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(54) **METHOD OF BATCH TRANSFERRING MICRO SEMICONDUCTOR STRUCTURES**

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

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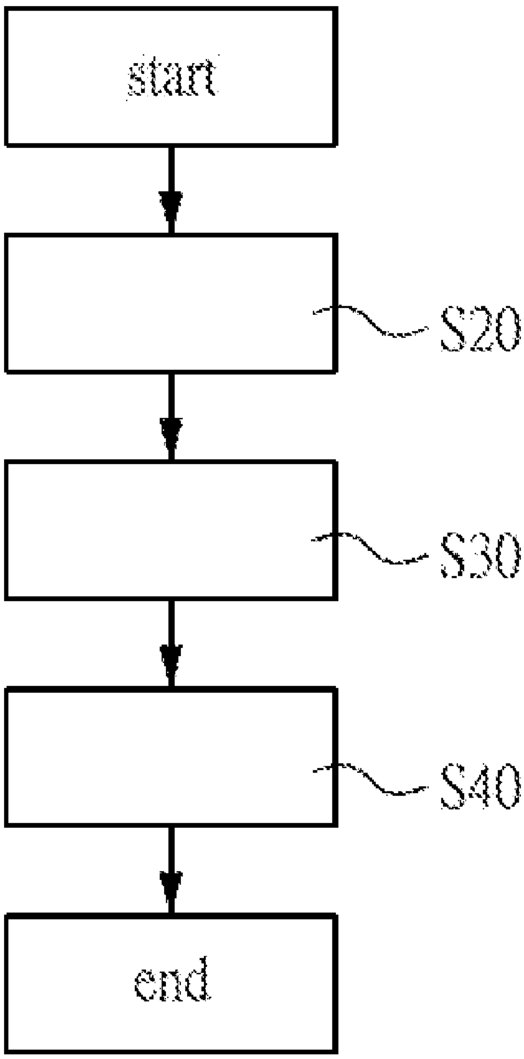
(57) **ABSTRACT**

A method of batch transferring micro semiconductor structures is provided. The method utilizes the selective laser lift-off (selective LLO) technology, and the micro semiconductor structures are selected in batch during the selective LLO process. Thus, the following transferring step does not need to prepare the concave patterns in advance, thereby avoiding the technical difficult derived by the micro-contact printing process.



