US010388634B2

(12) United States Patent
Zou

(10) Patent No.: US 10,388,634 B2
(45) Date of Patent: Aug. 20, 2019

(54) MICRO-LED TRANSFER METHOD, MANUFACTURING METHOD AND DISPLAY DEVICE

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/986,812**

(22) Filed: **May 23, 2018**

(65) **Prior Publication Data**

US 2019/0096859 A1 Mar. 28, 2019

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2017/104036, filed on Sep. 28, 2017.

(51) **Int. Cl.**

H01L 21/00	(2006.01)
H01L 25/075	(2006.01)
H01L 33/62	(2010.01)
H01L 33/00	(2010.01)

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

CPC ***H01L 25/0753*** (2013.01); ***H01L 33/0079*** (2013.01); ***H01L 33/62*** (2013.01); *H01L 33/007* (2013.01); *H01L 2933/0066* (2013.01)

(58) **Field of Classification Search**

CPC . H01L 25/0753; H01L 33/0079; H01L 33/62; H01L 33/007; H01L 2933/0066

See application file for complete search history.

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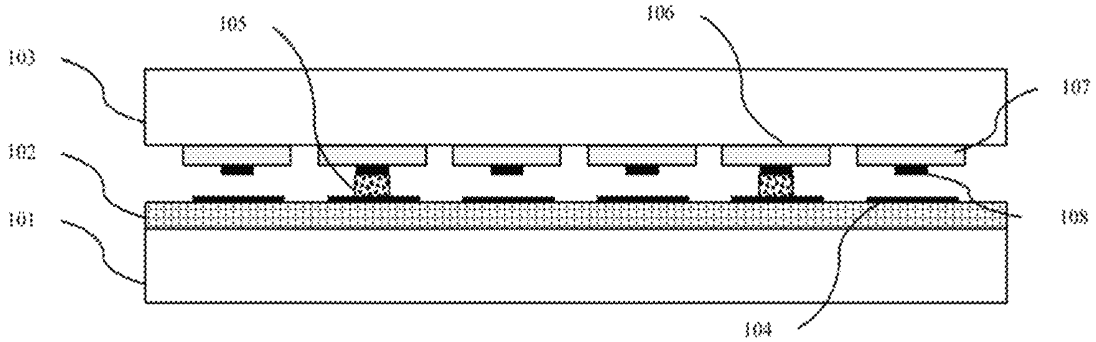
(57) **ABSTRACT**

A micro-LED transfer method, manufacturing method and display device are disclosed. The method comprises: coating conductive photoresist on a receiving substrate, wherein the conductive photoresist is positive-tone photoresist; bonding a carrier substrate with the receiving substrate via the conductive photoresist, wherein metal electrodes of micro-LEDs on the carrier substrate are aligned with electrodes on the receiving substrate and are bonded with the electrodes on the receiving substrate via the conductive photoresist, and the carrier substrate is a transparent substrate; selectively lifting-off micro-LEDs from the carrier substrate through laser lifting-off using a first laser; and separating the carrier substrate from the receiving substrate.

