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(54) **TRANSFER DEVICE**

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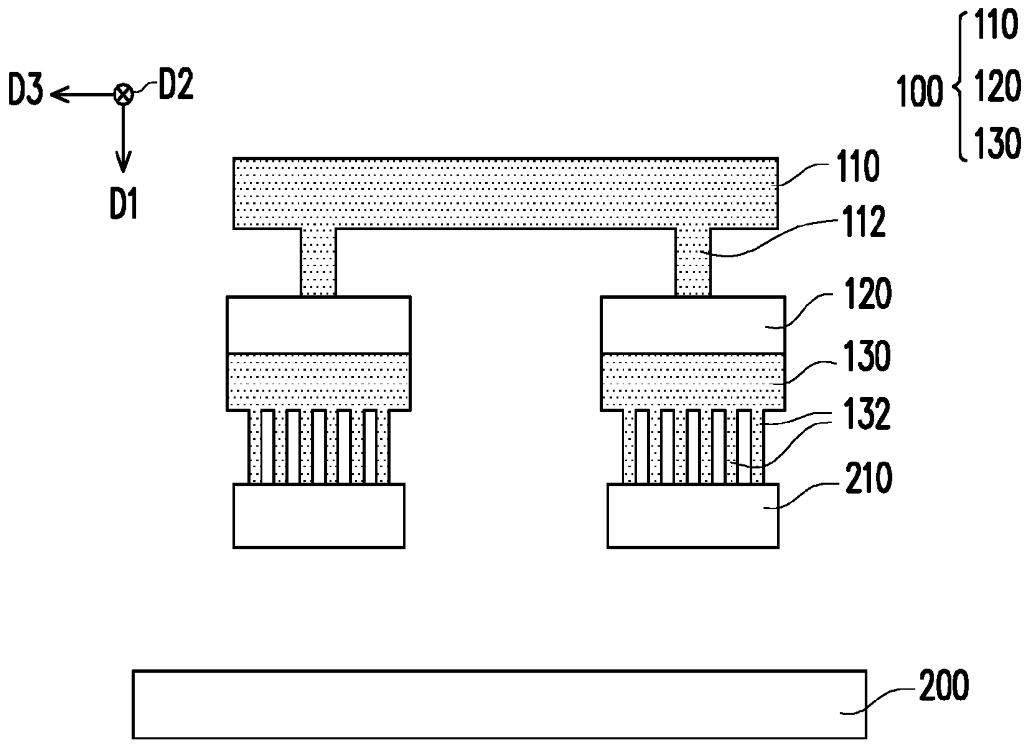
CPC ***H01L 21/67721*** (2013.01); ***H01L 33/00*** (2013.01); ***H01L 21/683*** (2013.01)

(57) **ABSTRACT**

A transfer device for transferring a plurality of micro LED dies is provided. The transfer device includes a carrier plate, a plurality of deformable components, and a plurality of transfer heads. The plurality of deformable components are disposed on the carrier plate. The plurality of transfer heads are respectively disposed on the plurality of deformable components. Each of the transfer heads includes a plurality of micro protrusions arranged in an array on a side away from the corresponding one deformable component. Deformation of the deformable components leads to deformation of the transfer heads, such that a number of the micro protrusions in contact with the micro LED dies is decreased. Accordingly, the transfer device can easily release the micro LED dies.