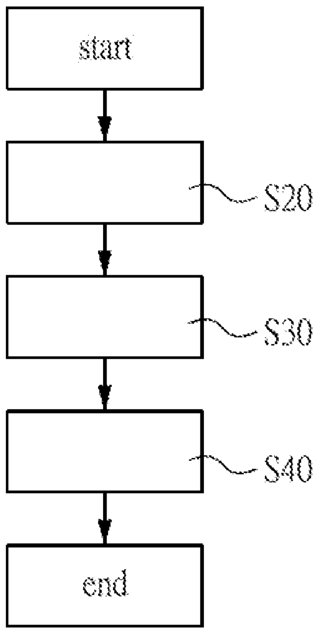


FIG. 1A

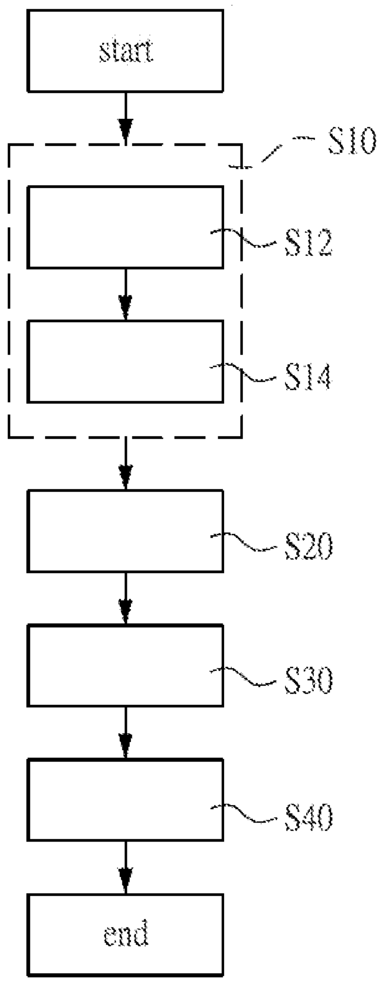


FIG. 1B

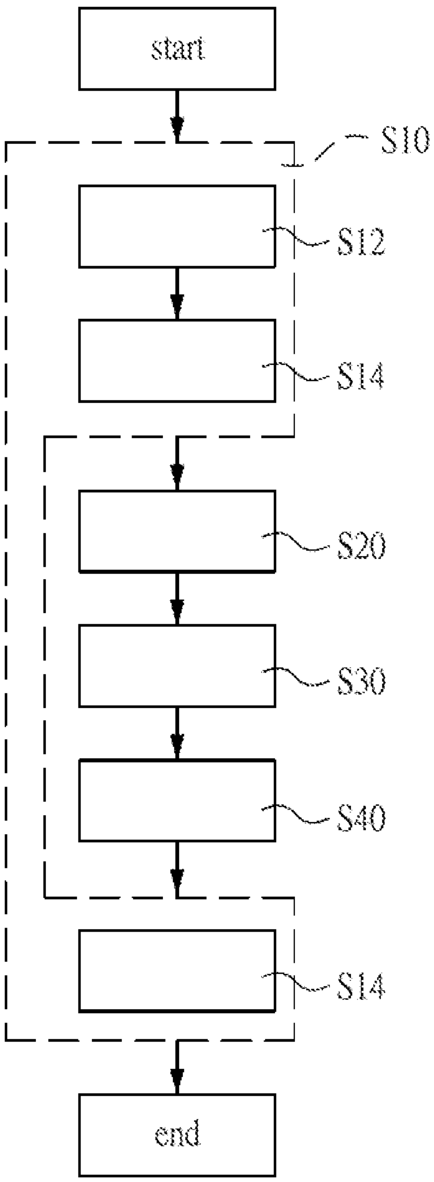


FIG. 1C

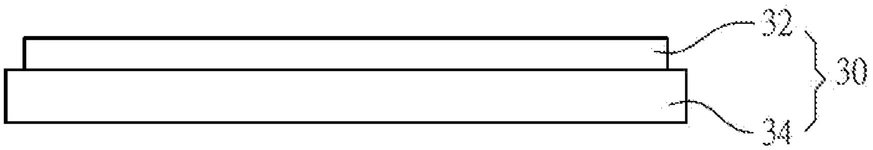


FIG. 2A

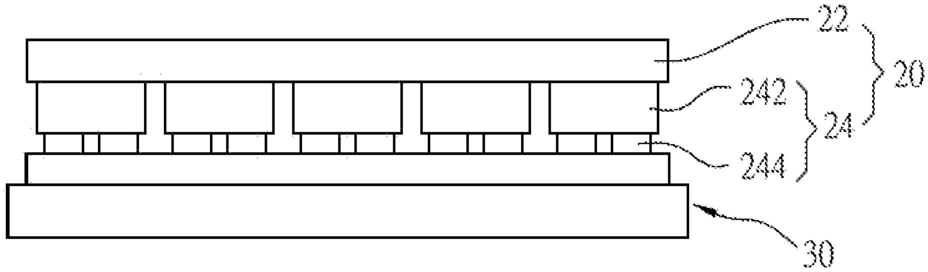


FIG. 2B

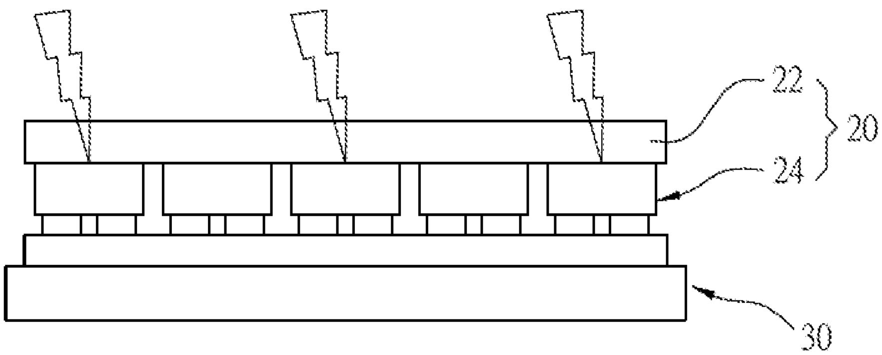


FIG. 2C

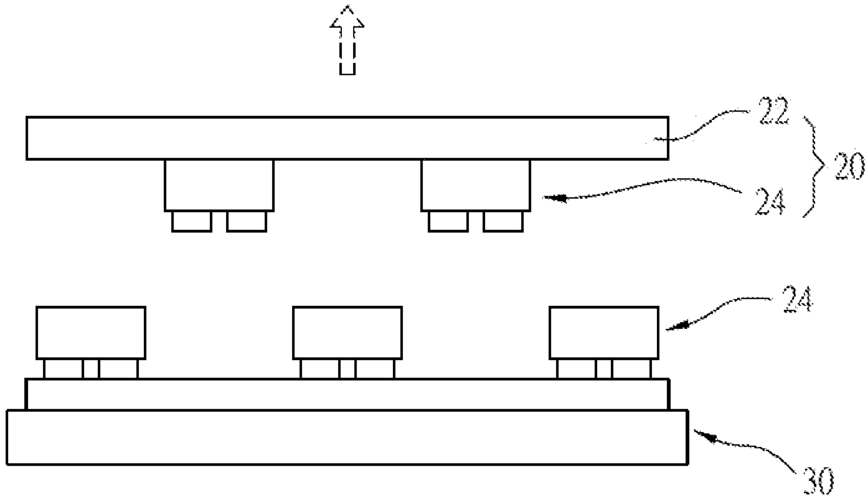


FIG. 2D

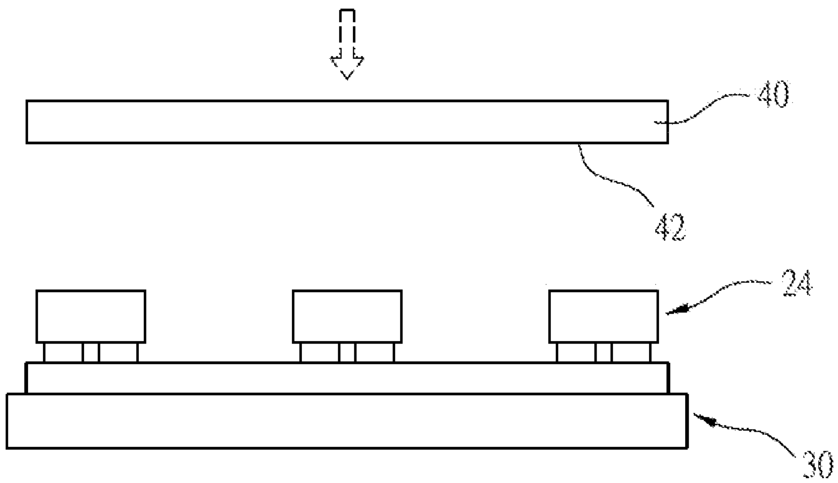


FIG. 2E

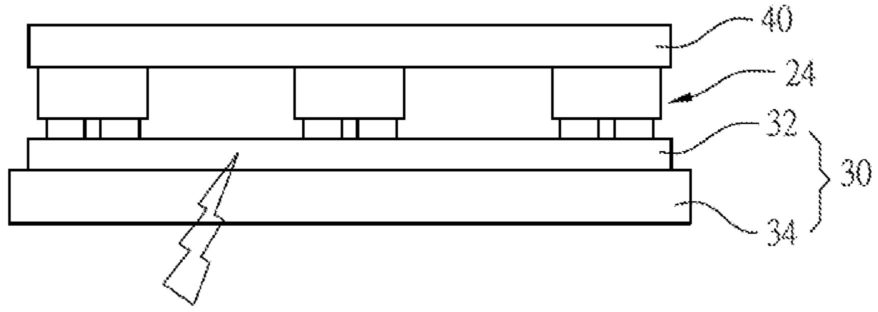


FIG. 2F

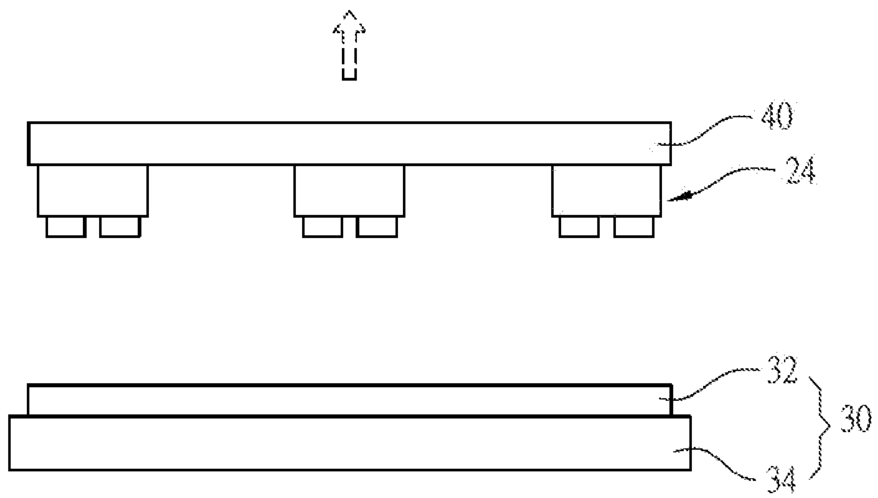


FIG. 2G

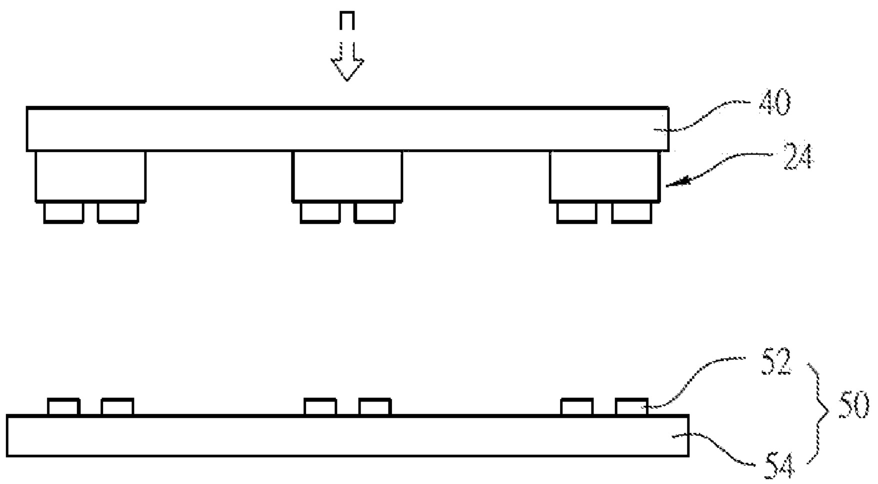


FIG. 2H

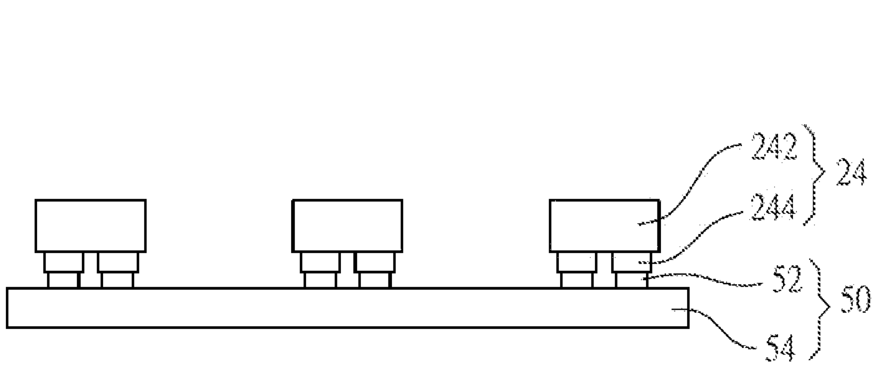


FIG. 2I

