US 20190147778A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2019/0147778 A1

(43) Pub. Date: May 16, 2019

XIA et al.

(54) TRANSFER PRINTING SUBSTRATE AND METHOD FOR PRODUCING THE SAME

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(21) Appl. No.: **15/960,901**

(22) Filed: **Apr. 24, 2018**

(30) **Foreign Application Priority Data**

Nov. 10, 2017 (CN) 201711105426.3

Publication Classification

(51) **Int. Cl.**

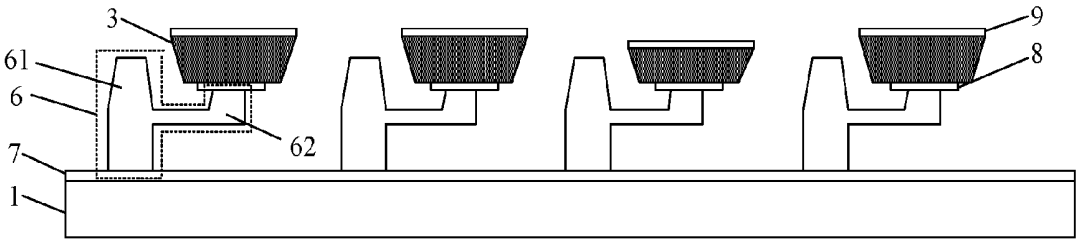
G09F 9/33	(2006.01)
B41C 1/06	(2006.01)
H01L 23/00	(2006.01)

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

CPC ***G09F 9/33*** (2013.01); ***B41C 1/06*** (2013.01); *B41F 16/00* (2013.01); *G09G 2300/0426* (2013.01); ***H01L 24/97*** (2013.01)

(57) **ABSTRACT**

Provided is a transfer printing substrate and a method for producing the same, in order to improve yield of picking up of the micro-components and further improve quality of image display. The transfer printing substrate includes a carrying substrate, a plurality of supporting structures, and a plurality of micro-components corresponding to the plurality of support structures in one-to-one correspondence, wherein each of the plurality of supporting structures includes a fixing part and a suspended supporting part, wherein an end of the fixing part is fixed on the carrying substrate, an end of the suspended supporting part is connected to the fixing part, the other end of the suspended supporting part supports a corresponding one of the plurality of micro-components, and a first moving space is provided between the suspended supporting part and the carrying substrate. The transfer printing substrate is used for transferring the micro-components.



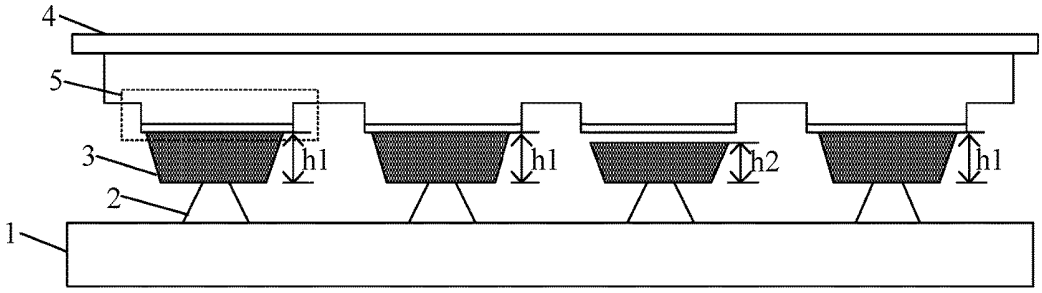


FIG. 1

(PRIOR ART)