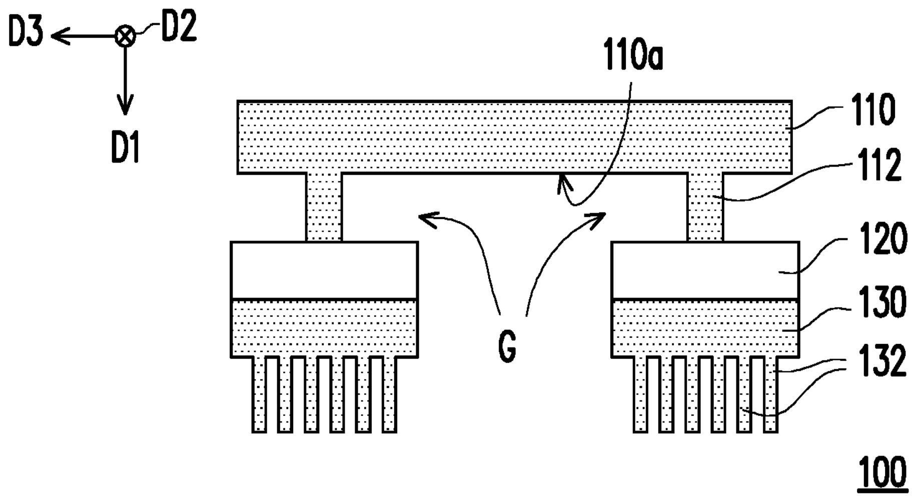


FIG. 1

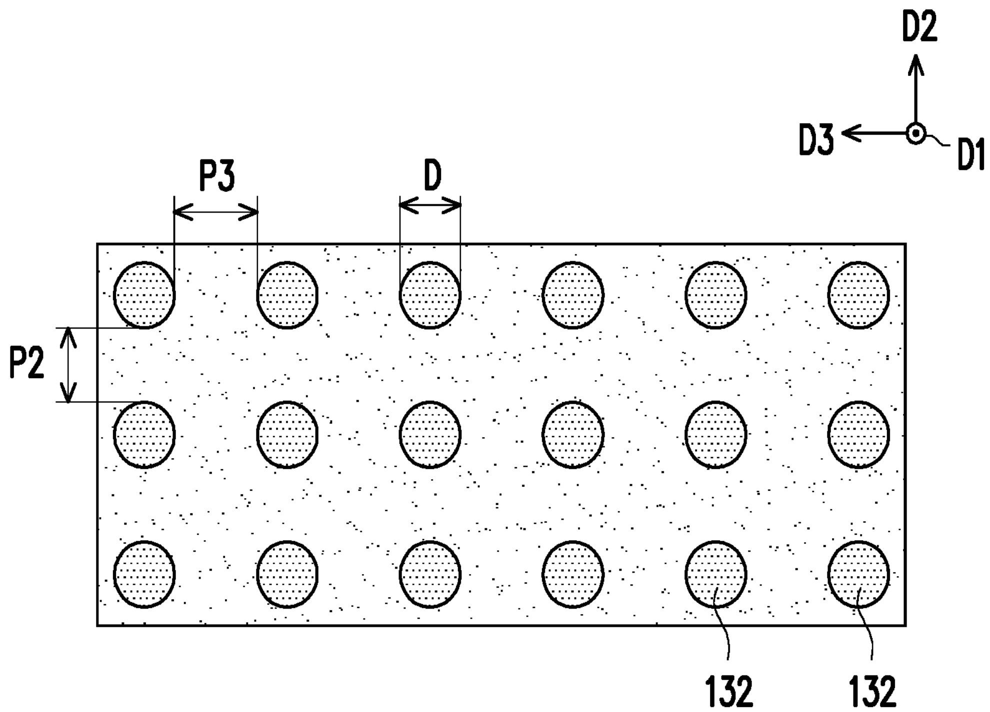


FIG. 2

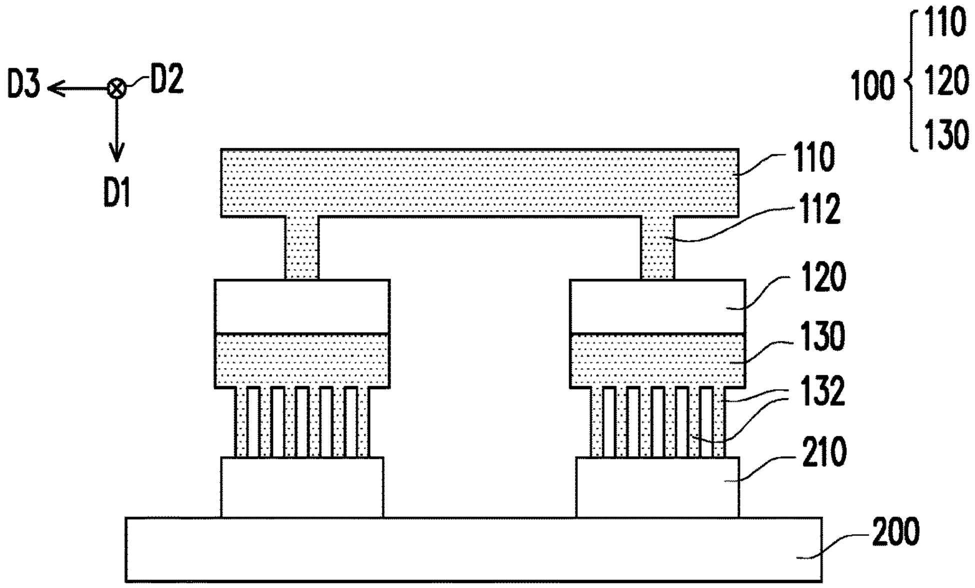

110
100
120
130
D3
D2
D1
110
112
120
130
132
210
200

FIG. 3A

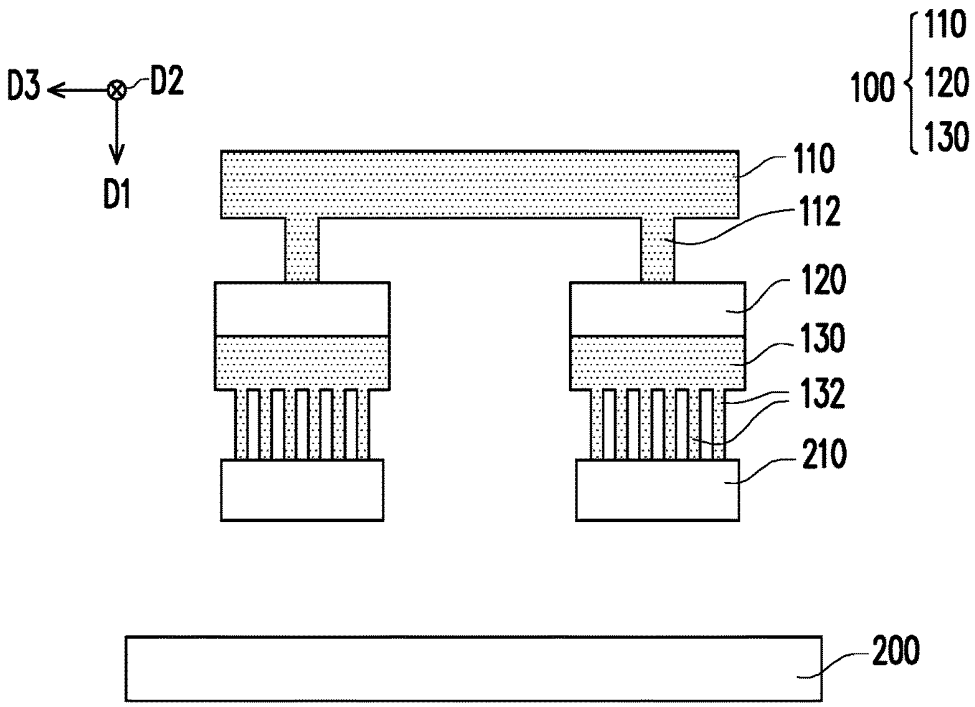

110
100
120
130
D3
D2
D1
110
112
120
130
132
210
200

FIG. 3B

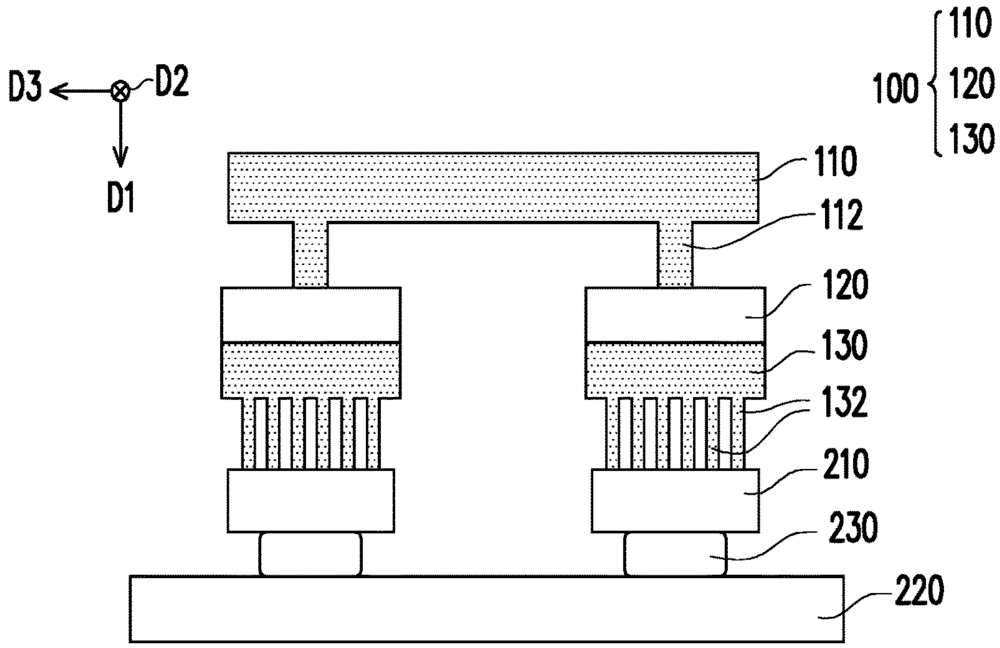

D3
D2
D1
100
110
120
130
110
112
120
130
132
210
230
220

FIG. 3C

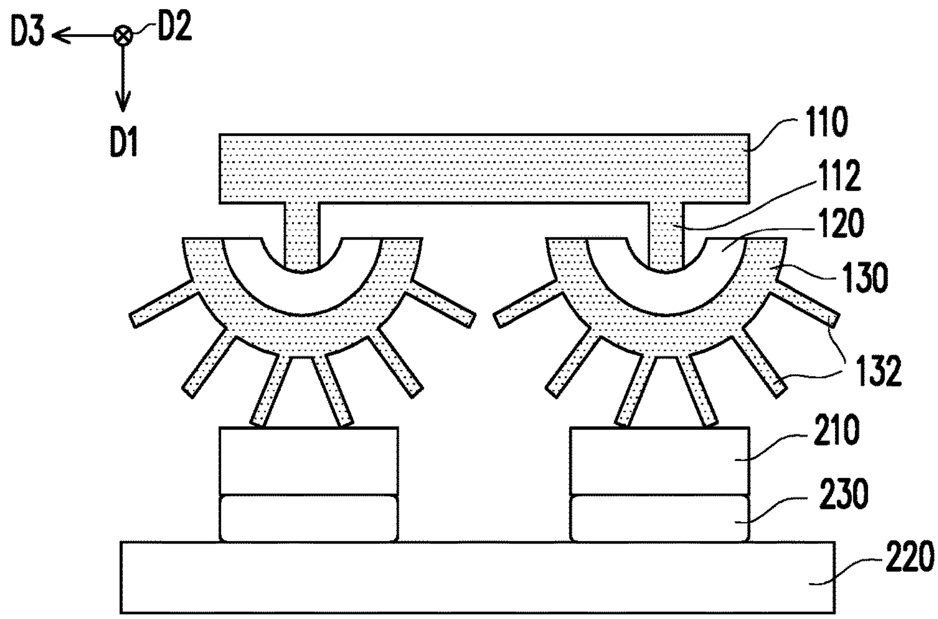

D3
D2
D1
110
112
120
130
132
210
230
220

FIG. 3D

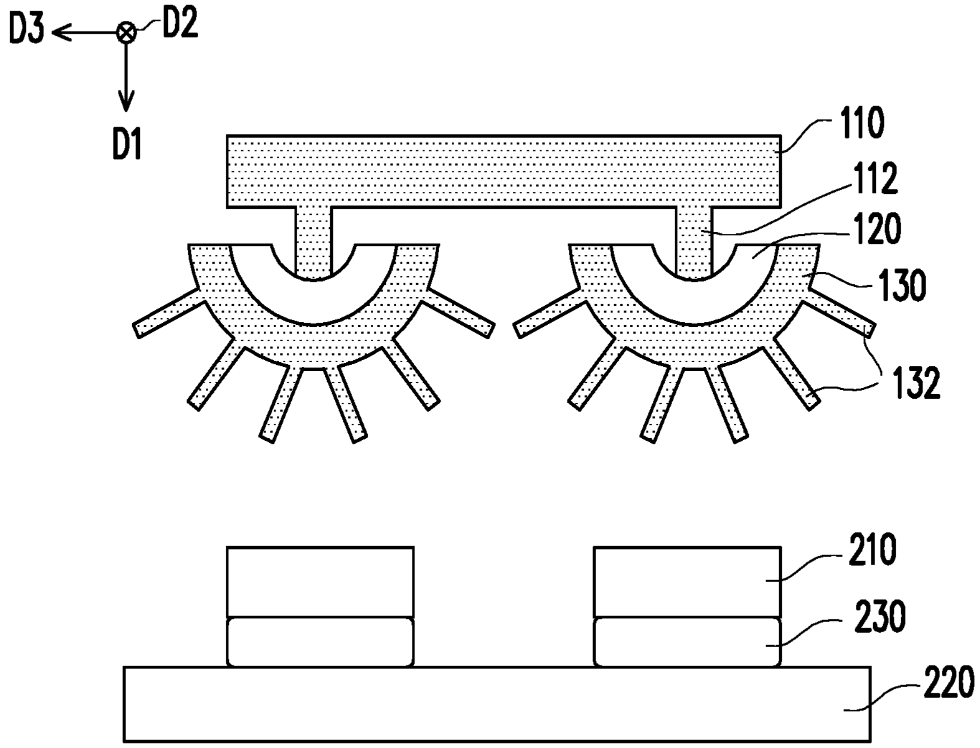


FIG. 3E

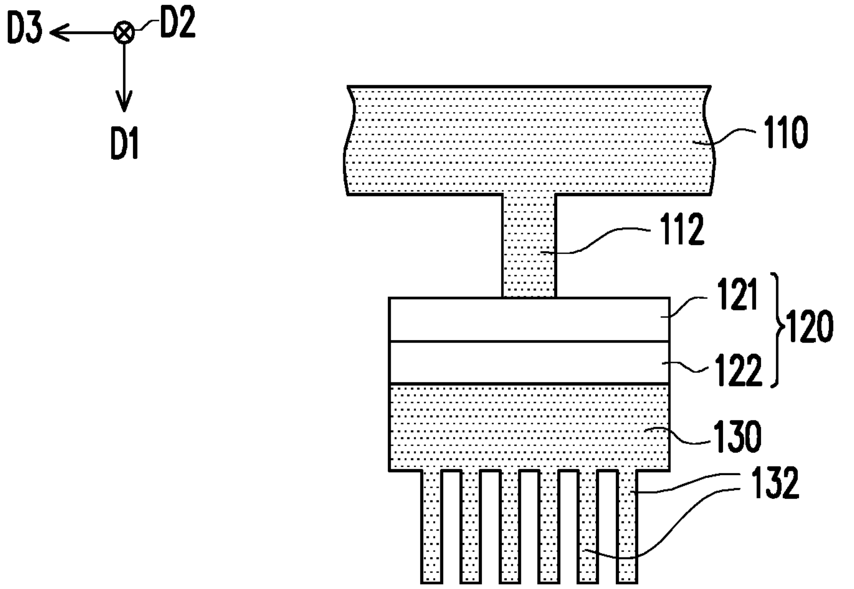

D3
D2
D1
110
112
121
120
122
130
132

FIG. 4

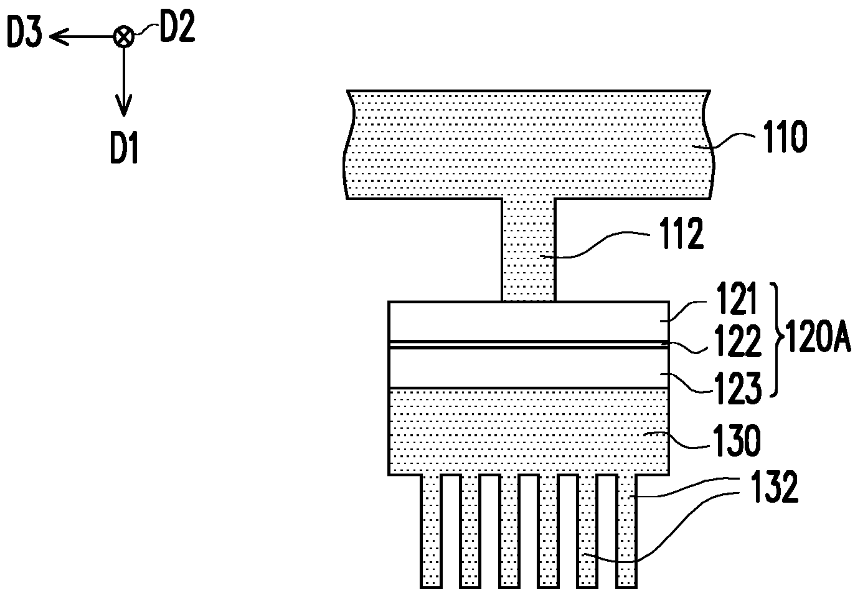

D3
D2
D1
110
112
121
122
120A
123
130
132

FIG. 5

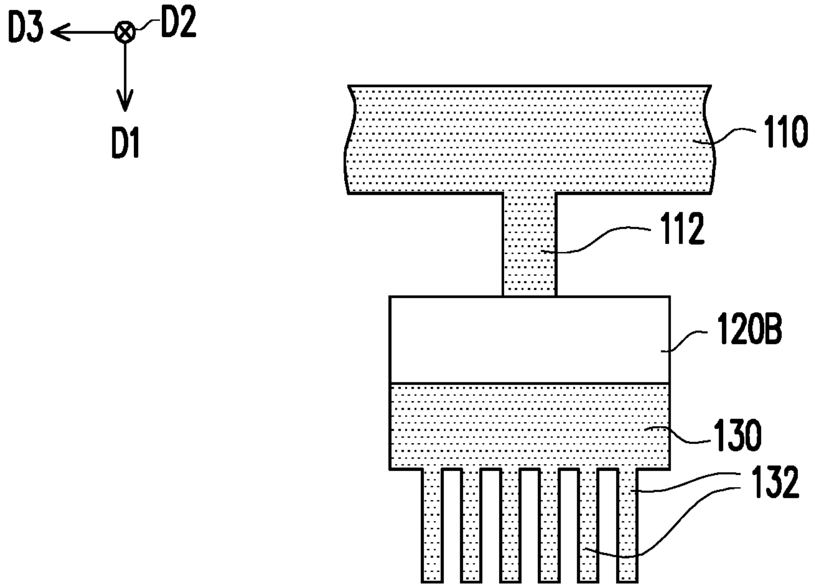


FIG. 6

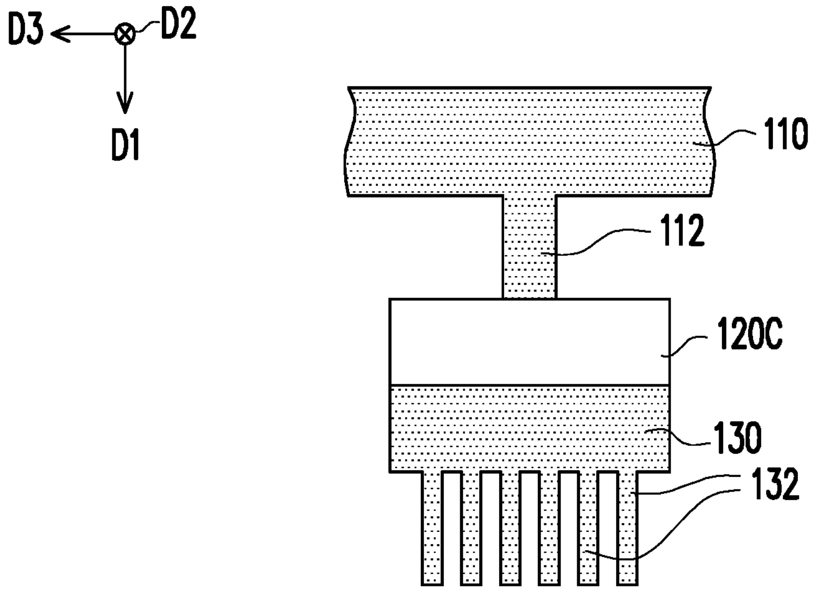


FIG. 7

TRANSFER DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of China application serial no. 201810117400.9, filed on Feb. 6, 2018. 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 disclosure relates to LED display manufacturing equipment, and in particular, to a transfer device for micro LED dies.