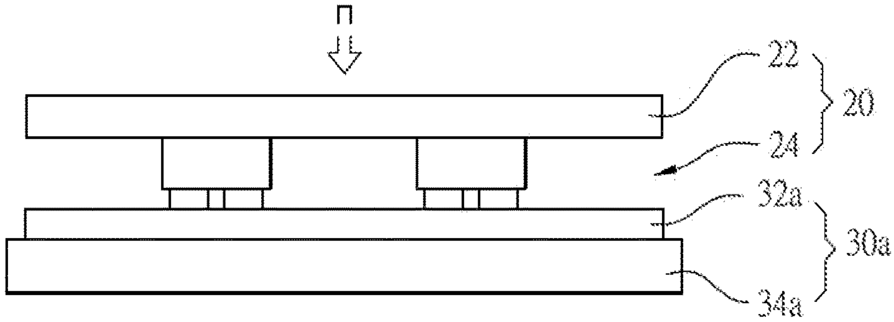


FIG. 3A

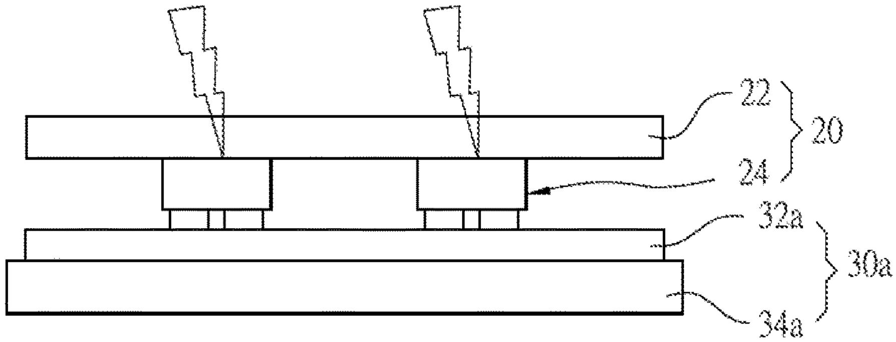


FIG. 3B

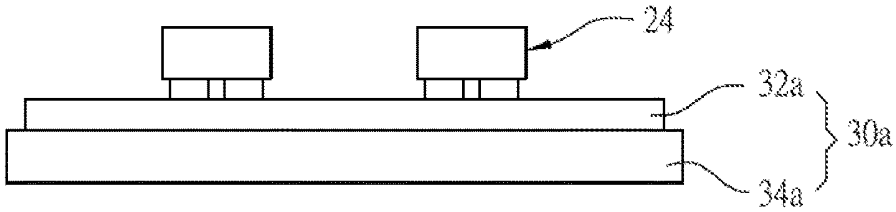


FIG. 3C

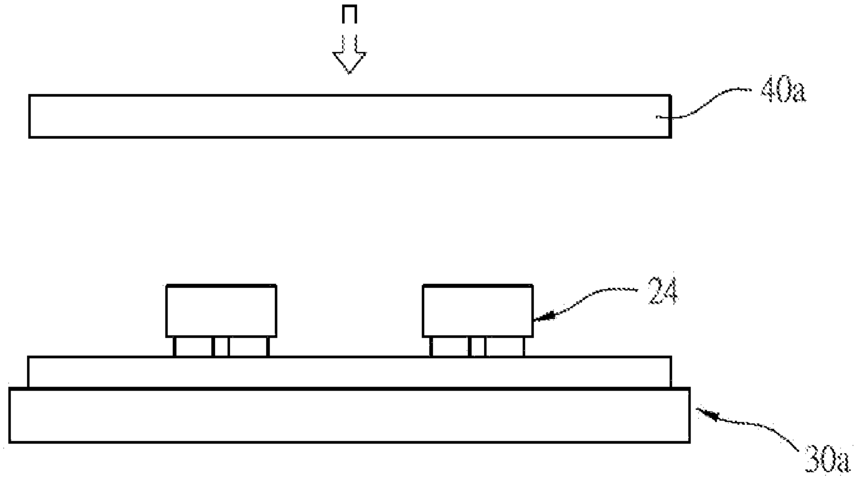


FIG. 3D

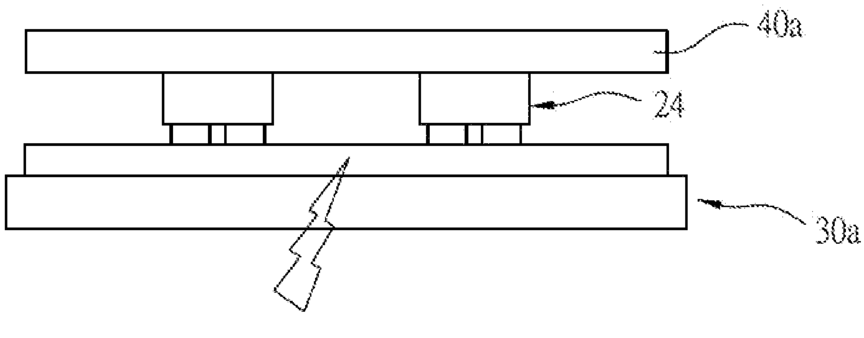


FIG. 3E

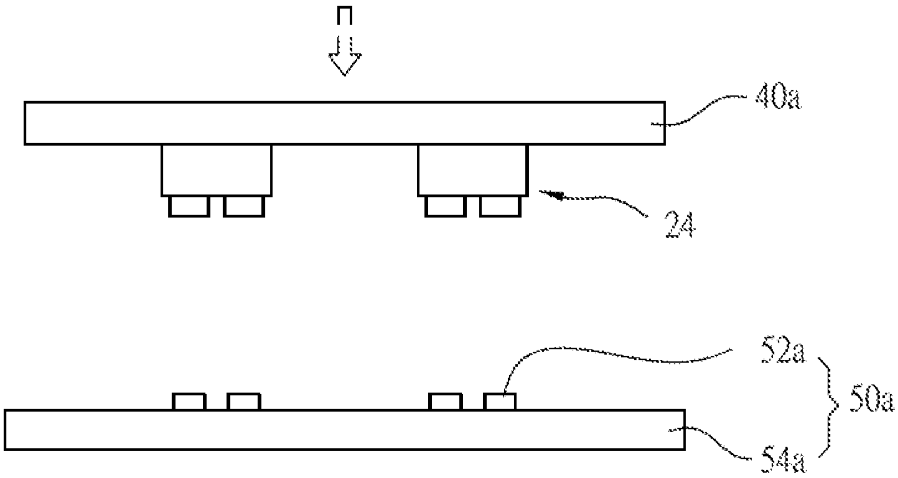


FIG. 3F

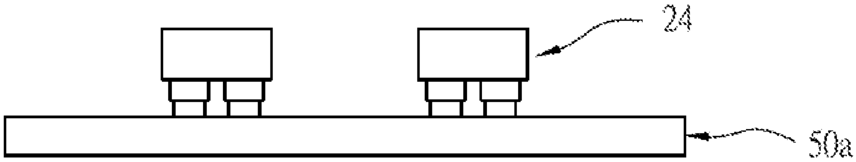


FIG. 3G

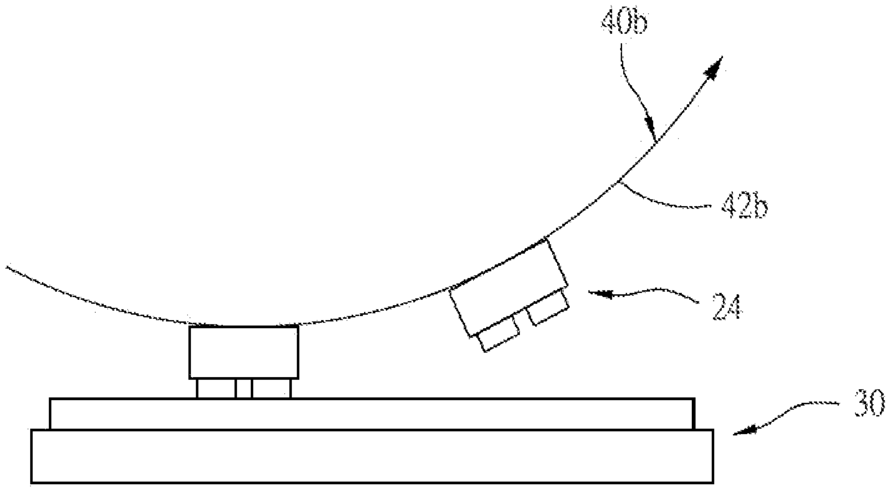


FIG. 4A

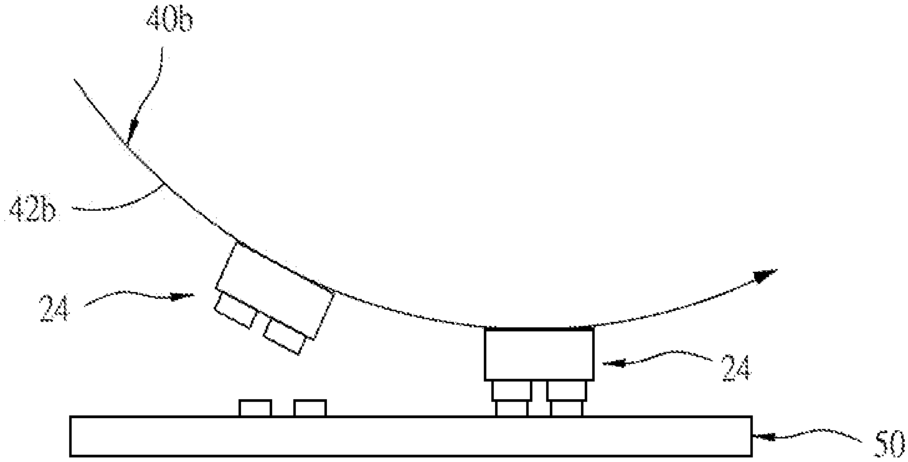


FIG. 4B

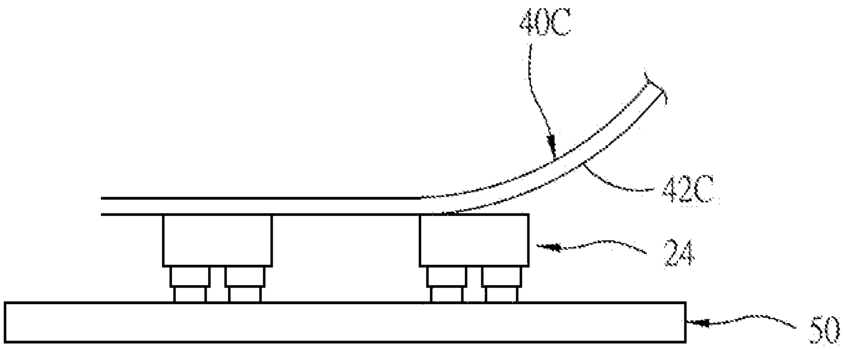


FIG. 5

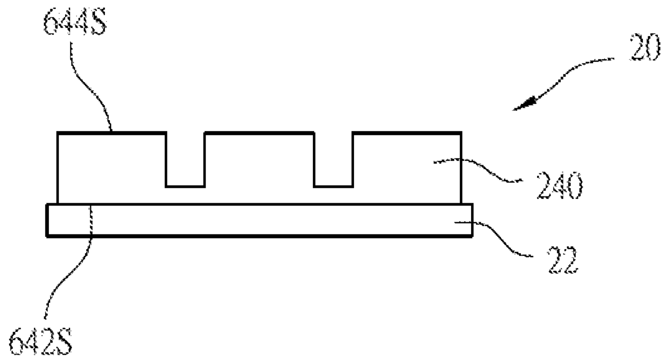


FIG. 6A

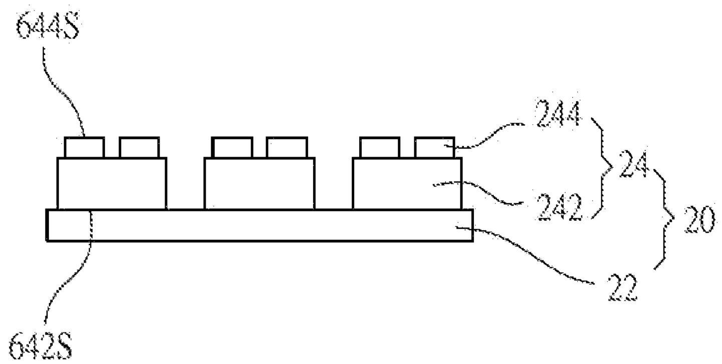


FIG. 6B

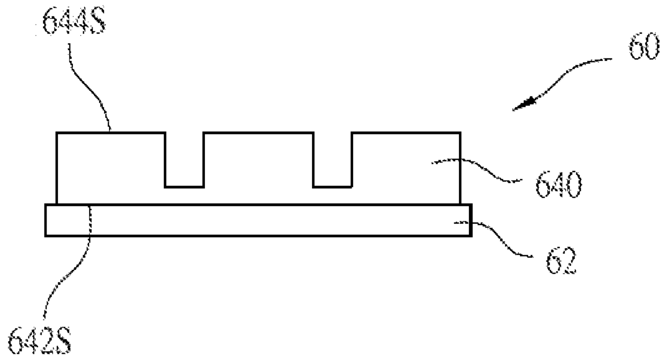