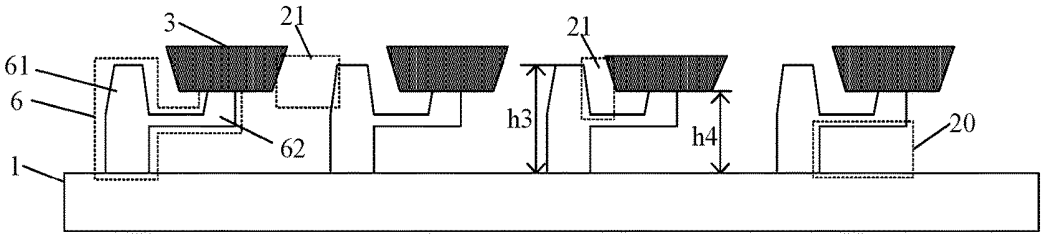


FIG. 2

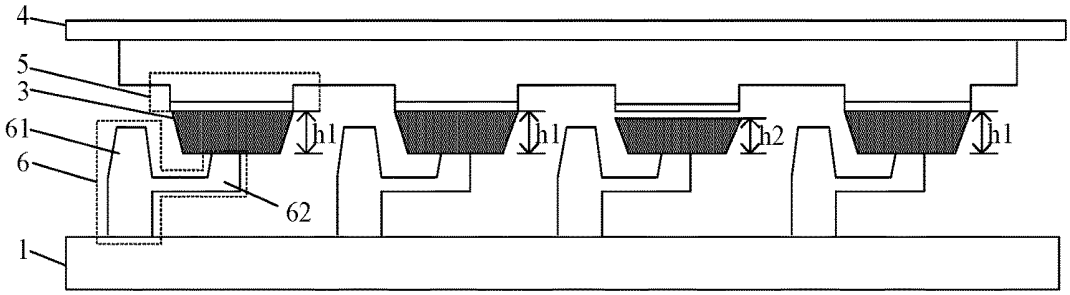


FIG. 3

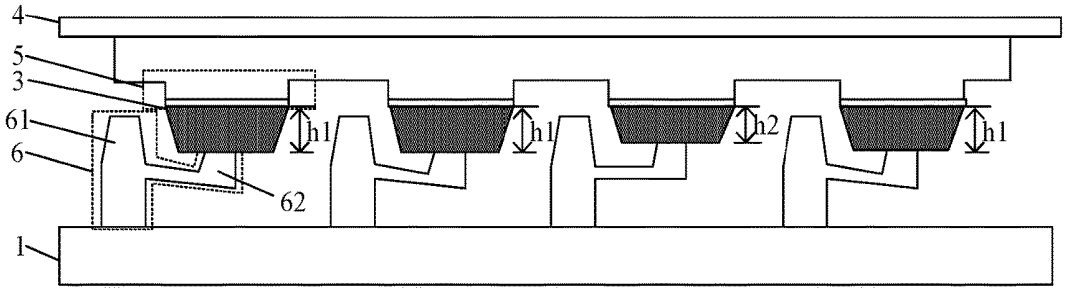


FIG. 4

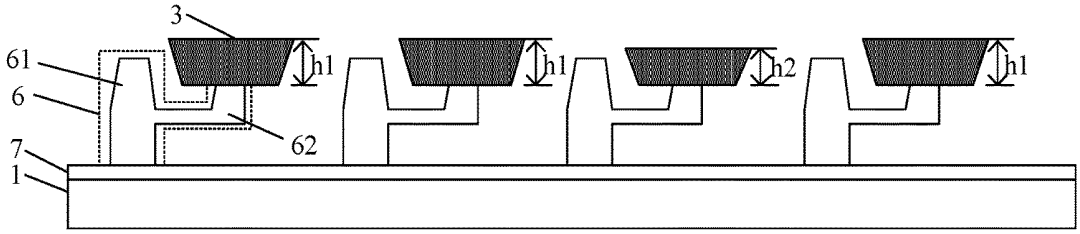


FIG. 5

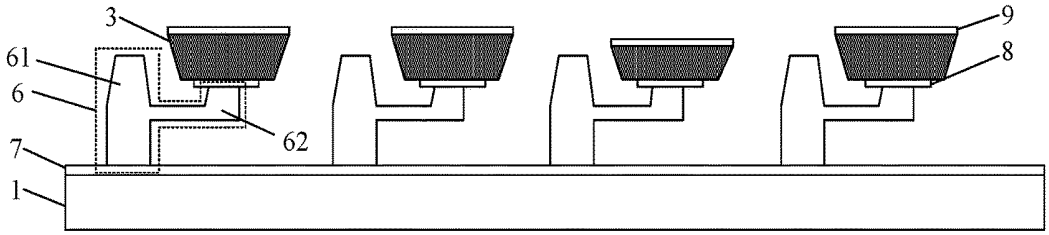


FIG. 6

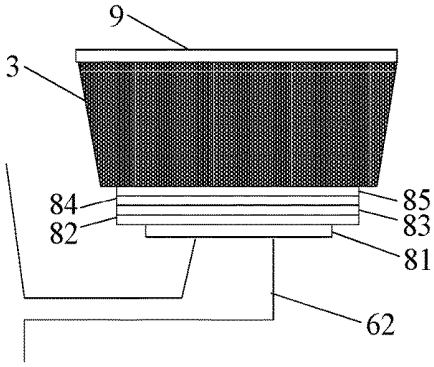


FIG. 7

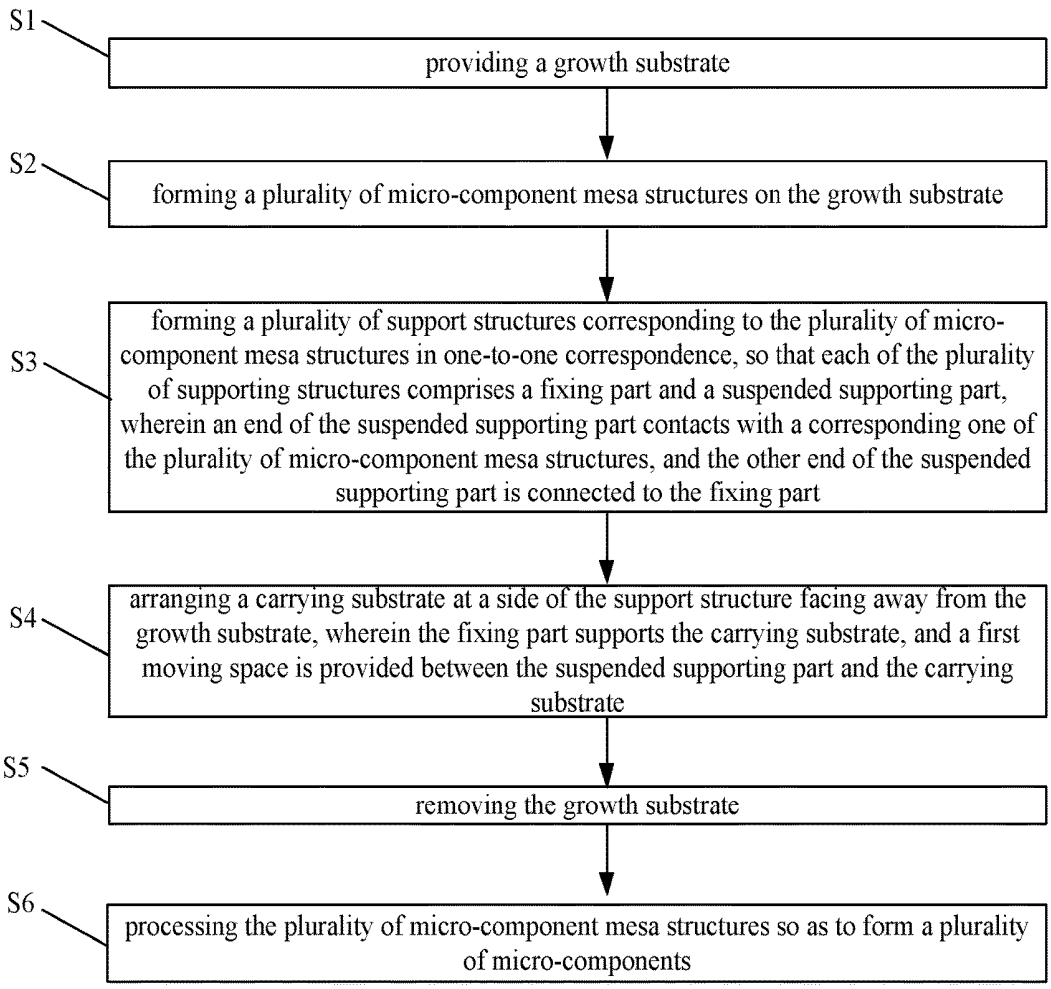

S1
providing a growth substrate
S2
forming a plurality of micro-component mesa structures on the growth substrate
S3
forming a plurality of support structures corresponding to the plurality of micro-component mesa structures in one-to-one correspondence, so that each of the plurality of supporting structures comprises a fixing part and a suspended supporting part, wherein an end of the suspended supporting part contacts with a corresponding one of the plurality of micro-component mesa structures, and the other end of the suspended supporting part is connected to the fixing part
S4
arranging a carrying substrate at a side of the support structure facing away from the growth substrate, wherein the fixing part supports the carrying substrate, and a first moving space is provided between the suspended supporting part and the carrying substrate
S5
removing the growth substrate
S6
processing the plurality of micro-component mesa structures so as to form a plurality of micro-components

FIG. 8

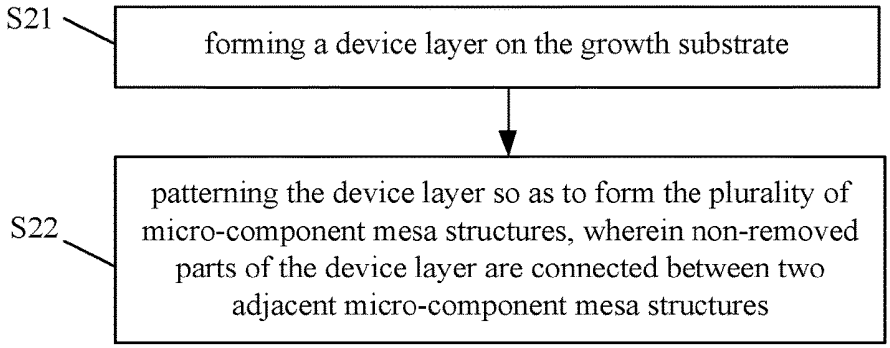

S21
forming a device layer on the growth substrate
S22
patterning the device layer so as to form the plurality of micro-component mesa structures, wherein non-removed parts of the device layer are connected between two adjacent micro-component mesa structures

FIG. 9

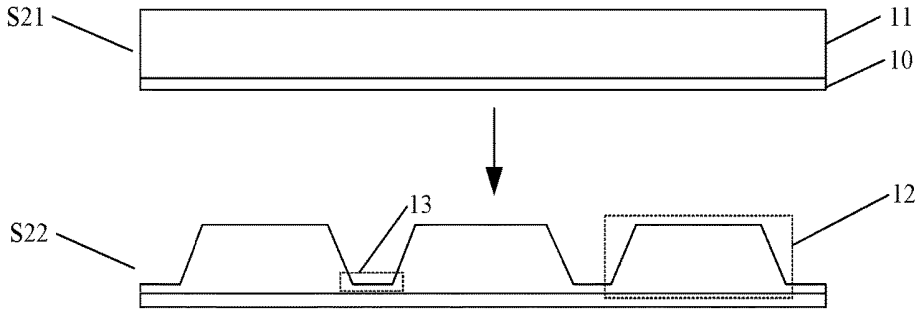

S21
11
10
S22
13
12

FIG. 10

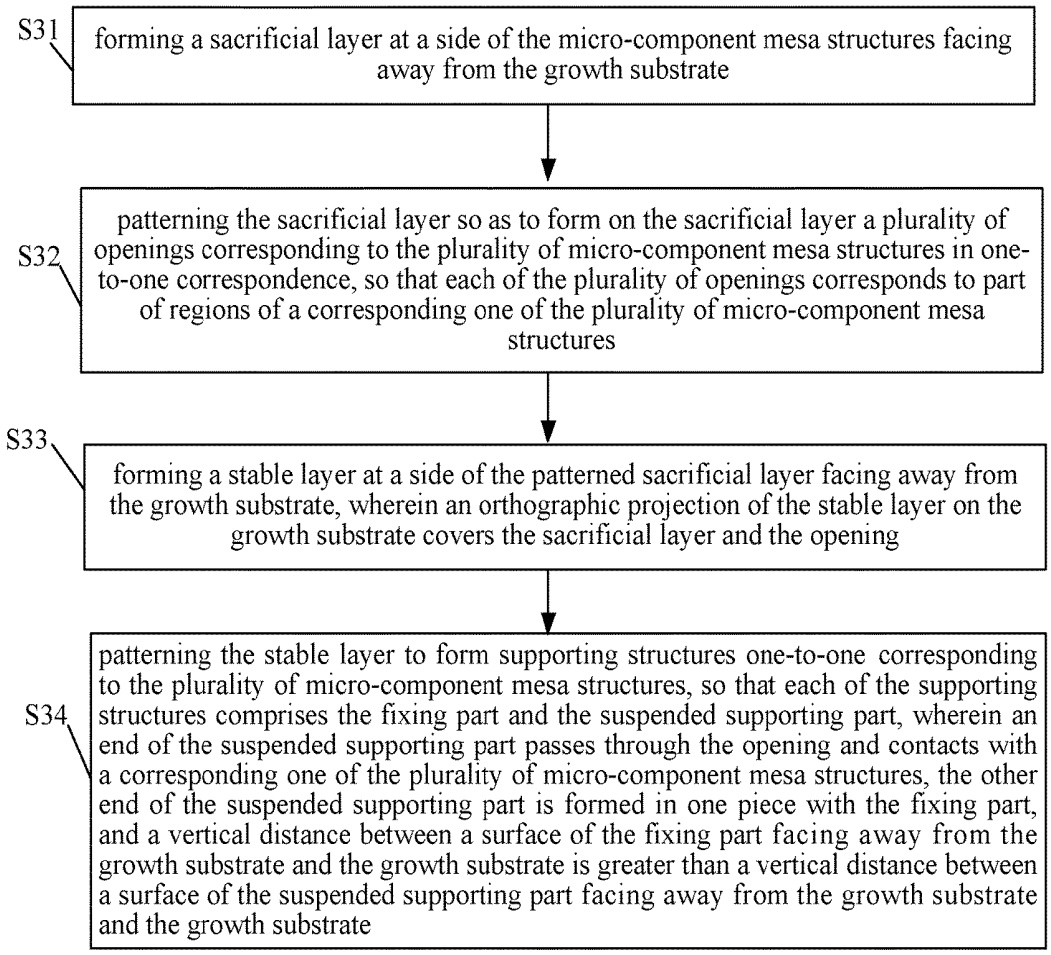

S31
forming a sacrificial layer at a side of the micro-component mesa structures facing away from the growth substrate
S32
patterning the sacrificial layer so as to form on the sacrificial layer a plurality of openings corresponding to the plurality of micro-component mesa structures in one-to-one correspondence, so that each of the plurality of openings corresponds to part of regions of a corresponding one of the plurality of micro-component mesa structures
S33
forming a stable layer at a side of the patterned sacrificial layer facing away from the growth substrate, wherein an orthographic projection of the stable layer on the growth substrate covers the sacrificial layer and the opening
S34
patterning the stable layer to form supporting structures one-to-one corresponding to the plurality of micro-component mesa structures, so that each of the supporting structures comprises the fixing part and the suspended supporting part, wherein an end of the suspended supporting part passes through the opening and contacts with a corresponding one of the plurality of micro-component mesa structures, the other end of the suspended supporting part is formed in one piece with the fixing part, and a vertical distance between a surface of the fixing part facing away from the growth substrate and the growth substrate is greater than a vertical distance between a surface of the suspended supporting part facing away from the growth substrate and the growth substrate