10 Claims, 3 Drawing Sheets



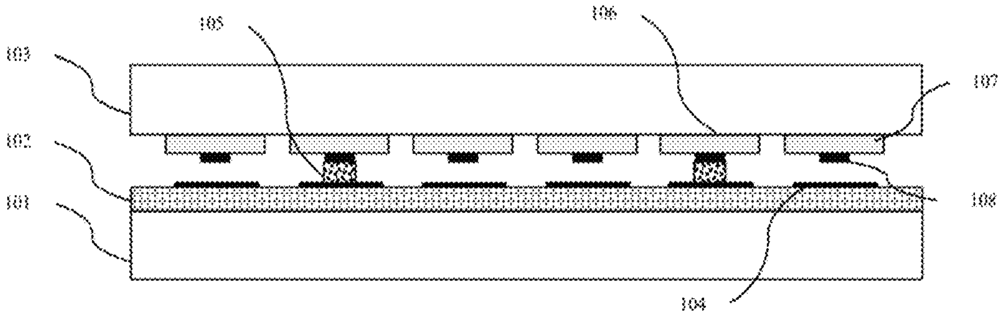


FIG. 1

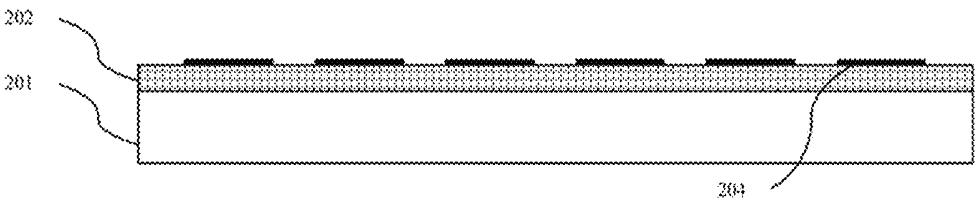


FIG. 2

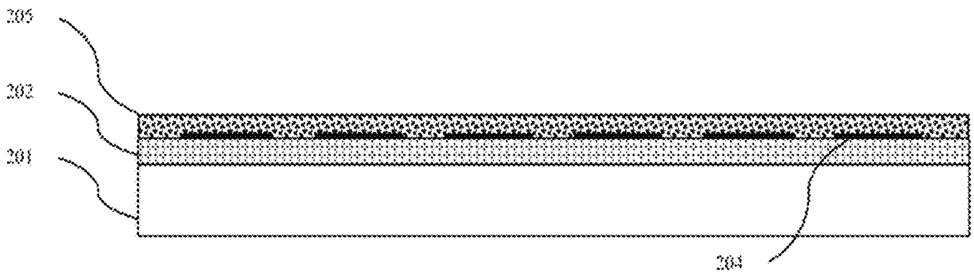


FIG. 3

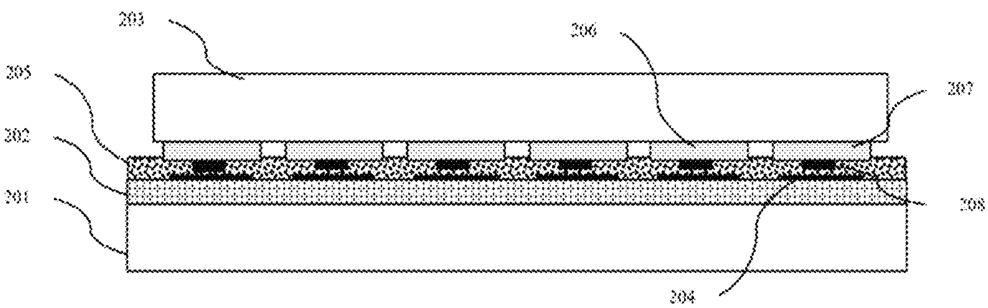


FIG. 4

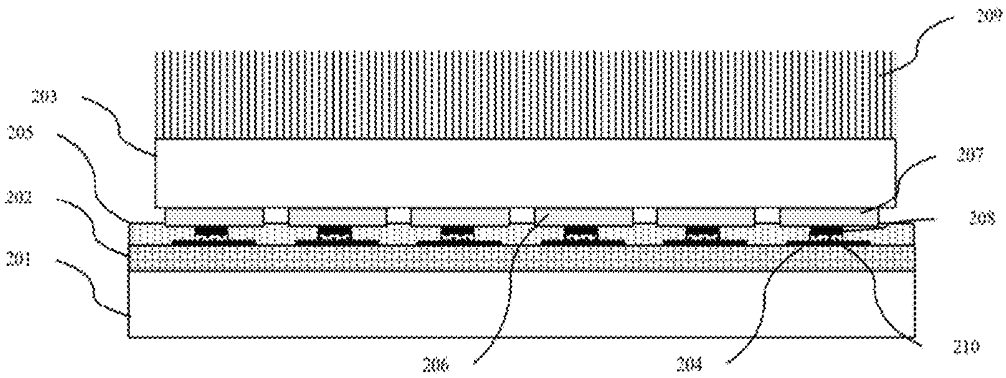


FIG. 5

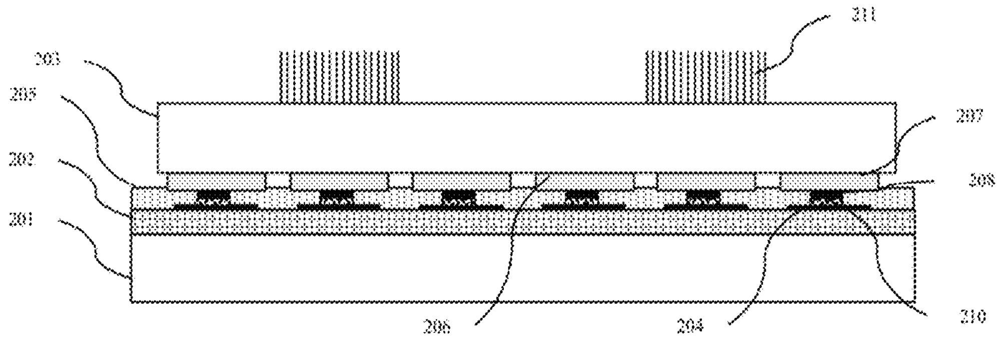


FIG. 6

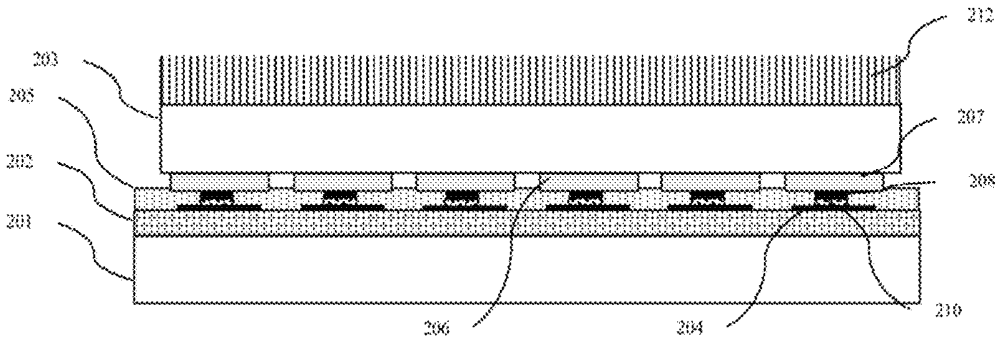


FIG. 7

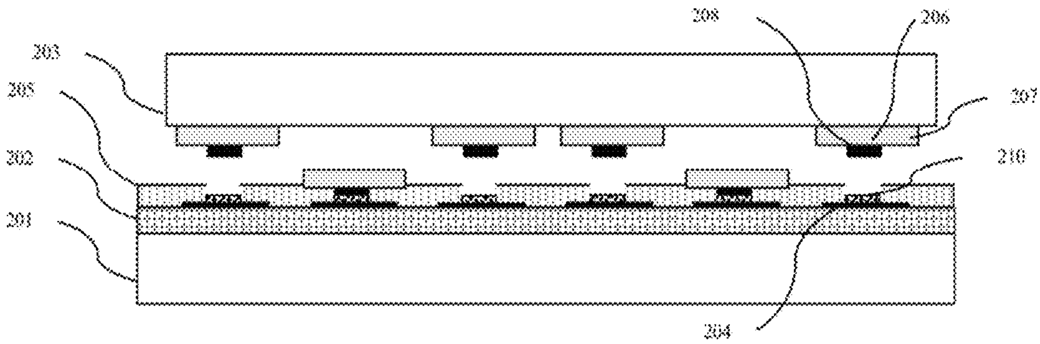


FIG. 8

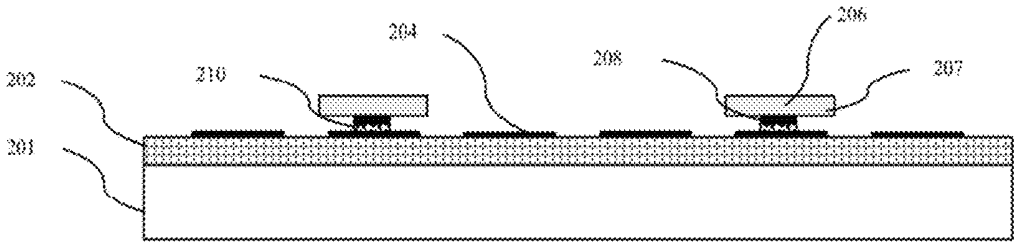


FIG. 9

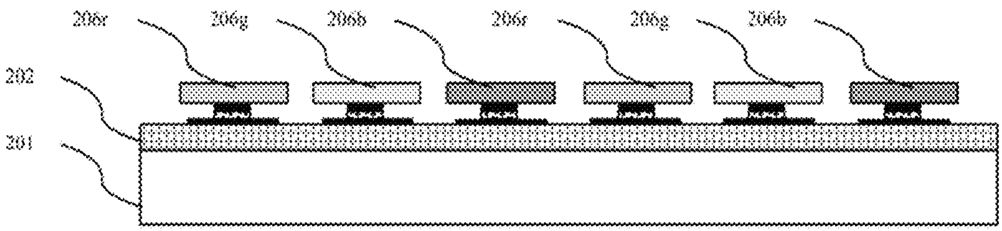


FIG. 10

MICRO-LED TRANSFER METHOD, MANUFACTURING METHOD AND DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of International Application No. PCT/CN2017/104036, filed on Sep. 28, 2017, which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to the technical field of micro-LED display, and more specifically, to a method for transferring micro-LEDs, method for manufacturing a micro-LED display device and a micro-LED display device.

BACKGROUND OF THE INVENTION

The micro-LED technology refers to the LED array of small size integrated on a substrate with high density. As the development of micro-LED technology, it is expected in the industry that a high-quality micro-LED product would come into the market. High quality micro-LED will have a deep impact on the conventional display products such as LCD/OLED that have already been in the market.

In the process of manufacturing micro-LEDs, a micro-LED array is first formed on a carrier substrate. The carrier substrate can be a growth substrate or an intermediate substrate. Then, the micro-LED array is transferred to a receiving substrate of a display device. The receiving