FIG. 7A

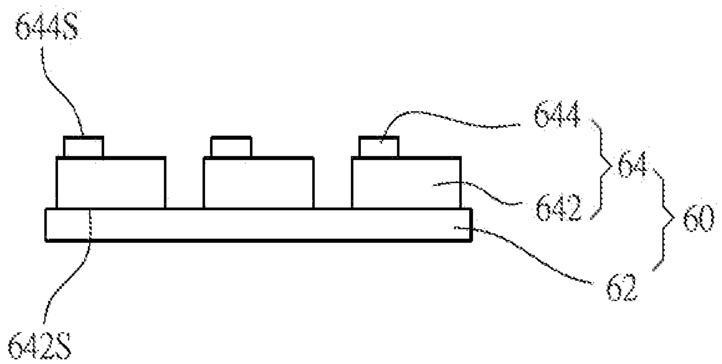


FIG. 7B

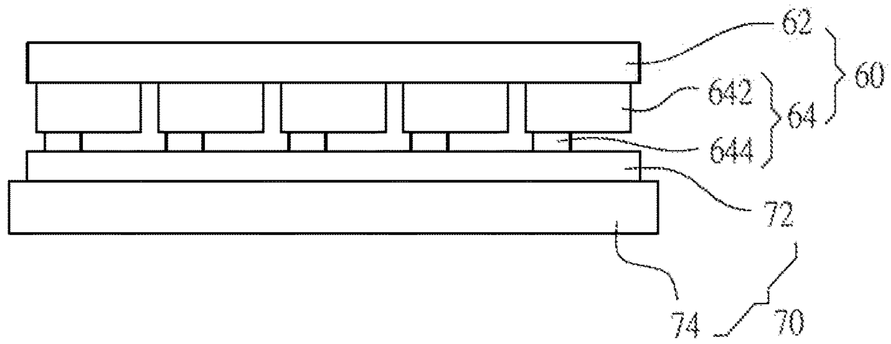


FIG. 8A

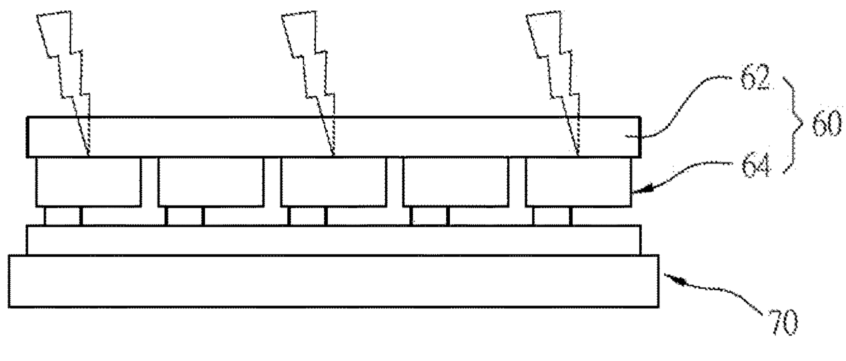


FIG. 8B

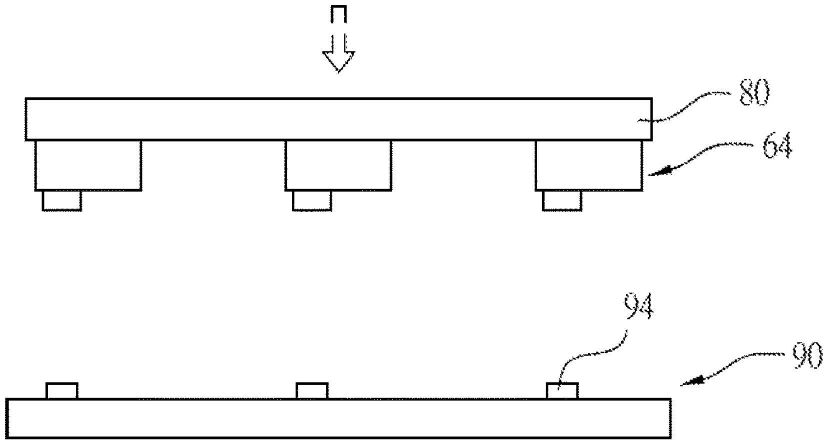


FIG. 8C

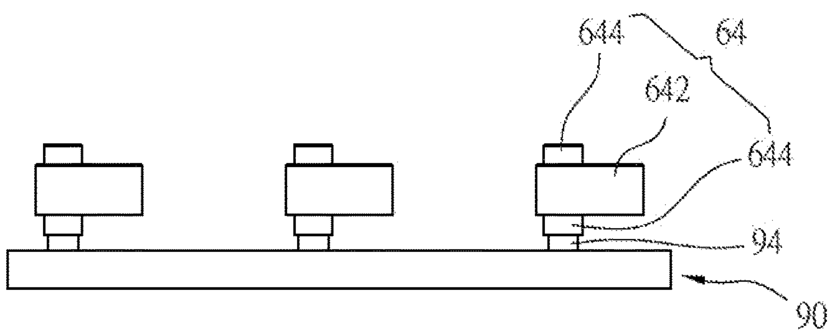


FIG. 8D

METHOD OF BATCH TRANSFERRING MICRO SEMICONDUCTOR STRUCTURES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This Non-provisional application claims priority under 35 U.S.C. § 119(a) on Patent Application No(s). 106125031 filed in Taiwan, Republic of China on Jul. 26, 2017, the entire contents of which are hereby incorporated by reference.

BACKGROUND

Technology Field

[0002] The present disclosure relates to a manufacturing process of the micro semiconductor structure and, in particular, to a manufacturing process of batch transferring micro semiconductor structures.

Description of Related Art

[0003] In some researches, it is found that the lifetime, energy consumption, viewing angle and resolution of micro LEDs are superior to those of flexible AMOLEDs, so that the micro LEDs have advantages in the market. However, in practice, the micro LEDs may have some technical limitations such as the circuit drive designs, LED uniformity, transferring for huge amount of workpieces.