FIG. 11

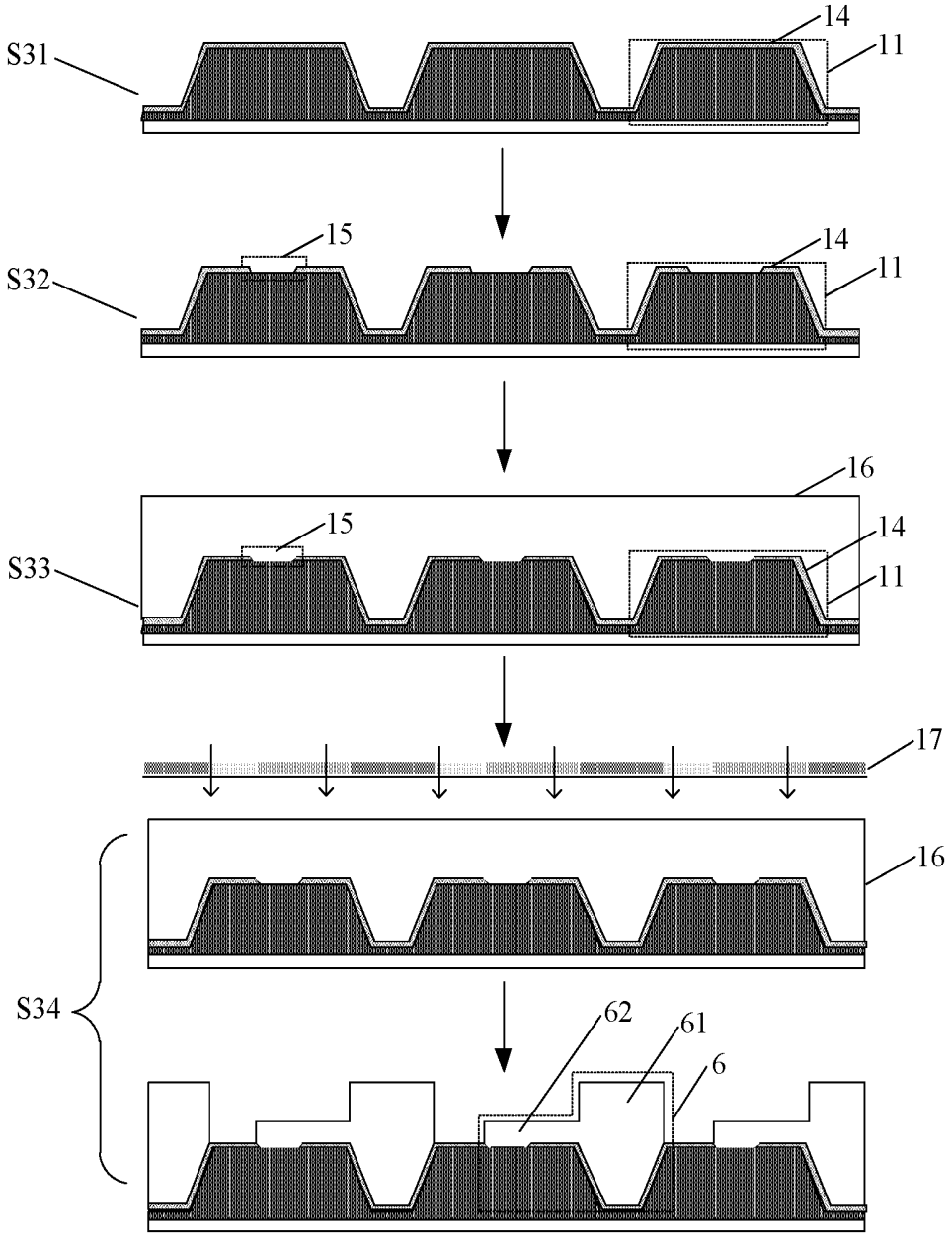


FIG. 12

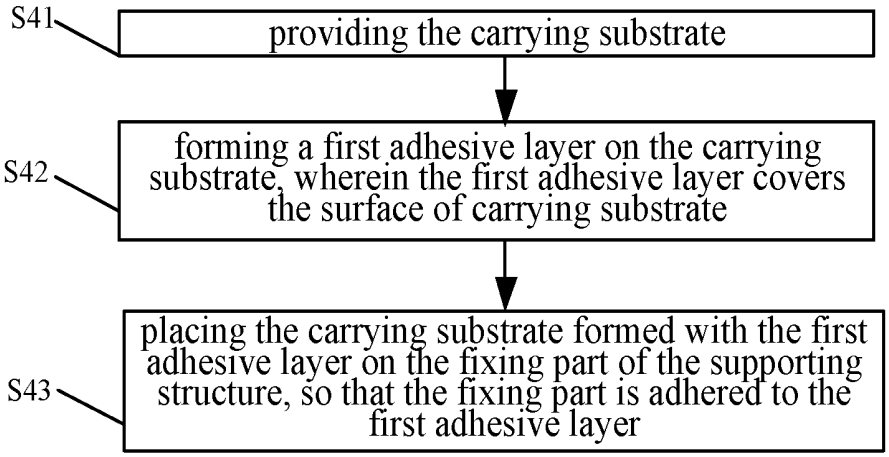

S41
providing the carrying substrate
S42
forming a first adhesive layer on the carrying substrate, wherein the first adhesive layer covers the surface of carrying substrate
S43
placing the carrying substrate formed with the first adhesive layer on the fixing part of the supporting structure, so that the fixing part is adhered to the first adhesive layer

FIG. 13

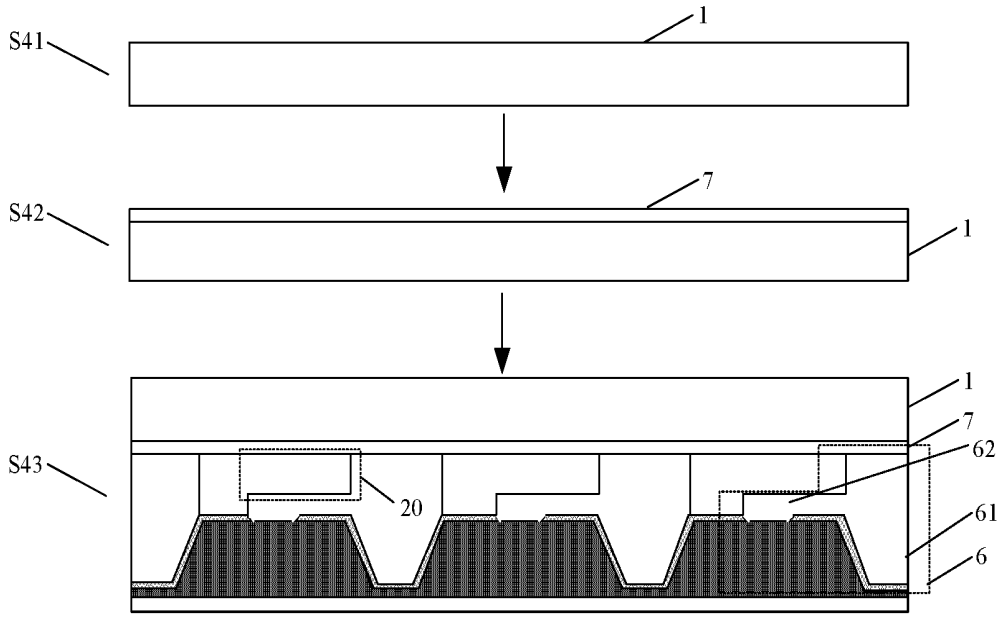

S41
1
S42
7
1
S43
1
7
62
20
61
6

FIG. 14

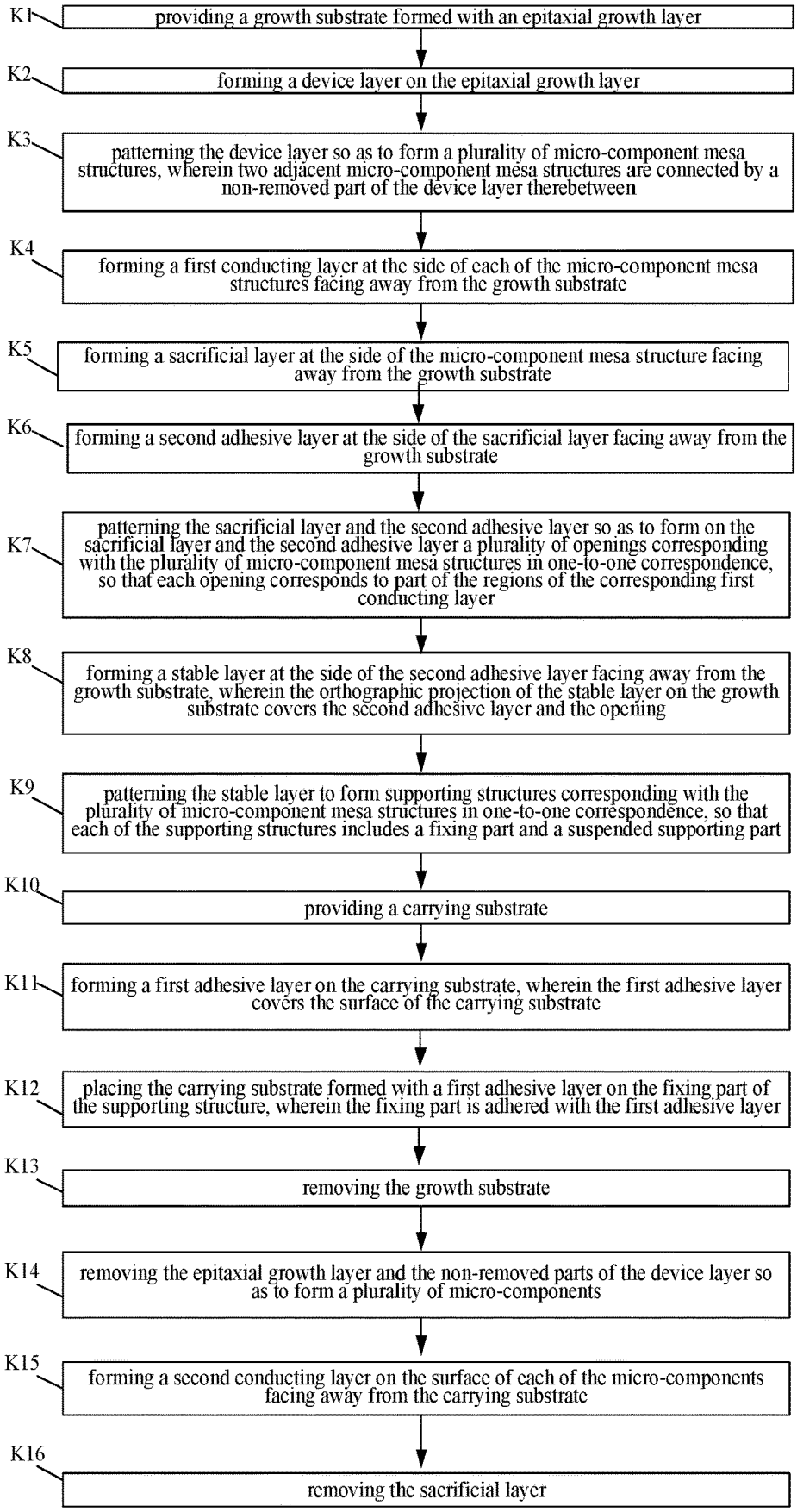
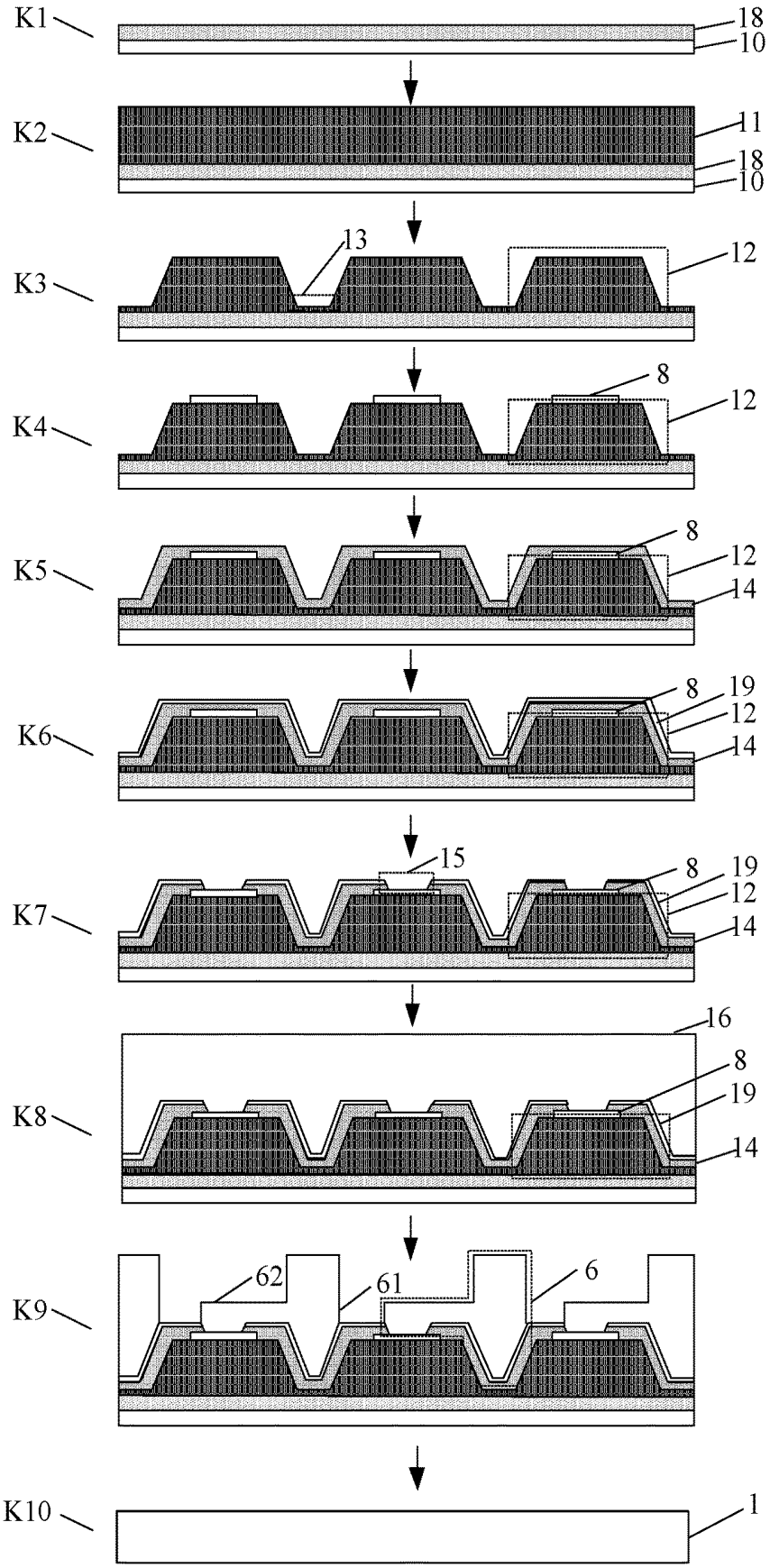