Description of Related Art

[0003] In recent years, organic light-emitting diode (OLED) display panels have gradually replaced liquid-crystal display (LCD) panels in the mobile communication device markets and have been slowly penetrating the large-screen TV markets. Although a color saturation, a response speed, and a contrast of OLED display panels are all more desirable than those of mainstream LCD panels, a lifetime of products is not comparable to that of the current mainstream displays.

[0004] With the OLED display panels incurring relatively high manufacturing costs, micro LED displays have come to attract attention from many manufacturers. Micro LED displays show optical performance comparable to the OLED display technology and further exhibit advantages of low power consumption and a long lifetime of materials. However, the manufacturing costs of micro LED displays are still higher than those of the OLED displays in the current techniques. One of the main reasons is that, in the manufacturing technique of the micro LED displays, manufactured micro LED dies are directly transferred onto a driving circuit plate through a die transfer method. Although such high-volume transfer technique exhibits potential advantages in manufacturing large-size products, there are bottlenecks to overcome in terms of the relevant manufacturing techniques as well as equipment.

[0005] The pick up method used in the current die transfer techniques includes methods involving an electrostatic force, an electromagnetic force, a van der Waals force, an adhesive material, or self-assembly. The electrostatic force method requires a higher external voltage, so there are high risks of arcing and dielectric breakdown. Although the self-assembly transfer technique has developmental potential in rapid die transfer, it requires a high-precision control technique for a fluid evaporation rate. Moreover, control difficulty is present in large-area manufacturing and may result in failed die transfers. When the van der Waals force is exploited to adsorb dies, adsorption and desorption of dies depend on a rate at which an elastomer macromolecular stamp is contacted with the dies. Therefore, precise control over actuations of the stamp is required, and a success rate of transfer is not high.

SUMMARY OF THE INVENTION

[0006] The embodiments of the invention provide a transfer device for transferring micro LED dies. By using the transfer device, a success rate of transferring the micro LED dies is high.

[0007] An embodiment of the invention provides a transfer device including a carrier plate, a plurality of deformable components, and a plurality of transfer heads. The plurality of deformable components are disposed on the carrier plate. The plurality of transfer heads are respectively disposed on the plurality of deformable components. Each of the transfer heads includes a plurality of micro protrusions arranged in an array on a side away from the corresponding one deformable component.

[0008] In another embodiment of the invention, each of the deformable components of the transfer device is adapted to be deformed due to an influence of light, heat, or electricity, and the deformed deformable components protrude towards a direction away from the carrier plate.