[0004] In the conventional manufacturing process of LED (having a length over 100 micrometers), a plurality of individually independent and arrayed LED dies are manufactured by a series processes (e.g. half cutting (electrical insulation), testing, and full cutting) after the epitaxial process. Then, a pick-up head is used to select and transfer the LED dies one by one to a carrier substrate. However, in the micronization of LEDs, the conventional process may encounter several difficulties. For example, the edge length of the micro LED die is relatively smaller (e.g. 100 micron or less), so the pick-up head, which has limitation in scale minimization, cannot effectively pick up the micro LED dies. For another example, the micronization of the die size means that the number of LED dies fabricated by the same sized wafer can be greatly increased. Unfortunately, the conventional process of picking and transferring the LED dies one by one cannot meet the needs of huge amount of manufactured LED dies and will result in a very low yield.

[0005] In the industry, the micro contact printing technology has been applied to form a huge number of concave patterns on the polymer material plate for correspondingly picking the micro LED dies. This method can achieve the requirement of transferring a huge number of micro LED dies. However, in practice, since the size of the micro LED dies is very small, the interval between two adjacent concaves (or convex parts) on the polymer material plate cannot be easily controlled. In particular, even if the convex parts can precisely align and pick up the target dies to be transferred, the polymer material plate may still have a high risk to be deformed and to simultaneously pick up the other dies next to the target dies while the hardness and adhesiveness of the polymer material is not precisely controlled.

[0006] Therefore, it is desired to develop a more flexible manufacturing process.

SUMMARY

[0007] In view of the foregoing, the present disclosure is to provide a method of batch transferring micro semiconductor structures, which can transfer a batch of or a huge amount of micro semiconductor structures and can be widely applied to the art of transferring various micro semiconductor structures in batch or in a huge amount.

[0008] In view of the foregoing, the present disclosure is to provide a method of batch transferring micro semiconductor structures, which can select the micro semiconductor structures by laser lift-off (LLO) for transferring the micro semiconductor structures in batch or in a huge amount.

[0009] To achieve the above, the present disclosure provides a method of batch transferring micro semiconductor structures, which comprises the following steps:

[0010] attaching an adhesive material on a semiconductor device, wherein the semiconductor device comprises a native substrate and array-type micro semiconductor structures grown on the native substrate, and the array-type micro semiconductor structures define a plurality of micro semiconductor structures arranged in an array;

[0011] selectively lifting a part of the array-type micro semiconductor structures off the native substrate, so that a batch of the selected array-type semiconductor structures is remained on the adhesive material after the native substrate is removed; and

[0012] providing an attaching device for transferring the batch of the selected array-type micro semiconductor structures to a target substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The disclosure will become more fully understood from the detailed description and accompanying drawings, which are given for illustration only, and thus are not limitative of the present disclosure, and wherein:

[0014] FIG. **1**A is a flow chart of a method of batch transferring micro semiconductor structures according to a first embodiment of this disclosure;

[0015] FIG. **1**B is a flow chart of a method of batch transferring micro semiconductor structures according to a second embodiment of this disclosure;

[0016] FIG. **1**C is a flow chart of a method of batch transferring micro semiconductor structures according to a third embodiment of this disclosure;

[0017] FIGS. **2**A to **2**I are schematic diagrams showing the manufacturing process of FIG. **1**A;

[0018] FIGS. **3**A to **3**G are schematic diagrams showing another manufacturing process of FIG. **1**A;

[0019] FIGS. **4**A to **4**B are schematic diagrams showing still another manufacturing process of FIG. **1**A;

[0020] FIG. **5** is a schematic diagram showing still yet manufacturing process of FIG. **1**A;

[0021] FIGS. **6**A to **6**B are schematic diagrams showing a part of the manufacturing process of FIG. **1**B; and

[0022] FIGS. **7**A to **7**B and FIGS. **8**A to **8**D are schematic diagrams showing the manufacturing process of FIG. **1**C.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0023] The present disclosure will be apparent from the following detailed description, which proceeds with reference to the accompanying drawings, wherein the same references relate to the same elements.

[0024] A method of batch transferring micro semiconductor structures of this disclosure is used to pick up array-type micro-scaled structures/devices in batch and integrate them on to a non-native substrate without damaging the structures/devices. The present disclosure will be apparent from the following detailed description, which proceeds with reference to the accompanying drawings, wherein the same references relate to the same elements.

[0025] In the following, the terms "semiconductor structure" and "semiconductor device" are synonyms generally referring to a semiconductor material, die, structure, device, component of a device, or semi-finished product. The term "micro" of micro semiconductor structures and micro semiconductor devices generally refers to microscales. Semiconductor devices include high-quality monocrystalline semiconductors and polycrystalline semiconductors, semiconductor materials fabricated by high temperature processing, doped semiconductor materials, organic and inorganic semiconductors, and combinations of semiconductor materials and structures having one or more additional semiconductor components or non-semiconductor components (such as dielectric layers or materials, or conductive layers or materials). Semiconductor devices include, but are not limited to, transistors, photovoltaic devices including solar cells, diodes, light-emitting diodes, laser diodes, p-n junction diodes, photodiodes, integrated circuits, and sensors. In addition, a semiconductor device may refer to a component or portion of a functional semiconductor device or product.

[0026] In the following, the term "target substrate" refers to a non-native substrate for receiving the "micro semiconductor structures". The material of the native substrate or non-native substrate includes polymers, plastics, resins, polyimide, polyethylene naphthalate, polyethylene terephthalate, metal, foil, glass, flexible glass, semiconductor, sapphire, thin film transistor (TFT), or the likes.

[0027] For ease of understanding and explanation, the "micro semiconductor structure" used herein is exemplified by a micro LED (light-emitting diode) die, or a semi-finished product of a plurality of micro semiconductor structures that has been formed with at least one epitaxial layer and has been defined. The "semiconductor device" includes a "micro semiconductor structure" and a wafer for growing a "micro semiconductor structure." The "target substrate" as used herein is exemplified by a thin film transistor.

First Embodiment

[0028] FIGS. **1**A, **2**A to **2**I, **3**A to **3**G; and **6**A to **6**B are schematic diagrams showing the flow chart and most manufacturing process of the method of batch transferring micro semiconductor structures of this disclosure.

[0029] With reference to FIG. **2**B, a semiconductor device **20** includes a native substrate **22** and array-type micro semiconductor structures **24** grown on the native substrate **22**. The definition of the array-type micro semiconductor structures **24** is a plurality of micro semiconductor structures **24** arranged in an array. In addition, each semiconductor structure **24** includes at least one electrode **244**. Alternatively, the array-type micro semiconductor structures **24** may include a plurality of individual micro LED dies fabricated by complete manufacturing processes.

[0030] As shown in FIG. **1**A, the method of batch transferring micro semiconductor structures of this disclosure at least includes the following steps S**30**, S**40** and S**50**.

[0031] Referring to FIGS. **2**A and **2**B, the step S**20** is to attach an adhesive material **30** on a semiconductor device **20**. To be noted, the adhesive material **30** of this embodiment can be different depending on various material properties, types of micro LEDs, or methods for removing the native substrate **22**. In general, the adhesive material **30** comprises a base layer **34** and an adhesive layer **32** disposed on the base layer **34**. The adhesive layer **32** can be a UV tape. The components and aspects of the adhesive material **30** disclosed in this embodiment are for illustrations only and are not to limit this disclosure.