K1
providing a growth substrate formed with an epitaxial growth layer
K2
forming a device layer on the epitaxial growth layer
K3
patterning the device layer so as to form a plurality of micro-component mesa structures, wherein two adjacent micro-component mesa structures are connected by a non-removed part of the device layer therebetween
K4
forming a first conducting layer at the side of each of the micro-component mesa structures facing away from the growth substrate
K5
forming a sacrificial layer at the side of the micro-component mesa structure facing away from the growth substrate
K6
forming a second adhesive layer at the side of the sacrificial layer facing away from the growth substrate
K7
patterning the sacrificial layer and the second adhesive layer so as to form on the sacrificial layer and the second adhesive layer a plurality of openings corresponding with the plurality of micro-component mesa structures in one-to-one correspondence, so that each opening corresponds to part of the regions of the corresponding first conducting layer
K8
forming a stable layer at the side of the second adhesive layer facing away from the growth substrate, wherein the orthographic projection of the stable layer on the growth substrate covers the second adhesive layer and the opening
K9
patterning the stable layer to form supporting structures corresponding with the plurality of micro-component mesa structures in one-to-one correspondence, so that each of the supporting structures includes a fixing part and a suspended supporting part
K10
providing a carrying substrate
K11
forming a first adhesive layer on the carrying substrate, wherein the first adhesive layer covers the surface of the carrying substrate
K12
placing the carrying substrate formed with a first adhesive layer on the fixing part of the supporting structure, wherein the fixing part is adhered with the first adhesive layer
K13
removing the growth substrate
K14
removing the epitaxial growth layer and the non-removed parts of the device layer so as to form a plurality of micro-components
K15
forming a second conducting layer on the surface of each of the micro-components facing away from the carrying substrate
K16
removing the sacrificial layer

FIG. 15


K1
18
10
K2
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18
10
K3
13
12
K4
8
12
K5
8
12
14
K6
8
19
12
14
K7
15
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19
12
14
K8
16
8
19
14
K9
62
61
6
K10
1

FIG. 16

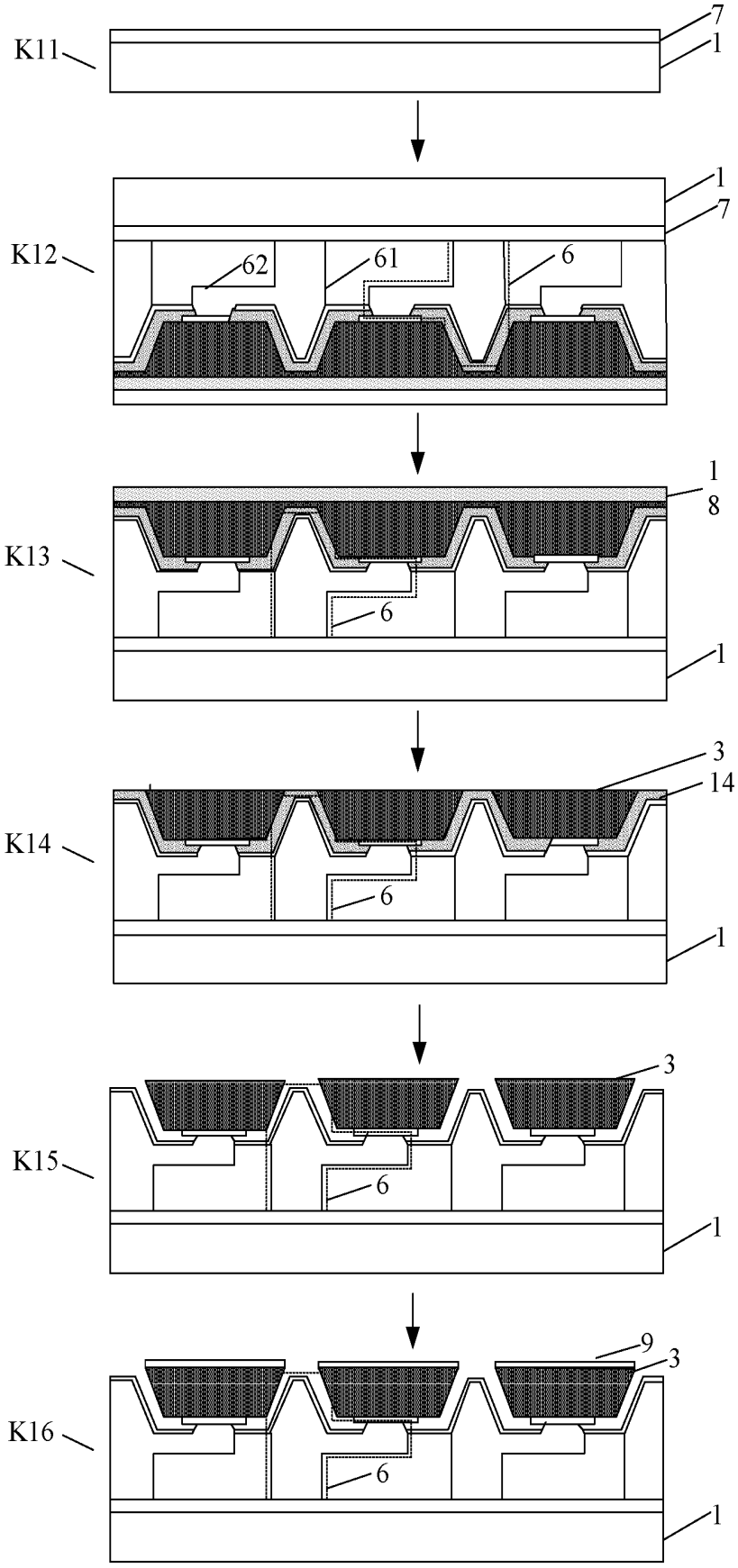

FIG. 17

TRANSFER PRINTING SUBSTRATE AND METHOD FOR PRODUCING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of priority to Chinese Patent Application No. 201711105426.3, filed on Nov. 10, 2017, the content of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of display technology, and more particularly to a transfer printing substrate and a method for producing the transfer printing substrate.

BACKGROUND

[0003] Micro transfer printing technology refers to a technology in which micro-components are selectively picked up and transferred to a substitute substrate by using high-precision motion control transfer printing heads.

[0004] Taking a micro light emitting diodes (LED) display panel as an example, when producing a micro LED display panel, LED particles are not directly formed on a display substrate but formed on a transfer printing substrate, and then the LED particles formed on the transfer printing substrate are picked up by transfer printing heads and are transferred onto the display substrate. However, the LED particles formed on the transfer printing substrate would have different thicknesses due to processing fluctuations, and thus the LED particles with a small thickness may not be successfully picked up, affecting yield of picking up and resulting in a poor image display.

SUMMARY

[0005] In the light of this, the embodiments of the present disclosure provide a transfer printing substrate and a method for producing the transfer printing substrate so as to improve yield of picking up of the micro-components and further improve quality of image display.

[0006] On one hand, embodiments of the present disclosure provide a transfer printing substrate including a carrying substrate, a plurality of supporting structures, and a plurality of micro-components corresponding to the plurality of support structures in one-to-one correspondence. Each of the plurality of supporting structures includes a fixing part and a suspended supporting part. An end of the fixing part is fixed on the carrying substrate. An end of the suspended supporting part is connected to the fixing part, and another end of the suspended supporting part supports the corresponding one of the plurality of micro-components. A first moving space is provided between the suspended supporting part and the carrying substrate.