substrate can be a display screen or display panel, etc. The display device can be used in an electronic apparatus, such as a micro-display in an argument reality device or a virtual reality device, a watch, a mobile phone a television and so on.

FIG. **1** shows that micro-LEDs **106** on a carrier substrate **103** are being transferred to a receiving substrate **101**. The carrier substrate **103** may be a sapphire substrate, for example. A thin film transistor (TFT) layer **102** is formed on the receiving substrate **101**. Electrodes **104** are formed on top of the TFT layer **102**. The micro-LEDs **106** include epitaxy layers **107** and metal electrodes **108**.

Generally, the metal electrodes **108** are P-metal electrodes, and the electrodes **104** are anodes. Alternatively, the metal electrodes **108** are N-metal electrodes and the electrodes **104** are cathodes. Alternatively, the micro-LEDs **106** have a flip structure. In this situation, the metal electrodes **108** may include both P-metal electrodes and N-metal electrodes, and the electrodes **104** may include both anodes and cathodes.

The receiving substrate **101** and the carrier substrate **103** are bonded via a patterned bonding layer (solder) **105**, such as solder bumps, resists, pastes, adhesives or polymers, and so on. Specifically, the metal electrodes **108** are bonded with the electrodes **104** via the bonding layer **105**.

Laser lifting-off technology can be used in the transfer of micro-LEDs. After the micro-LEDs **106** are bonded with the receiving substrate **101**, they can be lifted off by irradiating a laser from the carrier substrate side.