[0032] Referring to FIG. **2**C, the step S**30** is to selectively lift a part of the array-type micro semiconductor structures **24** off the native substrate **22**. In this embodiment, the part of the array-type micro semiconductor structures **24** are selectively lifted by laser lift-off (LLO) technology. In addition, a pattern of the selectively lifted array-type micro semiconductor structures **24** is usually corresponding to a pattern design on a target substrate **50** (see FIG. **21**). In this embodiment, the batch selecting event happens in the laser lift-off step, so whether the concave pattern is formed on the attaching device **40** in advance or not does not affect the following batch transferring step. In other words, the concave pattern formed by the conventional micro contact printing technology can also be used in this disclosure and is not excluded. Moreover, if a planar surface, instead of a surface with the concave pattern, is used, the technical trouble in the conventional micro contact printing technology can be avoided. As shown in FIG. **2**D, the semiconductor devices **20** are moved so that the batch of selected array-type micro semiconductor structures **24** can be remained on the adhesive material **30** after the native substrate **22** is removed. In addition, there are still some unselected micro semiconductor structures **24** remained on the native substrate **22**. These unselected array-type micro semiconductor structures **24** will be departed from the adhesive material **30** along with the native substrate **22**.

[0033] Referring to FIGS. **2**E to **2**H, the step S**40** is to provide an attaching device **40** for transferring the batch of the selected array-type micro semiconductor structures **24** to the target substrate **50**. In this embodiment, the attaching device **40** has a planar and uniform attaching surface **42**. As shown in FIG. **2**E, the attaching device **40** is an attaching plane, and the attaching surface **42** is formed on the attaching plane. The attaching plane moves toward the adhesive material **30** along a direction perpendicular to the adhesive material **30** for attaching the batch of selected array-type micro semiconductor structures **24**. As shown in FIG. **2**F, a UV light is provided to irradiate and cure the adhesive material **30**, which is made of a UV tape, thereby decreasing the adhesion between the adhesive material **30** and the batch of selected array-type micro semiconductor structures **24**. As shown in FIG. **2**G the attaching device **40** carries the batch of selected array-type micro semiconductor structures **24** to depart from the adhesive material **30** along the direction perpendicular to the adhesive material **30**. As shown in FIG. **2**H, the attaching device **40** transfers the batch of selected array-type micro semiconductor structures **24** to the target substrate **50**. In general, the target substrate **50** at least includes a thin-film substrate **52** and a plurality of conductive portions **54** disposed on the thin-film substrate **52**. The conductive portions **54** can include metal electrodes, which is pre-fusible and is attachable. Moreover, the conductive portions **54** may further include solders or similar attaching materials preset on the metal electrodes. To be noted, the above description of the conductive portions **54** is for an example and is not for limiting the scope of the disclosure. Referring to FIG. **21**, the conductive portions **54** of the target substrate **50** are contacted and adhered to the electrodes **244** of the batch of selected array-type micro semiconductor structures **24**, and the attaching device **40** is removed when or after the batch of selected array-type micro semiconductor structures **24** are positioned on the target substrate **50**.

[0034] In another embodiment, as shown in FIGS. **4**A to **4**B, the attaching device includes at least one attaching roller **40***b*, and an attaching surface **42***b* is formed on the attaching roller **40***b*. The attaching roller **40***b* can transfer and position the batch of selected array-type micro semiconductor structures **24** on the target substrate **50**.

[0035] As shown in FIG. **5**A, the attaching device is still an attaching plane **40***c*, and the attaching surface **42***c* is formed on the attaching plane **40***c*. The attaching plane **40***c* can transfer and position the batch of selected array-type micro semiconductor structures **24** on the target substrate **50**. Then, the attaching plane **40***c* is torn off by an angle. Similarly, the attaching plane **40***c* can attach (pick up) the batch of selected array-type micro semiconductor structures **24** by an angle.

[0036] With reference to FIGS. **1**A and **3**A to **3**G; the semiconductor device **20** containing the remained unselected micro semiconductor structures **24** can go through the steps S**20**, S**30** and S**40** again.

[0037] Referring to FIG. **3**A, in the semiconductor device **20**, the step S**20** is performed to selectively lift a part or all of the remained array-type micro semiconductor structures **24** off the native substrate **22**.

[0038] Referring to FIG. **3**B, in the step S**30**, the selectively lift-off pattern can be corresponding to the same target substrate **50** or another target substrate. If all of the remained unselected micro semiconductor structures **24** are lifted off, the native substrate **22** can be completely removed individually (see FIG. **3**C).

[0039] Referring to FIGS. **3**D to **3**G the step S**40** is to provide an attaching device for transferring the batch of the array-type micro semiconductor structures **24** to the target substrate. Herein, the provided attaching device can be the same attaching device **40** used in the previous step S**40** or another attaching device **40***a*. The target substrate can be the same target substrate **50** as shown in FIGS. **2**H and **21**, or another target substrate **50***a*. Similar to the above-mentioned target substrate **50**, the target substrate **50***a* also includes a thin-film substrate **52***a* and a plurality of conductive portions **54***a* disposed on the thin-film substrate **52***a*. The attaching device **40***a* also has a planar and uniform attaching surface **42***a*. As shown in FIG. **3**D, the attaching device **40***a* attaches the array-type micro semiconductor structures **24** remained on the adhesive material **30**. As shown in FIG. **3**E, a UV light is provided to irradiate and cure the adhesive material **30**, thereby decreasing the adhesion between the adhesive material **30** and the array-type micro semiconductor structures **24**. As shown in FIG. **3**F, the attaching device **40***a* carries the batch of selected remained array-type micro semiconductor structures **24** to depart from the adhesive material **30**. As shown in FIG. **3**G, the attaching device **40***a* transfers the batch of selected remained array-type micro semiconductor structures **24** to the target substrate **50***a*, and then the attaching device **40***a* is removed.

Second Embodiment

[0040] FIGS. **1**B and **6**A to **6**B are schematic diagrams showing the details of FIG. **1**A, and the steps and components having similar instructions and functions have the same reference numbers.

[0041] In this embodiment, before the step S**20**, the step S**10** is to prepare the semiconductor device **20**.

[0042] The step S**10** at least includes two steps S**12** and S**14**. The step S**12** is to provide a native substrate **22** grown with a structural layer **240** (see FIG. **6**A), and the step S**14** is to perform a following manufacturing process with the structural layer **240** to form a plurality of micro semiconductor structures **24** in an array on the native substrate **22** (see FIG. **6**B). The steps of preparing the structural layer **240** and forming a plurality of micro semiconductor structures **24** may not be continuous steps. In other words, the steps S**12** and S**14** can be not consequent steps, and an additional step or additional steps can be performed between the steps S**12** and S**14**. The structural layer **240** and the array-type micro semiconductor structures **24** have the same first surface **242***s* and the same second surface **244***s*. The first surface **242***s* of the array-type micro semiconductor structures **24** is defined by the micro semiconductor semi-structures **242**, and the first surface **242***s* of the array-type micro semiconductor structures **24** is attached to the native substrate **22**. The second surface **244***s* of the array-type micro semiconductor structures **24** is opposite to the first surface **242***s* and defined by the electrodes **244**.