[0007] On the other hand, embodiments of the present disclosure further provide a method for producing a transfer printing substrate, the transfer printing substrate including a carrying substrate, a plurality of supporting structures, and a plurality of micro-components corresponding to the plurality of support structures in one-to-one correspondence. Each of the plurality of supporting structures includes a fixing part and a suspended supporting part. An end of the fixing part is fixed on the carrying substrate. An end of the suspended supporting part is connected to the fixing part, and another end of the suspended supporting part supports the corresponding one of the plurality of micro-components. A first moving space is provided between the suspended supporting part and the carrying substrate. The method includes steps of: providing a growth substrate; forming a plurality of micro-component mesa structures on the growth substrate; forming a plurality of support structures corresponding to the plurality of micro-component mesa structures in one-to-one correspondence, so that each of the plurality of supporting structures includes a fixing part and a suspended supporting part, wherein an end of the suspended supporting part contacts with a corresponding one of the plurality of micro-component mesa structures, and another end of the suspended supporting part is connected to the fixing part; arranging a carrying substrate at a side of the support structure facing away from the growth substrate, wherein the fixing part supports the carrying substrate, and the first moving space is provided between the suspended supporting part and the carrying substrate; and removing the growth substrate after arranging the carrying substrate, and processing the plurality of micro-component mesa structures so as to form a plurality of micro-components.

[0008] Any one of the said technical solutions has the following advantageous effects:

[0009] When picking up the micro-components formed on the transfer printing substrate by transfer printing heads, since different micro-components have different thicknesses, the micro-component with a greater thickness contacts with the corresponding micro-component first during a process of a transfer printing head fixing component driving the transfer printing heads to move towards the carrying substrate. Since a first moving space is provided between the suspended supporting part and the carrying substrate of the supporting structure, when part of the transfer printing heads contact with the micro-components with greater thicknesses, the transfer printing head fixing component continues driving the transfer printing heads to move towards the carrying substrate. At this moment, the suspended supporting parts for the micro-components with greater thicknesses are deformed towards the carrying substrate until all of the micro-components contact with the corresponding transfer printing heads. Then the transfer printing heads pick up all of the micro-components and transfer them to the display substrate based on the principle of electrostatic clamping that charges of different polarities attract each other. Therefore, using said technical solutions can ensure sufficient contact of the micro-components with different thicknesses formed on the transfer printing substrate and the corresponding transfer printing heads, so that all of the micro-components are picked up by the corresponding transfer printing heads, the yield of picking up is improved, and the problem of uneven image brightness caused by missing of part of the micro-components on the display substrate is avoided.

BRIEF DESCRIPTION OF DRAWINGS

[0010] In order to explain the technical solutions of the embodiments of the present disclosure more clearly, the drawings to be used by the embodiments are briefly described hereinafter. The drawings described hereinafter are only some of the embodiments of the present disclosure. A person skilled in the art may obtain other drawings according to these drawings without involving any inventive skills.

[0011] FIG. **1** is a schematic diagram of a transfer printing heads picking up the micro-components in the related art;

[0012] FIG. **2** is a structural schematic diagram of a transfer printing substrate provided in an embodiment of the present disclosure;

[0013] FIG. **3** is a procedural schematic diagram of the transfer printing heads picking up the micro-components formed on the transfer printing substrate provided in the embodiment of the present disclosure;

[0014] FIG. **4** is another procedural schematic diagram of the transfer printing heads picking up the micro-components formed on the transfer printing substrate provided in the embodiment of the present disclosure;

[0015] FIG. **5** is a structural schematic diagram of a transfer printing substrate provided in another embodiment of the present disclosure;

[0016] FIG. **6** is a structural schematic diagram of a transfer printing substrate provided in another embodiment of the present disclosure;

[0017] FIG. **7** is a structural schematic diagram of the first conducting layer of the transfer printing substrate provided in the embodiments of the present disclosure;

[0018] FIG. **8** is a schematic diagram of a method for producing the transfer printing substrate provided in a first embodiment of the present disclosure;

[0019] FIG. **9** is a schematic diagram of a method for producing the transfer printing substrate provided in a second embodiment of the present disclosure;

[0020] FIG. **10** is a process flow diagram of the method for producing the transfer printing substrate provided in the second embodiment of the present disclosure;

[0021] FIG. **11** is a schematic diagram of a method for producing the transfer printing substrate provided in a third embodiment of the present disclosure;

[0022] FIG. **12** is a process flow diagram of the method for producing the transfer printing substrate provided in the third embodiment of the present disclosure;

[0023] FIG. **13** is a schematic diagram of a method for producing the transfer printing substrate provided in a fourth embodiment of the present disclosure;

[0024] FIG. **14** is a process flow diagram of the method for producing the transfer printing substrate provided in the fourth embodiment of the present disclosure;

[0025] FIG. **15** is a schematic diagram of a method for producing the transfer printing substrate according to a fifth embodiment of the present disclosure;

[0026] FIG. **16** is a process flow diagram of the method for producing the transfer printing substrate provided in the fifth embodiment of the present disclosure; and

[0027] FIG. **17** is a process flow diagram of the method for producing the transfer printing substrate provided in the fifth embodiment of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0028] For a better understanding of the technical solutions of the present disclosure, the embodiments of the present disclosure are hereinafter described in details with reference to the drawings.

[0029] It should be clear that the described embodiments are only part of the embodiments, rather than all of the embodiments of the present disclosure. Based on the embodiments in the present disclosure, any other embodiments obtained by a person skilled in the art without involving any inventive skills falls within the protection scope of the present disclosure.

[0030] The terms used in the embodiments of the present disclosure are only used for the purpose of describing particular embodiments and do not intend to limit the present disclosure. The words "a/an", "said" and "the" in the singular form used in the embodiments and the appended Claims of the present disclosure also intend to include the plural form, unless otherwise clearly indicated in the context.

[0031] It should be understood that the term "and/or" used in the text only indicates a related relation describing related objects and indicates that there may be three relations, for example A and/or B may indicates three conditions of: A only, both A and B, and B only. Furthermore, the character "/" in the text generally indicates an "or" relation of the previous and following related objects.

[0032] It should be understood that the embodiments of the present disclosure may use the terms "first", "second", etc. to describe the conducting layers, these conducting layers, however, should not be limited by these terms. These terms are only used for distinguishing the conducting layers from each other. For example, without departing from the scope of the embodiments of the present disclosure, the first conducting layer may also be called as the second conducting layer. Similarly, the second conducting layer may also be called as the first conducting layer.

[0033] The transfer printing substrate in the related art includes a carrying substrate **1**, a plurality of supporting columns **2** formed on the carrying substrate **1**, and micro-components **3** correspond to the plurality of supporting columns **2** in one-to-one correspondence, as shown in FIG. **1**. However, different micro-components **3** would have different thicknesses due to processing fluctuations. For example, during the process of forming the micro-components **3**, part of the formed micro-components **3** would have a thickness h2 smaller than the thickness h1 of other micro-components **3** due to influences of photolithographic technology and the like. In that case, when a transfer printing head fixing component **4** drives a plurality of transfer printing heads **5** to move towards a carrying substrate **1** so that the transfer printing heads **5** pick up the micro-components **3**, the micro-components **3** having a thickness of h2 still have a distance of h1-h2 from the corresponding transfer printing heads **5** when the transfer printing heads **5** contact with the micro-components **3** having a thickness of h1, so that the micro-components **3** having a thickness of h2 cannot contact with the corresponding transfer printing heads **5** and then cannot be picked up by the transfer printing heads **5**.

[0034] Thus, when the transfer printing heads **5** transfer the picked-up micro-components **3** to the display substrate, the display substrate will lack part of the micro-components **3**, so that the areas lacking the micro-components **3** display a black spot, instead of displaying a normal brightness, during displaying images, which causes an uneven brightness of the displayed images.

[0035] It should be pointed out that it is only illustrative that the micro-components **3** formed on the transfer printing substrate shown in FIG. **1** include the micro-components **3** having a thickness of h1 and the micro-components **3** having a thickness of h2. Actually, the thicknesses of the formed micro-components **3** may have various differences. When

micro-components **3** of various thicknesses are formed on the transfer printing substrate, the same problem will occur, which is not repeated herein.

[0036] In order to solve said problem, the embodiments of the present disclosure provide a transfer printing substrate as shown in FIG. **2**. The transfer printing substrate includes a carrying substrate **1**, a plurality of supporting structures **6** and a plurality of micro-components **3**, wherein the plurality of micro-components **3** correspond to the plurality of supporting structures **6** one by one.

[0037] The supporting structure **6** includes a fixing part **61** and a suspended supporting part **62**, wherein an end of the fixing part **61** is fixed on the carrying substrate **1**, an end of the suspended supporting part **62** is connected to the fixing part **61**, the other end of the suspended supporting part **62** supports the corresponding micro-component **3**, and a first moving space **20** is provided between the suspended supporting part **62** and the carrying substrate **1**.

[0038] When picking up the micro-components **3** formed on the transfer printing substrate by using the transfer printing heads **5**, since different micro-components **3** have different thicknesses, the micro-components **3** with greater thicknesses will contact with the corresponding micro-components **3** first during the transfer printing head fixing component **4** driving the transfer printing heads **5** to move towards the carrying substrate **1**. Since a first moving space **20** is provided between the suspended supporting part **62** and the carrying substrate **1** of the supporting structure **6**, when part of the transfer printing heads **5** contact with the micro-components **3** with greater thicknesses, the transfer printing head fixing component **4** continues driving the transfer printing heads **5** to move towards the carrying substrate **1**. At this moment, the suspended supporting parts **62** for the micro-components **3** with greater thicknesses are deformed towards the carrying substrate **1** until all of the micro-components **3** contact the corresponding transfer printing heads **5**. Then the transfer printing heads **5** pick up all of the micro-components **3** and transfer them to the display substrate based on the principle of electrostatic clamping that charges of different polarities attract each other.

[0039] Referring to FIG.s **3** and **4**, taking micro-components **3** having a thickness of h1 and micro-components **3** having a thickness of h2 formed on the transfer printing substrate as an example, when picking up the micro-components **3** formed on the transfer printing substrate by using the transfer printing heads **5**, the transfer printing head fixing component **4** drives the transfer printing heads **5** to move towards the carrying substrate **1**. Since h1>h2, part of the transfer printing heads **5** contact with the micro-components **3** having a thickness of h1 first, as shown in FIG. **3**. At this moment, the micro-components **3** having a thickness of h2 have a distance of h1-h2 from the corresponding transfer printing heads **5**. The transfer printing head fixing component **4** then continues driving the transfer printing heads **5** to move towards the carrying substrate **1**, as shown in FIG. **4**. At this moment, the suspended supporting parts **62** for supporting the micro-components **3** having a thickness of h1 are deformed towards the carrying substrate **1** until the remaining part of transfer printing heads **5** contacts with the micro-components **3** having a thickness of h2.