[0009] In another embodiment of the invention, the deformable components of the transfer device include a first material layer and a second material layer. The first material layer is disposed on the carrier plate and has a first coefficient of thermal expansion. The second material layer is disposed on the first material layer and has a second coefficient of thermal expansion. The second coefficient of thermal expansion is larger than the first coefficient of thermal expansion.

[0010] In another embodiment of the invention, the deformable components of the transfer device include an alloy formed of at least two metals having different resistivities.

[0011] In another embodiment of the invention, the deformable components of the transfer device include a titanium layer and a first nickel layer. The titanium layer is disposed on the carrier plate. The first nickel layer is disposed on the titanium layer.

[0012] In another embodiment of the invention, the deformable components of the transfer device further include a second nickel layer. The titanium layer is sandwiched between the first nickel layer and the second nickel layer.

[0013] In another embodiment of the invention, the deformable components of the transfer device include macromolecules having azobenzene group in a molecular structure.

[0014] In another embodiment of the invention, the plurality of micro protrusions of the transfer device include a plurality of pillars spaced apart from each other.

[0015] In another embodiment of the invention, the carrier plate of the transfer device includes a plurality of carrying bumps spaced apart from each other, and the plurality of deformable components are respectively disposed on the plurality of carrying bumps.

[0016] In another embodiment of the invention, each of the carrying bumps is located within an area of the corresponding one deformable component.

[0017] The transfer device of the embodiments of the invention picks up the micro LED dies by using the transfer heads. When the transfer device is to release the micro LED dies, the deformable components are deformed, which leads to bending of the transfer heads, such that a number of the micro protrusions of the transfer heads in contact with the micro LED dies is decreased. When the number of the micro protrusions in contact with the micro LED dies is decreased to the extent that a van der Waals force cannot be sufficiently generated, the micro LED dies are naturally released from the transfer heads and successfully transferred onto a target (e.g., a driving circuit plate). Accordingly, a success rate of transferring the micro LED dies is high, and the micro LED dies can be rapidly transferred in large quantities.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The accompanying drawings are included to allow further understanding of the embodiments of invention, and the drawings are incorporated into the specification and form a part of the specification. The drawings illustrate the embodiments of the invention, and the drawings and the description together are used to interpret the principles of the invention.

[0019] FIG. **1** is a cross-sectional schematic diagram illustrating a transfer device according to an embodiment of the invention.

[0020] FIG. **2** is a top-view schematic diagram illustrating a transfer head according to an embodiment of the invention.

[0021] FIG. **3**A to FIG. **3**E illustrate a process of transferring a plurality of micro LED dies by using a transfer device according to an embodiment of the invention.

[0022] FIG. **4** illustrates a cross-section of a deformable component according to an embodiment of the invention.

[0023] FIG. **5** illustrates a cross-section of a deformable component according to another embodiment of the invention.

[0024] FIG. **6** illustrates a cross-section of a deformable component according to another embodiment of the invention.

[0025] FIG. **7** is a cross-sectional schematic diagram illustrating a deformable component according to another embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

[0026] Reference will now be made in detail to the exemplary embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0027] FIG. **1** is a cross-sectional schematic diagram illustrating a transfer device according to an embodiment of the invention. Referring to FIG. **1**, a transfer device **100** includes a carrier plate **110**, a plurality of deformable components **120**, and a plurality of transfer heads **130**. The plurality of deformable components **120** are disposed on the carrier plate **110**. In the present embodiment, the carrier plate **110** is selectively an elastomer. For example, a material of the carrier plate **110** includes polysiloxane, or more specifically, polydimethyl siloxane, but the invention is not limited hereto.

[0028] For example, in the present embodiment, the carrier plate **110** selectively includes a plurality of carrying bumps **112** spaced apart from each other, and the plurality of deformable components **120** are respectively disposed on the plurality of carrying bumps **112**. The carrier plate **110** includes a working surface **110***a* configured to face micro LED dies (not illustrated). The carrying bump **112** is located within an area of the deformable component **120**. By disposing the deformable components **120** on the carrying bumps **112**, a space G is present between the deformable components **120** and the working surface **110***a* of the carrier plate **110** to allow the deformable components **120** to stretch when they are deformed. However, the invention is not limited hereto. In other embodiments, the space G may also be maintained between the deformable components **120** and the working surface **110***a* of the carrier plate **110** by using other components, or the deformable components **120** may also be directly disposed on the working surface **110***a* of the carrier plate **110**.

[0029] The plurality of transfer heads **130** are respectively disposed on the plurality of deformable components **120**. The transfer head **130** includes a plurality of micro protrusions **132** arranged in an array on a side away from the deformable component **120**. For example, in the present embodiment, the plurality of micro protrusions **132** may be a plurality of pillars extending towards micro LED dies **210** (illustrated in FIG. 3A) to be transferred, and the plurality of pillars are spaced apart from each other.