Third Embodiment

[0043] FIGS. **1**C, **7**A, **7**B and **8**A to **8**D show a third embodiment of this disclosure, wherein the electrodes of the micro semiconductor structures are different. To make this embodiment be more easily understood, the electrodes of the micro semiconductor structures are vertical electrodes for example. The steps referring to similar indications and functions of the second embodiment will use the same reference numbers.

[0044] The step S**10** at least includes the steps S**12**, S**14** and S**16**.

[0045] The step S**12** is to provide a native substrate **62** grown with a structural layer **640** (see FIG. **7**A).

[0046] The step S**14** is to perform a following manufacturing process with the structural layer **640** to form a plurality of micro semiconductor structures **64** in an array on the native substrate **62**. In this embodiment, each of the array-type micro semiconductor structures **64** comprises a single electrode **644** only (either an upper electrode or a lower electrode). The first surface **642***s* of the array-type micro semiconductor structures **64** is defined by the micro semiconductor semi-structures **642**, and the first surface **642***s* of the array-type micro semiconductor structures **64** is attached to the native substrate **62**. The second surface **644***s* of the array-type micro semiconductor structures **64** is opposite to the first surface **642***s* and defined by the electrodes **644** (see FIG. **7**B).

[0047] In the step S**20**, one end of the micro semiconductor structures **64** configured with the electrodes **644** is attached to the adhesive material **70** (see FIG. **8**A) so as to selectively lift off a batch of selected array-type micro semiconductor structures **64** (see FIG. **8**B).

[0048] After the step S**40**, the batch of the array-type micro semiconductor structures **64** are transferred to a target substrate **90**. The target substrate **90** is configured with a plurality of conductive portions **94**, and the single electrode **644** of each micro semiconductor structure **64** is connected with the conductive portion **94** of the target substrate **90** (see FIG. **8**C).

[0049] The step S**16** is to prepare another electrode **644** on the batch of the array-type micro semiconductor structures **64** (see FIG. **8**D).

[0050] In this disclosure, the term "batch transferring" (transfer a batch of micro semiconductor structures) is to select and transfer at least a part of at least one row of the micro semiconductor structures **24** or **64**. In some embodiments, to transfer a batch of micro semiconductor structures can be to select and transfer a plurality of rows of micro semiconductor structures **24** or **64**, to select and transfer a part of a row of micro semiconductor structures **24** or **64**, to select and transfer a part of a plurality of rows of micro semiconductor structures **24** or **64**, or any combination of the above. Similarly, the term "batch transferring" is usually determined by the design requirement of the target substrate **50** or **50***a*. These examples are for illustrations only and not to limit the explanation of the term "batch transferring".

[0051] The above-described embodiments and their processing flows may all be disassembled, misplaced, replaced, or mixed, and implemented together with permission of process conditions.

[0052] Therefore, the present disclosure can be implemented by any combination, under the permission of process conditions, according to the concept of replacing the main steps, disassembling/substituting sub-steps, or adjusting the implementation order of at least one sub-step in another main step.

[0053] Accordingly, the method of batch transferring micro semiconductor structures of this disclosure can efficiently and effectively select and pick up the micro semiconductor structures **24** or **64** (micro-scaled structures/devices) in batch or in a huge amount and integrate them on to the target substrate **50**, **50***a* or **90** (non-native substrate). This method can be applied to different micro LED dies, devices or semi-products, and can be further widely used to transfer various micro semiconductor structures in batch or in a huge amount.

[0054] As mentioned above, the method of batch transferring micro semiconductor structures of this disclosure includes, for example but not limited to, the following functions.

[0055] 1. The batch selecting event happens in the laser lift-off step, so whether the concave pattern is formed on the attaching device in advance or not does not affect the following batch transferring step. Therefore, the manufacturing process becomes more flexible.

[0056] 2. The batch selecting event happens in the laser lift-off step, so it is unnecessary to form the concave pattern on the attaching device in advance, which can avoid the technical difficult derived by the micro-contact printing process.

[0057] 3. The method can be used to select and transfer the ultra-thin, fragile and/or small devices without causing the damage of the devices.

[0058] 4. The method can efficiently and effectively transfer the micro semiconductor structures in batch or in a huge amount on to the target substrate.

[0059] 5. The method can reduce the assembling cost and increase the production yield, so it can be widely applied to transfer the micro semiconductor structures in batch or in a huge amount.

[0060] Although the disclosure has been described with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as alternative embodiments, will be apparent to persons skilled in the art. It is, therefore, contemplated that the appended claims will cover all modifications that fall within the true scope of the disclosure.

What is claimed is:

1. A method of batch transferring micro semiconductor structures, comprising:

attaching an adhesive material on a semiconductor device, wherein the semiconductor device comprises a native substrate and array-type micro semiconductor structures grown on the native substrate, and the array-type micro semiconductor structures define a plurality of micro semiconductor structures arranged in an array;

selectively lifting a part of the array-type micro semiconductor structures off the native substrate, so that a batch of the selected array-type semiconductor structures is remained on the adhesive material after the native substrate is removed; and

providing an attaching device for transferring the batch of the selected array-type micro semiconductor structures to a target substrate.

2. The method according to claim **1**, after or in the step of selectively lifting the part of the array-type micro semiconductor structures off the native substrate, further comprising:

removing the unselected array-type semiconductor structures from the attaching material along with the native substrate.

3. The method according to claim **1**, wherein the step of selectively lifting the part of the array-type micro semiconductor structures off the native substrate comprises:

selectively lifting the part of the array-type micro semiconductor structures off the native substrate by laser lift-off technology.

4. The method according to claim **1**, wherein the attaching device has a planar and uniform attaching surface.

5. The method according to claim **4**, wherein the attaching device comprises an attaching plane, and the attaching surface is formed on the attaching plane.

6. The method according to claim **4**, wherein the attaching device comprises at least an attaching roller, and the attaching surface is formed on the attaching roller.

7. The method according to claim **3**, wherein the attaching device has a planar and uniform attaching surface.

8. The method according to claim **7**, wherein the attaching device comprises an attaching plane, and the attaching surface is formed on the attaching plane.

9. The method according to claim **7**, wherein the attaching device comprises at least an attaching roller, and the attaching surface is formed on the attaching roller.

10. The method according to claim **1**, before the step of attaching the adhesive material on the semiconductor device, further comprising:

growing the array-type micro semiconductor structures on the native substrate, wherein the grown array-type micro semiconductor structures are a plurality of defined micro semiconductor structures, each of which comprises at least an epitaxial layer.

11. The method according to claim **1**, wherein the batch of the array-type micro semiconductor structures on the target substrate are horizontal-electrode micro light-emitting diode dies.

12. The method according to claim **1**, wherein the batch of the array-type micro semiconductor structures on the target substrate are vertical-electrode micro light-emitting diode dies.

* * * * *

专利名称(译)	批量转移微半导体结构的方法		
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[标]发明人	CHEN HSIEN TE		
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摘要(译)

提供了一种批量转移微半导体结构的方法。该方法利用选择性激光剥离（选择性LLO）技术，并且在选择性LLO工艺期间批量选择微半导体结构。因此，以下转移步骤不需要预先制备凹形图案，从而避免了通过微接触印刷工艺产生的技术难题。