[0040] Therefore, using the transfer printing substrate provided in this embodiment can ensure sufficient contact of the micro-components **3** with different thicknesses formed on the transfer printing substrate with the corresponding transfer printing heads **5**, so that all of the micro-components **3** are picked up by the corresponding transfer printing heads **5**, the yield of picking up is improved, and the problem of uneven image brightness caused by missing of part of the micro-components **3** on the display substrate is avoided.

[0041] Furthermore, when the transfer printing heads **5** continue moving towards the carrying substrate after the transfer printing heads **5** contact with the corresponding micro-components **3**, the suspended supporting parts **62** supporting this part of micro-components **3** will be deformed towards the carrying substrate **1**. Based on the mechanics principles, when the suspended supporting parts **62** are deformed towards the carrying substrate **1**, the suspended supporting parts **62** will produce a rebounding force facing away from the carrying substrate **1** at the same time. The rebounding force leads to a tighter contact between the suspended supporting parts **62** and the corresponding micro-components **3**, so that the yield of picking up is further improved.

[0042] Referring to FIG. **2** again, the fixing part **61** of each of the supporting structures **6** is located between two adjacent micro-components **3**, and the vertical distance h3 between the carrying substrate **1** and a surface of the fixing part **61** facing away from the carrying substrate **1** (the upper surface of the fixing part **61** shown in FIG. **2**) is greater than the vertical distance h4 between the carrying substrate **1** and a surface of the micro-component **3** facing towards the carrying substrate **1** (the lower surface of the micro-component **3** shown in FIG. **2**).

[0043] Since the micro-components **3** are only supported by the suspended supporting parts **62**, the micro-components **3** may be deviated from their corresponding suspended supporting parts **62**, and then the corresponding locations between the micro-components **3** and the transfer printing heads **5** are deviated, resulting in a poor contact between the micro-components **3** and the transfer printing heads **5**, so that the micro-components **3** cannot be picked up successfully. However, the fixing parts **61** can limit the location of the micro-components **3** by arranging the fixing part **61** of each of the supporting structures **6** between two adjacent micro-components **3** and making the vertical distance between the carrying substrate **1** and the surface of the fixing part **61** facing away from the carrying substrate **1** greater than the vertical distance between the carrying substrate **1** and the surface of the micro-component **3** facing towards the carrying substrate **1**, so as to reduce deviation of the micro-components **3**, so that the micro-components **3** can be better picked up by the corresponding transfer printing heads **5**.

[0044] Furthermore, referring to FIG. **2** again, a second moving space may be provided between the fixing parts **61** and the adjacent micro-components **3**. In this way, abrasion to the micro-components **3** by the fixing parts **61** caused by an excessive close distance between the fixing parts **61** and the adjacent micro-components **3** can be avoided, and a disadvantageous influence to the display performance can also be avoided.

[0045] Optionally, the fixing part **61** and the suspended supporting part **62** of each of the supporting structures **6** can be formed in one piece. That is to say, the fixing part **61** and the suspended supporting part **62** are formed by applying the same design technology to the same film layer in the production process. According to such an arrangement, on one hand, the production process can be simplified and

processes can be reduced. On the other hand, when the suspended supporting part **62** is deformed, the probability of the suspended supporting part **62** being broken from the fixing part **61** can be reduced by forming the suspended supporting part **62** and the fixing part **61** in one piece, compared with the manner in which the fixing part **61** and the suspended supporting part **62** are two independent structures and the suspended supporting part **62** is adhered on the fixing part **61**.

[0046] When part of the transfer printing heads **5** contact with the micro-components **3** with greater thicknesses, in order to pick up the micro-components **3** having smaller thicknesses, the transfer printing head fixing component **4** has to continue driving the transfer printing heads **5** to move towards the carrying substrate **1**, which deforms the suspended supporting parts **62** supporting the micro-components **3** having greater thicknesses towards the carrying substrate **1**. When the micro-components **3** have great thickness differences, the suspended supporting parts **62** are deformed greatly, which may lead to breaking of the suspended supporting parts **62**. In this way, when the transfer printing heads **5** drive the transfer printing heads **3** away from the carrying substrate **1**, the suspended supporting parts **62** broken from the fixing parts **61**, together with the corresponding micro-components **3**, will be driven away from the carrying substrate **1** and then be transferred to the display substrate together with the corresponding micro-components **3**, which leads to a poor contact between wiring of the display substrate and this part of the micro-components **3** and further impacts normal display.

[0047] In order to solve said problem, the transfer printing substrate provided in this embodiment may also include a first adhesive layer **7** arranged on the carrying substrate **1**, wherein the orthographic projection of the first adhesive layer **7** covers the surface of the carrying substrate **1**, as shown in FIG. **5**. The fixing part **61** of each of the supporting structures **6** is fixedly connected to the carrying substrate **1** in a manner of being adhered on the first adhesive layer **7**.

[0048] By means of arranging a first adhesive layer **7** on the carrying substrate **1**, on one hand, the fixing part **61** can be adhered, achieving a more stable connection between the fixing parts **61** and the carrying substrate **1** and a better stability of the supporting structures **6**. On the other hand, when the suspended supporting part **62** is broken, the broken suspended supporting part **62** will be adhered on the first adhesive layer **7**, in which way the broken suspended supporting part **62** cannot be driven away from the carrying substrate **1** together with the corresponding micro-components **3** by the transfer printing heads **5**, so that the influence on normal display is prevented.

[0049] When the micro-components **3** are micro-LEDs, the transfer printing substrate also includes a first conducting layer **8** arranged between the micro-components **3** and the corresponding suspended supporting parts **62**, and a second conducting layer **9** arranged on the surface of the micro-components **3** facing away from the carrying substrate **1**, as shown in FIG. **6**.

[0050] The first conducting layer **8** may include a bonding layer **81**, a diffusion blocking layer **82**, a sticking-blocking layer **83**, a reflector layer **84** and an electrode layer **85** arranged on the suspended supporting part **62** in sequence, as shown in FIG. **7**. The bonding layer **81** herein is used for increasing adhesive force between the micro-component **3** and the display substrate after the micro-components **3** are transferred to the display substrate. The bonding layer **81** may be made of a conducting material such as pure metal, an alloy, etc. The diffusion blocking layer **82** of the bonding layer **81** may be made of a metallic material such as platinum. The sticking-blocking layer **83** may be made of a metallic material such as titanium. The reflector layer **84** is used for reflecting visible light of different wavelengths and may be made of a metallic material such as silver. The electrode layer **85** forms an ohmic contact with the doped semiconductor layer of the micro-component **3** and may be made of a metallic material having a high work function, such as nickel.

[0051] It should be pointed out that the transfer printing head fixing component **4** drives the transfer printing heads **5** to continue moving towards the carrying substrate **1** after part of the transfer printing heads **5** contact with the corresponding micro-components **3**, so that the force applied on the bonding layer **81** of the first conducting layer **8** by the transfer printing heads **5** can be dispersed when the suspended supporting parts **62** are deformed towards the carrying substrate **1**, which can effectively reduce the damage to the bonding layer **81** when the transfer printing heads **5** pick up the micro-components **3**.

[0052] In order to arrange the micro-components **3** more regularly, the plurality of micro-components **3** formed on the carrying substrate may be arranged in matrix.

[0053] Embodiments of the present disclosure further provide a method for producing the transfer printing substrate, which method is applicable to the transfer printing substrate described as above.

[0054] As shown in FIG. **8**, the method for producing the transfer printing substrate provided by this embodiment includes:

[0055] Step S1: providing a growth substrate.

[0056] Step S2: forming a plurality of micro-component mesa structures on the growth substrate.

[0057] Step S3: forming a plurality of supporting structures corresponding to the plurality of micro-component mesa structures in one-to-one correspondence, such that each of the supporting structures includes a fixing part and a suspended supporting part, wherein an end of the suspended supporting part contacts with the corresponding micro-component mesa structure, and the other end of the suspended supporting part is connected to the fixing part.

[0058] Step S4: arranging a carrying substrate at a side of the supporting structure facing away from the growth substrate, wherein the carrying substrate is supported by the fixing part, and a first moving space is provided between the suspended supporting part and the carrying substrate.

[0059] Step S5: removing the growth substrate.

[0060] Step S6: processing the plurality of micro-component mesa structures so as to form a plurality of micro-components.

[0061] With respect to the transfer printing substrate produced by said method, since a first moving space is provided between the suspended supporting part and the carrying substrate of the supporting structure, when part of the transfer printing heads contact with the micro-components with greater thicknesses, the transfer printing heads can continue moving towards the carrying substrate. At this moment, the suspended supporting parts for supporting this part of the micro-components are deformed towards the carrying substrate until all of the transfer printing heads contact with the micro-components. Therefore, the method

for producing a transfer printing substrate provided by this embodiment can ensure sufficient contact of the micro-components having different thicknesses formed on the transfer printing substrate with the corresponding transfer printing heads, so that all of the micro-components are picked up by the corresponding transfer printing heads, thus the yield of picking up is improved, and the problem of uneven image brightness caused by missing of part of the micro-components on the display substrate is avoided.

[0062] The material of the growth substrate can be selected according to the type of the micro-components. For example, when the micro-components are micro-LEDs, the growth substrate is generally made of sapphire glass.

[0063] Furthermore, after the step S**1** provides the growth substrate, an epitaxial growth layer can be further formed on the growth substrate by means of epitaxial growth technology so as to eliminate dislocation in the layers, wherein the epitaxial growth layer may be made of gallium nitride base material.

[0064] As shown in FIG.s **9** and **10**, the step S**2** may include:

[0065] Step S**21**: forming a device layer **11** on the growth substrate **10**.

[0066] The device layer **11** herein relates to a film layer used for forming the micro-components. The device layer **11** may be made of different materials according to the characteristics of the formed micro-components. Exemplarily, when the micro-components are micro-LEDs, the device layer **11** may include a first doped semiconductor layer, a quantum well layer and a second doped semiconductor layer formed on the growth substrate **10** in sequence. The first doped semiconductor layer is an n-doped semiconductor layer and the second doped semiconductor layer is a p-doped semiconductor layer, or the first doped semiconductor layer is a p-doped semiconductor layer and the second doped semiconductor layer is an n-doped semiconductor layer.

[0067] Step S**22**: patterning the device layer **11** so as to form a plurality of micro-component mesa structures **12**, wherein two adjacent micro-component mesa structures **12** are connected by a non-removed part **13** of the device layer **11** therebetween. A photolithography technology can be used when patterning the device layer **11**.