[0030] FIG. **2** is a top-view schematic diagram illustrating a transfer head according to an embodiment of the invention. Specifically, FIG. **2** is a top-view schematic diagram of the transfer head **130** viewed along an opposite direction of a direction D1 in FIG. **1**. Referring to FIG. **1** and FIG. **2**, in the present embodiment, the micro protrusion **132** has a diameter D. The micro protrusion **132** extends in the direction D**1**. Two adjacent micro protrusions **132** have a gap P2 in a direction D2 perpendicular to the direction D**1**. Two adjacent micro protrusions **132** have a gap P**3** in a direction D**3** perpendicular to the direction D**1** and the direction D**2**. By adjusting the diameter D, the gap P**2**, and/or the gap P**3** of the micro protrusions **132**, a magnitude of pick up force of the transfer head **130** with respect to the micro LED die **210** can be controlled. For example, in an embodiment, the diameter D, the gap P**2**, and/or the gap P**3** of the micro protrusions **132** are respectively 0.05 μm, 0.05 μm, and 0.05 μm, and the transfer head **130** including the plurality of micro protrusions **132** has a capability of picking up the micro LED dies **210** of various sizes. However, the invention is not limited hereto. In other embodiments, the diameter D, the gap P**2**, and/or the gap P**3** may also be other adequate values. In the present embodiment, the transfer head **130** is an elastomer. For example, a material of the transfer head **130** includes polysiloxane, or more specifically, polydimethyl siloxane, but the invention is not limited hereto.

[0031] FIG. **3**A to FIG. **3**E illustrate a process of transferring a plurality of micro LED dies by using a transfer device according to an embodiment of the invention. Referring to FIG. **3**A, first, the plurality of transfer heads **130** of the transfer device **100** are aligned with the plurality of micro LED dies **210** located on a die temporary storage substrate **200**. Next, the plurality of transfer heads **130** of the transfer device **100** are respectively contacted with the plurality of micro LED dies **210**. Referring to FIG. **3**B, then, the transfer device **100** is moved away from above the die temporary storage substrate **200**. At this time, the transfer heads **130** bring the plurality of micro LED dies **210** away from the die temporary storage substrate **200** through a van der Waals force. Referring to FIG. **3**C, next, the transfer device **100** carries the micro LED dies **210** to above a target (e.g., a driving circuit plate **220**). Then, the plurality of micro LED dies **210** are respectively aligned and contacted with a plurality of conductive bumps **230** on the driving circuit plate **220**.

[0032] Referring to FIG. **3**D, after the micro LED dies **210** and the conductive bumps **230** are electrically connected, the deformable components **120** are deformed in preparation for releasing the micro LED dies **210**. For example, in the present embodiment, the deformable components **120** are heated to cause the deformable components **120** to be deformed and protrude towards the direction D1 away from the carrier plate **110**. At this time, the deformable components **120** lead to bending of the transfer heads **130**, such that a number of the micro protrusions **132** of the transfer heads **130** in contact with the micro LED dies **210** is decreased to reduce the van der Waals force between the transfer heads **130** and the micro LED dies **210**. Referring to FIG. **3**E, next, the transfer device **100** is moved away from above the micro LED dies **210**. Since the van der Waals force between the transfer heads **130** and the micro LED dies **210** is reduced, the micro LED dies **210** can naturally be successfully released from the transfer heads **130** and left on the target (e.g., the driving circuit plate **220**). Accordingly, the micro LED dies **210** can be easily released without precisely controlling a speed of releasing a macromolecular stamp from above the micro LED dies or precisely controlling an evaporation rate of fluid in a manufacturing environment, and thereby the plurality of micro LED dies **210** can be transferred rapidly in large quantities.

[0033] FIG. **4** illustrates a cross-section of a deformable component according to an embodiment of the invention. Referring to FIG. **4**, in the present embodiment, the deformable component **120** includes a first material layer **121** disposed on the carrier plate **110** and a second material layer **122** disposed on the first material layer **121**. The first material layer **121** is located between the carrier plate **110** and the second material layer **122**. The first material layer **121** has a first coefficient of thermal expansion, the second material layer **122** has a second coefficient of thermal expansion, and the second coefficient of thermal expansion is larger than the first coefficient of thermal expansion. Since the coefficients of thermal expansion of the first material layer **121** and the second material layer **122** are different, when the deformable component **120** is heated in the foregoing process of transferring the micro LED die **210**, the deformable component **120** protrudes towards the direction D1 away from the carrier plate **110**, which thereby causes the transfer head **130** to successfully release the micro LED die **210**. For example, in the present embodiment, the first material layer **121** is a titanium layer, and the second material layer **122** is a nickel layer. However, the invention is not limited hereto. In other embodiments, the deformable component **120** may also be present in other suitable configurations, such that a method of deforming the deformable component **120** is not limited to heating. Examples are illustrated below with reference to FIG. **5**, FIG. **6**, and FIG. **7**.

[0034] FIG. **5** illustrates a cross-section of a deformable component according to another embodiment of the invention. Referring to FIG. **5**, in another embodiment, a deformable component **120**A includes a first material layer **121**, a second material layer **122**, and a third material layer **123** sequentially stacked from the carrier plate **110** to the transfer head **130**. The first material layer **121** has a first coefficient of thermal expansion, the second material layer **122** has a second coefficient of thermal expansion, the third material layer **123** has a third coefficient of thermal expansion, the second coefficient of thermal expansion is larger than the first coefficient of thermal expansion and the third coefficient of thermal expansion, and the first coefficient of thermal expansion is equal to the third coefficient of thermal expansion. For example, in the present embodiment, the first material layer **121** is a nickel layer, the second material layer **122** is a titanium layer, and the third material layer **123** is a nickel layer, but the invention is not limited hereto. The deformable component **120**A is used to replace the deformable component **120** in FIG. **3**A to FIG. **3**E. The deformable component **120**A is heated and deformed in the foregoing process of transferring the micro LED die **210** to lead to bending of the transfer head **130**, which thereby causes the transfer head **130** to successfully release the micro LED die **210**.

