laser light **160** introduced by the laser apparatus **150**, so that the micro devices **234** irradiated with the laser light **160** lose adhesive force and transfer to the receiving substrate **100**. In FIG. **2**F, a technical mechanism similar to which described in the above FIG. **2**B is used. By designing the location of the opening of the mask **244**, a space corresponding to an opening, where the plurality of micro devices **234** is located, is left uncovered and irradiated with the laser light **160**. Thus, a portion of the laser debonding gel **120** between the micro devices **234** and the first surface **S1** loses adhesive force, resulting the micro devices **234** to fall and transfer to the receiving substrate **100**. As such, the transfer of micro LEDs emitting lights in different colors (red LEDs, green LEDs and blue LEDs) is accomplished.

[0043] To sum up, the method of transferring micro devices of the invention overcomes the technical obstacle of mass transfer process by using the mask and laser debonding gel, wherein the mask design corresponds to the micro devices intended to be debonded and transferred. In detail, the method of transferring micro devices of the invention is capable of transferring a mass of micro LEDs at one time, is adaptable for micro LEDs of tiny sizes (10 μm or smaller), and is further capable of selecting a micro LED at a particular location during the transfer process to solve the problem of removing a malfunctioned LED. Therefore, various shortcomings of conventional methods to perform mass transfer process, namely mechanical electrostatic attraction or adhesion by adhesive tape, are overcome.

[0044] It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed embodiments without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the invention covers modifications and variations of this disclosure provided that they fall within the scope of the following claims and their equivalents.

1. A method of transferring micro devices, comprising:

providing a carrier substrate having a first surface and a second surface opposite to each other, wherein a plurality of micro devices is disposed on the first surface, and each of the plurality of micro devices binds to the first surface through a laser debonding gel, the laser debonding gel is coated on the first surface continuously;

subjecting a receiving substrate to the first surface and providing a mask on the second surface; and

irradiating the second surface with the mask with a laser light, so as to keep the plurality of micro devices without laser irradiation binding on the first surface, and the plurality of micro devices irradiated with the laser light loses adhesive force and transfers to the receiving substrate.

2. (canceled)

3. (canceled)

4. The method of transferring micro devices according to claim **1**, wherein the plurality of micro devices disposed on the first surface is a plurality of micro light-emitting diodes emitting lights in a same color.

5. The method of transferring micro devices according to claim **1**, wherein the plurality of micro devices disposed on the first surface is a plurality of micro light-emitting diodes emitting lights in different colors.

6. The method of transferring micro devices according to claim **1**, wherein the carrier substrate is a glass substrate, and the receiving substrate is a driver integrated circuit on glass substrate.

7. The method of transferring micro devices according to claim **1**, wherein a material of the laser debonding gel comprises polyimide.

8. The method of transferring micro devices according to claim **1**, wherein the laser debonding gel loses adhesive force when irradiated with a laser light having a wave length in a range from 200 nm to 1064 nm.

9. The method of transferring micro devices according to claim **1**, wherein the laser debonding gel is coated on the first surface continuously at least from an edge of the leftmost micro device to an edge of the rightmost micro device.

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摘要(译)

提供了一种传送微器件的方法。提供具有彼此相对的第一表面和第二表面的载体基板，其中多个微器件设置在第一表面上，并且每个微器件通过激光剥离凝胶与第一表面结合。接下来，使接收基板相对靠近第一表面，并且在第二表面上设置掩模。然后，用激光照射带有掩模的第二表面，以保持没有激光照射的微型器件结合在第一表面上，并且用激光照射的微型器件失去粘合力并转移到接收基板。