[0068] Correspondingly, the step S**6** includes: patterning the micro-component mesa structures **12** to remove the non-removed parts **13** of the device layer **11** so as to form a plurality of micro-components.

[0069] As shown in FIG.s **11** and **12**, the step S**3** includes:

[0070] Step S**31**: forming a sacrificial layer **14** at the side of the micro-component mesa structure **12** facing away from the growth substrate **10**.

[0071] Optionally, the sacrificial layer **14** can be deposited by sputtering or low-temperature plasma enhanced chemical vapor deposition. Compared with a sacrificial layer **14** deposited by atomic layer deposition or high-temperature plasma enhanced chemical vapor deposition, the sacrificial layer **14** formed in this way are much easier to be removed than other film layers. The sacrificial layer **14** may be made of an oxide or nitride material.

[0072] Step S**32**: patterning the sacrificial layer **14** to form on the sacrificial layer **14** a plurality of openings **15** corresponding to the plurality of micro-component mesa structures **12** in one-to-one correspondence, so that each of the openings **15** corresponds to part of regions of the corresponding micro-component mesa structure **12**.

[0073] Step S**33**: forming a stable layer **16** at the side of the patterned sacrificial layer **14** facing away from the growth substrate **10**, wherein the orthographic projection of the stable layer on the growth substrate **10** covers the sacrificial layer **14** and the opening **15**.

[0074] It can be understood that the stable layer **16** is a film layer used for forming a supporting structure. Then the stable layer **16** can be provided with a great thickness, such that, on one hand, the subsequently formed supporting structure **6** has better stability and the micro-components can be supported more stably; on the other hand, the suspended supporting part **62** of the supporting structure **6** and the carrying substrate **1** can be provided with a sufficient first moving space therebetween so as to ensure that the micro-components with small thicknesses can also be picked up and to improve the yield of picking up.

[0075] Step S**34**: patterning the stable layer to form supporting structures **6** corresponding to the plurality of micro-component mesa structures **12** in one-to-one correspondence, so that each of the supporting structures **6** includes a fixing part **61** and a suspended supporting part **62**, wherein an end of the suspended supporting part **62** passes through the opening **15** and contacts with the corresponding micro-component mesa structure **12**, the other end of the suspended supporting part **62** is formed with the fixing part **61** in one piece, and the vertical distance between the growth substrate **10** and the surface of the fixing part **61** facing away from the growth substrate **10** (the upper surface of the fixing part **61** shown in FIG. **12**) is greater than the vertical distance between the growth substrate **10** and the surface of the suspended supporting part **62** facing away from the growth substrate **10** (the upper surface of the suspended supporting part **62** shown in FIG. **12**).

[0076] In one embodiment, a photolithography technology, for example a halftone mask technology, can be used for patterning the stable layer. Referring to FIG. **12** again, the stable layer **16** can be exposed by using a halftone mask plate **17**, and then the stable layer **16** is corroded so as to form a supporting structure **6**.

[0077] The vertical distance between the growth substrate **10** and the surface of the fixing part **61** facing away from the growth substrate **10** is greater than the vertical distance between the growth substrate **10** and the surface of the suspended supporting part **62** facing away from the growth substrate **10**. That is to say, after the carrying substrate **1** is subsequently placed on the fixing part **61**, the suspended supporting part **62** and the carrying substrate **1** will have a particular first moving space therebetween, which leaves a motion space for the transfer printing heads **5** moving towards the carrying substrate **1** so as to ensure all of the micro-components with different thicknesses formed on the transfer printing substrate sufficiently contact with the corresponding transfer printing heads **5**, so that all of the micro-components are picked up by the corresponding transfer printing heads **5**. Furthermore, it can be seen based on the structure of the fixing part **61** that the vertical distance between the surface of the fixing part **61** facing towards the growth substrate (the lower surface of the fixing part **61** shown in FIG. **12**) and the subsequently placed carrying substrate **1** is greater than the vertical distance between the surface of the micro-component facing away from the growth substrate (the upper surface of the micro-component mesa structure **12** shown in FIG. **12**) and the subsequently placed carrying substrate **1**. The location of the micro-

components can thus be defined and the deviation of the micro-components can be reduced, so that the micro-components are picked up by the corresponding transfer printing heads **5** in a better way.

[0078] Correspondingly, the method for producing the transfer printing substrate further includes removing the sacrificial layer **14** after the step S**6**. After the sacrificial layer **14** is removed, a second moving space is provided between the fixing part **61** and the adjacent micro-component, which prevents the fixing part **61** from abrading the micro-component.

[0079] Furthermore, in order to produce a strong adhesive force between the formed stable layer **16** and the sacrificial layer **14**, after the sacrificial layer **14** is formed in the step S**31**, a second adhesive layer may be formed on the surface of the sacrificial layer **14** facing away from the growth substrate **10**. Correspondingly, patterning the sacrificial layer **14** in the step S**32** includes: patterning the sacrificial layer **14** and the second adhesive layer to form on the sacrificial layer **14** and the second adhesive layer a plurality of openings **15** corresponding to the plurality of micro-component mesa structures **12** in one-to-one correspondence.

[0080] As shown in FIG.s **13** and **14**, the step S**4** includes:

[0081] Step S**41**: providing a carrying substrate **1**.

[0082] Step S**42**: forming a first adhesive layer **7** on the carrying substrate **1**, wherein the first adhesive layer **7** covers the surface of the carrying substrate **1**.

[0083] Step S**43**: placing the carrying substrate **1** formed with a first adhesive layer **7** on the fixing part **61** of the supporting structure **6**, wherein the fixing part **61** is adhered with the first adhesive layer **7**, so that the fixing part **61** supports the carrying substrate **1**, and a first moving space **20** is provided between the suspended supporting part **62** and the carrying substrate **1**.

[0084] By means of arranging a first adhesive layer **7** on the carrying substrate **1**, on one hand, the fixing part **61** can be adhered, achieving a more stable connection between the fixing parts **61** and the carrying substrate **1** and a better stability of the supporting structures **6**. On the other hand, when the suspended supporting part **62** is broken due to a great deformation of the suspended supporting part **62**, the broken suspended supporting part **62** can be adhered on the first adhesive layer **7**, in which way the broken suspended supporting part **62** cannot be driven away from the carrying substrate **1** together with the corresponding micro-components by the transfer printing heads **5**.

[0085] In one embodiment, when the micro-components are micro-LEDs, between the steps S**2** and S**3**, the method for producing a transfer printing substrate further includes: forming a first conducting layer on the surface of each of the micro-component mesa structures facing away from the growth substrate, respectively. After the step S**5**, the method for producing the transfer printing substrate further includes: forming a second conducting layer on the surface of each of the micro-components facing away from the carrying substrate, respectively.

[0086] When the first conducting layer particularly includes a bonding layer, a diffusion blocking layer, a sticking-blocking layer, a reflector layer and an electrode layer, the process of forming the first conducting layer includes: forming an electrode layer on the surface of the micro-component facing away from the growth substrate, forming a reflector layer on the surface of the electrode layer facing away from the growth substrate, forming a sticking-blocking layer on the surface of the reflector layer facing away from the electrode layer, forming a diffusion blocking layer on the surface of the sticking-blocking layer facing away from the reflector layer, and forming a bonding layer on the surface of the diffusion blocking layer facing away from the sticking-blocking layer.

[0087] Taking the micro-components being micro-LEDs as an example, with reference to FIG.s **15-17**, the technological processes of the method for producing a transfer printing substrate are fully described in the followings:

[0088] Step K**1**: providing a growth substrate **10** formed with an epitaxial growth layer **18**.

[0089] Step K**2**: forming a device layer **11** on the epitaxial growth layer **18**.

[0090] Step K**3**: patterning the device layer **11** so as to form a plurality of micro-component mesa structures **12**, wherein two adjacent micro-component mesa structures **12** are connected by a non-removed part **13** of the device layer **11** therebetween.

[0091] Step K**4**: forming a first conducting layer **8** at the side of each of the micro-component mesa structures **12** facing away from the growth substrate **10**.

[0092] Step K**5**: forming a sacrificial layer **14** at the side of the micro-component mesa structure **12** facing away from the growth substrate **10**.

[0093] Step K**6**: forming a second adhesive layer **19** at the side of the sacrificial layer **14** facing away from the growth substrate **10**.

[0094] Step K**7**: patterning the sacrificial layer **14** and the second adhesive layer **19** so as to form on the sacrificial layer **14** and the second adhesive layer **19** a plurality of openings **15** corresponding with the plurality of micro-component mesa structures **12** in one-to-one correspondence, so that each opening **15** corresponds to part of the regions of the corresponding first conducting layer **8**.

[0095] Step K**8**: forming a stable layer **16** at the side of the second adhesive layer **19** facing away from the growth substrate **10**, wherein the orthographic projection of the stable layer on the growth substrate **10** covers the second adhesive layer **19** and the opening **15**.

[0096] Step K**9**: patterning the stable layer to form supporting structures **6** corresponding with the plurality of micro-component mesa structures **12** in one-to-one correspondence, so that each of the supporting structures **6** includes a fixing part **61** and a suspended supporting part **62**.

[0097] Step K**10**: providing a carrying substrate **1**.

[0098] Step K**11**: forming a first adhesive layer **7** on the carrying substrate **1**, wherein the first adhesive layer **7** covers the surface of the carrying substrate **1**.

[0099] Step K**12**: placing the carrying substrate **1** formed with a first adhesive layer **7** on the fixing part **61** of the supporting structure **6**, wherein the fixing part **61** is adhered with the first adhesive layer **7**.

[0100] Step K**13**: removing the growth substrate **10**.

[0101] Step K**14**: removing the epitaxial growth layer **18** and the non-removed parts **13** of the device layer **11** so as to form a plurality of micro-components **3**.

[0102] Step K**15**: forming a second conducting layer **9** on the surface of each of the micro-components **3** facing away from the carrying substrate **1**.

[0103] Step K**16**: removing the sacrificial layer **14**.

[0104] With respect to a transfer printing substrate formed by using said method, a first moving space is provided

between the suspended supporting part of the supporting structure and the carrying substrate. When part of the transfer printing heads contact with the micro-components with greater thicknesses first, the transfer printing heads can continue moving towards the carrying substrate, which ensures sufficient contact of the micro-components having different thicknesses with the corresponding transfer printing heads, so that all of the micro-components are picked up by the corresponding transfer printing heads, thus the yield of picking up is improved, and the problem of uneven image brightness caused by missing of part of the micro-components on the display substrate is avoided.