However, the bonding between the metal electrodes **108** and the electrodes **104** is weak. When the micro-LEDs **106** are lifted off from the carrier substrate **103** by using a laser lifting-off, the bonding may be broken and thus the yield loss may be high.

Therefore, there is a demand in the art that a new solution for transferring micro-LEDs shall be proposed to address at least one of the problems in the prior art.

SUMMARY OF THE INVENTION

One object of this invention is to provide a new technical solution for transferring micro-LEDs.

According to a first aspect of the present invention, there is provided 1. A method for transferring micro-LEDs, comprising: coating conductive photoresist on a receiving substrate, wherein the conductive photoresist is positive-tone photoresist; bonding a carrier substrate with the receiving substrate via the conductive photoresist, wherein metal electrodes of micro-LEDs on the carrier substrate are aligned with electrodes on the receiving substrate and are bonded with the electrodes on the receiving substrate via the conductive photoresist, and the carrier substrate is a transparent substrate; selectively lifting-off micro-LEDs from the carrier substrate through laser lifting-off using a first laser; and separating the carrier substrate from the receiving substrate.

Alternatively or optionally, the method further comprises: exposing the conductive photoresist and the micro-LEDs with ultraviolet light, wherein the metal electrodes are not transparent for the ultraviolet light. Optionally, epitaxy layers of the micro-LEDs are transparent for at least one component of the ultraviolet light.