[0035] FIG. **6** illustrates a cross-section of a deformable component according to another embodiment of the invention. Referring to FIG. **6**, in another embodiment, a deformable component **120**B includes macromolecules having a double-bond structure such as azobenzene group in a molecular structure. The deformable component **120**B is used to replace the deformable component **120** in FIG. **3**A to FIG. **3**E. The deformable component **120**B is irradiated by light and deformed in the foregoing process of transferring the micro LED die **210** to lead to bending of the transfer head **130**, which thereby causes the transfer head **130** to successfully release the micro LED die **210**.

[0036] FIG. **7** is a cross-sectional schematic diagram illustrating a deformable component according to another embodiment of the invention. Referring to FIG. **7**, in an embodiment, a deformable component **120**C includes an alloy formed of at least two metals having different resistivities, e.g., a nickel-titanium alloy having a nickel content of 55-60 wt %. The deformable component **120**C is used to replace the deformable component **120** in FIG. **3**A to FIG. **3**E. The deformable component **120**C is applied with a current and deformed in the foregoing process of transferring the micro LED die **210** to thereby cause the transfer head **130** to successfully release the micro LED die **210**. In the present embodiment, a material having a smaller resistivity is titanium, for example, and a material having a larger resistivity is nickel. However, the invention is not limited hereto. In other embodiments, other materials may also be adopted to manufacture the deformable component **120**C.

[0037] In summary of the above, the transfer device of the embodiments of the invention includes the carrier plate, the plurality of deformable components, and the plurality of transfer heads. The plurality of deformable components are disposed on the carrier plate. The plurality of transfer heads are respectively disposed on the plurality of deformable components. Each of the transfer heads includes the plurality of micro protrusions arranged in an array on a side away from the corresponding one deformable component. When the transfer device is to release the micro LED dies, the deformable components are deformed, which leads to bending of the transfer heads, such that the number of the micro protrusions of the transfer heads in contact with the micro LED dies is decreased. When the number of the micro protrusions in contact with the micro LED dies is decreased to the extent that the van der Waals force cannot be sufficiently generated, the transfer heads can easily release the micro LED dies and successfully transfer the micro LED dies onto the target (e.g., the driving circuit plate). Accordingly, a success rate of transferring the micro LED dies is high, and the micro LED dies can be rapidly transferred in large quantities.

[0038] Lastly, it shall be noted that the foregoing embodiments are meant to illustrate, rather than limit, the technical solutions of the embodiments of the invention. Although the invention has been detailed with reference to the foregoing embodiments, persons ordinarily skilled in the art shall be aware that they may still make modifications to the technical solutions recited in the foregoing embodiments or make equivalent replacements of part or all of the technical features therein, and these modifications or replacements do not cause the nature of the corresponding technical solutions to depart from the scope of the technical solutions of the embodiments of the invention.

What is claimed is:

1. A transfer device for transferring a plurality of micro LED dies, the transfer device comprising:

a carrier plate;

a plurality of deformable components disposed on the carrier plate; and

a plurality of transfer heads respectively disposed on the plurality of deformable components, wherein each of the transfer heads comprises a plurality of micro protrusions arranged in an array on a side away from the corresponding one deformable component.

2. The transfer device according to claim **1**, wherein each of the deformable components is adapted to be deformed due to an influence of light, heat, or electricity, and each of the deformed deformable components protrudes towards a direction away from the carrier plate.

3. The transfer device according to claim **1**, wherein each of the deformable components comprises:

a first material layer disposed on the carrier plate and having a first coefficient of thermal expansion; and

a second material layer disposed on the first material layer and having a second coefficient of thermal expansion, wherein the second coefficient of thermal expansion is larger than the first coefficient of thermal expansion.

4. The transfer device according to claim **1**, wherein each of the deformable components comprises an alloy formed of at least two metals having different resistivities.

5. The transfer device according to claim **1**, wherein each of the deformable components comprises:

a titanium layer disposed on the carrier plate; and

a first nickel layer disposed on the titanium layer.

6. The transfer device according to claim **5**, wherein each of the deformable components further comprises:

a second nickel layer, the titanium layer being sandwiched between the first nickel layer and the second nickel layer.

7. The transfer device according to claim **1**, wherein the deformable components comprise macromolecules having azobenzene group in a molecular structure.

8. The transfer device according to claim **1**, wherein the plurality of micro protrusions comprise a plurality of pillars spaced apart from each other.

9. The transfer device according to claim **1**, wherein the carrier plate comprises a plurality of carrying bumps spaced apart from each other, and the plurality of deformable components are respectively disposed on the plurality of carrying bumps.

10. The transfer device according to claim **9**, wherein each of the carrying bumps is located within an area of the corresponding one deformable component.

* * * * *

专利名称(译)	转移装置		
公开(公告)号	[US20190244846A1]	公开(公告)日	2019-08-08
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申请(专利权)人(译)	中华映管股份有限公司.		
当前申请(专利权)人(译)	中华映管股份有限公司.		
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CPC分类号	H01L21/67721 H01L21/683 H01L33/00		
优先权	201810117400.9 2018-02-06 CN		
外部链接	Espacenet USPTO		

摘要(译)

提供一种用于转移多个微LED管芯的转移装置。转移装置包括承载板，多个可变形部件和多个转移头。多个可变形部件设置在承载板上。多个转移头分别设置在多个可变形部件上。每个转移头包括多个微突起，这些微突起在远离相应的一个可变形部件的一侧上排列成阵列。可变形部件的变形导致转移头的变形，使得与微LED管芯接触的多个微突起减小。因此，转移装置可以容易地释放微LED管芯。