[0105] Taking the micro-components being micro-LEDs as an example, the micro-components formed on the transfer printing substrate may particularly be R, G, B tri-color micro-LEDs. During the process of transferring, the R, G, B tri-color micro-LEDs may be correspondingly picked up in batches by a plurality of transfer printing heads and the LED particles picked up in batches are transferred to corresponding regions of the display substrate respectively. For example: firstly, a plurality of red LED particles are picked up and transferred to corresponding regions of the display substrate. Then, a plurality of green LED particles are picked up and transferred to corresponding regions of the display substrate. Finally, a plurality of blue LED particles are picked up and transferred to corresponding regions of the display substrate. After forming a complete display panel by subsequent production, according to actual requirements, the micro-LEDs transferred to the display substrate may be driven to emit light of different colors during displaying images, so that a full-color LED display of the display panel is realized.

[0106] It should be pointed out that the micro-components generally relate to tiny components with sizes from 1 μm to 100 μm. However, the sizes of the formed micro-components in the embodiments of the present disclosure are not limited thereto. Furthermore, the micro-components involved in the embodiments of the present disclosure are not limited to the micro-LEDs only, but can also be silicon chips provided with logical units and storages, or gallium arsenide circuits used for radio frequency communication, or, certainly, other structures. Correspondingly, the substrate used for receiving the micro-components in the embodiments of the present disclosure is not limited to the display substrate. According to the particular type of the transferred micro-components, the substrate used for receiving the micro-components may be a lighting base substrate, or a base substrate having functional devices such as transistors or integrated circuits, or a base substrate having metal distribution lines.

[0107] The above descriptions are only preferred embodiments of the present disclosure and are not used to limit the present disclosure. Any modification, equivalent substitution, improvements and the like made within the spirit and principles of the present disclosure should be included in the scope protected by the present disclosure.

What is claimed is:

1. A transfer printing substrate, comprising a carrying substrate, a plurality of supporting structures, and a plurality of micro-components corresponding to the plurality of support structures in one-to-one correspondence; wherein

each of the plurality of supporting structures comprises a fixing part and a suspended supporting part, wherein an end of the fixing part is fixed on the carrying substrate, an end of the suspended supporting part is connected to the fixing part, and another end of the suspended supporting part supports the corresponding one of the plurality of micro-components, and

wherein a first moving space is provided between the suspended supporting part and the carrying substrate.

2. The transfer printing substrate according to claim **1**, wherein the fixing part of each of the plurality of supporting structures is located between the corresponding micro-component and another micro-component adjacent to the corresponding micro-component, and a vertical distance between the carrying substrate and a surface of the fixing part facing away from the carrying substrate is greater than a vertical distance between the carrying substrate and a surface of the corresponding micro-component facing towards the carrying substrate.

3. The transfer printing substrate according to claim **2**, wherein a second moving space is provided between the fixing part and one of the micro-components adjacent to the fixing part.

4. The transfer printing substrate according to claim **1**, wherein, for each of the supporting structures, the fixing part and the suspended supporting part are formed in one piece.

5. The transfer printing substrate according to claim **1**, wherein the transfer printing substrate further comprises a first adhesive layer provided on the carrying substrate, wherein the fixing part of the supporting structure is adhered to the first adhesive layer.

6. The transfer printing substrate according to claim **1**, wherein each of the plurality of micro-components is a micro light emitting diode (micro-LED), and the transfer printing substrate further comprises a first conducting layer provided between the micro-LED and the corresponding suspended supporting part and a second conducting layer provided on a surface of the micro-LED facing away from the carrying substrate.

7. The transfer printing substrate according to claim **6**, wherein the first conducting layer comprises a bonding layer, a diffusion blocking layer, a sticking-blocking layer, a reflector layer and an electrode layer located on the suspended supporting part in sequence.

8. The transfer printing substrate according to claim **1**, wherein the plurality of micro-components is arranged in matrix.

9. A method for producing a transfer printing substrate comprising a carrying substrate, a plurality of supporting structures, and a plurality of micro-components corresponding to the plurality of support structures in one-to-one correspondence, wherein each of the plurality of supporting structures comprises a fixing part and a suspended supporting part, wherein an end of the fixing part is fixed on the carrying substrate, an end of the suspended supporting part is connected to the fixing part, and another end of the suspended supporting part supports the corresponding one of the plurality of micro-components, and wherein a first moving space is provided between the suspended supporting part and the carrying substrate,

wherein the method comprises steps of:

providing a growth substrate;

forming a plurality of micro-component mesa structures on the growth substrate;

forming a plurality of support structures corresponding to the plurality of micro-component mesa structures in one-to-one correspondence, so that each of the plurality

of supporting structures comprises a fixing part and a suspended supporting part, wherein an end of the suspended supporting part contacts with a corresponding one of the plurality of micro-component mesa structures, and another end of the suspended supporting part is connected to the fixing part;

arranging a carrying substrate at a side of the support structure facing away from the growth substrate, wherein the fixing part supports the carrying substrate, and the first moving space is provided between the suspended supporting part and the carrying substrate; and

removing the growth substrate after arranging the carrying substrate, and processing the plurality of micro-component mesa structures so as to form a plurality of micro-components.

10. The method for producing a transfer printing substrate according to claim **9**, wherein the step of forming the plurality of micro-component mesa structures on the growth substrate comprises:

forming a device layer on the growth substrate;

patterning the device layer so as to form the plurality of micro-component mesa structures, wherein non-removed parts of the device layer are connected between two adjacent micro-component mesa structures;

processing the plurality of micro-component mesa structures so as to form a plurality of micro-components; patterning the plurality of micro-component mesa structures and removing the non-removed parts of the device layer so as to form the plurality of micro-components.

11. The method for producing a transfer printing substrate according to claim **9**, wherein the step of forming a plurality of supporting structures corresponding to the plurality of micro-component mesa structures in one-to-one correspondence comprises:

forming a sacrificial layer at a side of the micro-component mesa structures facing away from the growth substrate;

patterning the sacrificial layer so as to form on the sacrificial layer a plurality of openings corresponding to the plurality of micro-component mesa structures in one-to-one correspondence, so that each of the plurality of openings corresponds to part of regions of a corresponding one of the plurality of micro-component mesa structures;

forming a stable layer at a side of the patterned sacrificial layer facing away from the growth substrate, wherein an orthographic projection of the stable layer on the growth substrate covers the sacrificial layer and the opening; and

patterning the stable layer so as to form supporting structures corresponding to the plurality of micro-component mesa structures in one-to-one correspondence, so that each of the supporting structures comprises the fixing part and the suspended supporting part, wherein an end of the suspended supporting part passes through the opening and contacts with a corresponding one of the plurality of micro-component mesa structures, the other end of the suspended supporting part is formed in one piece with the fixing part, and a vertical distance between the growth substrate and a surface of the fixing part facing away from the growth substrate is greater than a vertical distance between the growth substrate and a surface of the suspended supporting part facing away from the growth substrate;

after removing the growth substrate and processing the plurality of micro-component mesa structures so as to form a plurality of micro-components, the method for producing a transfer printing substrate further comprises: removing the sacrificial layer.

12. The method for producing a transfer printing substrate according to claim **10**, wherein, before forming a stable layer at a side of the patterned sacrificial layer facing away from the growth substrate, the method for producing a transfer printing substrate further comprises: forming a second adhesive layer on a surface of the sacrificial layer facing away from the growth substrate;

patterning the sacrificial layer comprises: patterning the sacrificial layer and the second adhesive layer so as to form, on the sacrificial layer and the second adhesive layer, a plurality of openings corresponding to the plurality of micro-component mesa structures in one-to-one correspondence.

13. The method for producing a transfer printing substrate according to claim **10**, wherein patterning the stable layer comprises: patterning the stable layer by using a halftone mask plate.

14. The method for producing a transfer printing substrate according to claim **9**, wherein the step of arranging a carrying substrate at the side of the support structure facing away from the growth substrate comprises:

providing the carrying substrate;

forming a first adhesive layer on the carrying substrate, wherein the first adhesive layer covers the surface of carrying substrate; and

placing the carrying substrate formed with the first adhesive layer on the fixing part of the supporting structure, so that the fixing part is adhered to the first adhesive layer.

15. The method for producing a transfer printing substrate according to claim **9**, wherein each of the plurality of micro-components is a micro light emitting diode (micro-LED);

before the step of forming a plurality of supporting structures corresponding to a plurality of the micro-components in one-to-one correspondence, the method for producing a transfer printing substrate further comprises: forming a first conducting layer on a surface of each of the plurality of micro-component mesa structures facing away from the growth substrate;

after the step of removing the growth substrate, the method for producing a transfer printing substrate further comprises: forming a second conducting layer on a surface of each of the plurality of micro-components facing away from the carrying substrate.

16. The method for producing a transfer printing substrate according to claim **15**, wherein forming a first conducting layer on a surface of each of the plurality of micro-component mesa structures facing away from the growth substrate comprises:

forming an electrode layer on the surface of the micro-component facing away from the growth substrate, forming a reflector layer on a surface of the electrode layer facing away from the growth substrate, forming a sticking-blocking layer on a surface of the reflector layer facing away from the electrode layer, forming a diffusion blocking layer on a surface of the sticking-

blocking layer facing away from the reflector layer, and forming a bonding layer on a surface of the diffusion blocking layer facing away from the sticking-blocking layer.

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专利名称(译)	转印基板及其制造方法		
公开(公告)号	US20190147778A1	公开(公告)日	2019-05-16
申请号	US15/960901	申请日	2018-04-24
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IPC分类号	G09F9/33 B41C1/06 H01L23/00		
CPC分类号	G09F9/33 B41C1/06 H01L24/97 G09G2300/0426 B41F16/00 H01L2924/12041 B41C1/00 B41F16/0066 H01L21/6835 H01L24/29 H01L24/32 H01L24/83 H01L25/0753 H01L33/0095 H01L2221/68354 H01L2224/2919 H01L2224/83005 H01L2224/97 H01L2224/83 H01L2924/00014		
优先权	201711105426.3 2017-11-10 CN		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供一种转印基板及其制造方法，以提高微小元件的拾取率，并进一步提高图像显示的质量。转印基板包括承载基板，多个支撑结构，以及与多个支撑结构一一对应的多个微元件，其中多个支撑结构中的每一个包括固定部分和悬挂支撑部，其中固定部的一端固定在承载基板上，悬挂支撑部的一端连接固定部，悬挂支撑部的另一端支撑多个微型中相应的一个 - 组件和第一移动空间设置在悬挂的支撑部分和承载基板之间。转印基板用于转移微元件。