Alternatively or optionally, the metal electrodes includes at least one of a P-metal electrode and a N-metal electrode.

Alternatively or optionally, the method further comprises: de-bonding the epitaxy layers of the micro-LEDs from the conductive photoresist by using a second laser for which the metal electrodes are not transparent and the epitaxy layers are transparent.

Alternatively or optionally, wavelength of the second laser is larger than 365 nm.

Alternatively or optionally, the carrier substrate is a sapphire substrate and the epitaxy layers are GaN layers.

Alternatively or optionally, the method further comprises: stripping off the conductive photoresist on the receiving substrate.

Alternatively or optionally, the first laser has a wavelength of 193 nm, 248 nm or 308 nm.

According to a first aspect of the present invention, there is provided a method for manufacturing a micro-LED display device, including: transferring micro-LEDs from a carrier substrate to a receiving substrate of the display device by using the above method.

According to a first aspect of the present invention, there is provided a micro-LED display device manufactured by using the above method.

According to an embodiment of this invention, the present invention can improve the bonding strength between micro-LEDs and the receiving substrate during a transfer using a laser lifting-off.

Further features of the present invention and advantages thereof will become apparent from the following detailed description of exemplary embodiments according to the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description thereof, serve to explain the principles of the invention.

FIG. 1 schematically shows a prior art laser lifting-off process.

FIGS. 2-10 schematically show a process of transferring micro-LEDs according to an embodiment of this disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Various exemplary embodiments of the present invention will now be described in detail with reference to the drawings. It should be noted that the relative arrangement of the components and steps, the numerical expressions, and numerical values set forth in these embodiments do not limit the scope of the present invention unless it is specifically stated otherwise.

The following description of at least one exemplary embodiment is merely illustrative in nature and is in no way intended to limit the invention, its application, or uses.

Techniques, methods and apparatus as known by one of ordinary skill in the relevant art may not be discussed in detail but are intended to be part of the specification where appropriate.

In all of the examples illustrated and discussed herein, any specific values should be interpreted to be illustrative only and non-limiting. Thus, other examples of the exemplary embodiments could have different values.

Notice that similar reference numerals and letters refer to similar items in the following figures, and thus once an item is defined in one figure, it is possible that it need not be further discussed for following figures.

Examples and embodiments will be described below with reference to the figures.

FIGS. **2-10** schematically show a process of transferring micro-LEDs according to an embodiment of this disclosure.

As shown in FIG. **2**, a receiving substrate **201** is prepared. A TFT layer **202** may be formed on top of the receiving substrate **201**. Electrodes **204** may be formed on top of the TFT layer **202**. Preferably, the electrodes **204** are anodes. Alternatively, they can be cathodes, or can include both anodes and cathodes for micro-LEDs of flip structure. The preparation of the receiving substrate **201** can be performed in a prior art manner and thus will not be described in detail here.

As shown in FIG. **3**, conductive photoresist **205** is coated on the receiving substrate **201**. The conductive photoresist is positive-tone photoresist. For example, the conductive photoresist **205** can be a mixture of commercial photoresist and conductive nano-particle powder such as silver, carbon or other metals/alloys.

As appreciated by a person skilled in the art, the conductive photoresist **205** can be soft-baked.

The conductive photoresist **205** is coated on the receiving substrate **201**, so that the conductive photoresist **205** can be placed on the receiving substrate **201** in a blanked manner. This will simplify the manufacturing process, compared with a patterned bonding layer of the prior art.

As shown in FIG. **4**, a carrier substrate **203** is bonded with the receiving substrate **201** via the conductive photoresist **205**.

For example, the bonding is a low temperature (close to room temperature) process with pressure. For example, it is performed at 20-100' C, or preferably 20-50' C.

Micro-LEDs **206** are formed on the carrier substrate **203**. The micro-LEDs **206** include epitaxy layers **207** and metal electrodes **208**. The metal electrodes **208** of micro-LEDs on the carrier substrate are aligned with electrodes **204** on the receiving substrate and are bonded with the electrodes **204** on the receiving substrate via the conductive photoresist **205**. As explained above, the metal electrodes **206** may include at least one of a P-metal electrode and a N-metal electrode.

The carrier substrate **203** is a transparent substrate, which is suitable for laser lifting-off. For example the carrier substrate **203** is a sapphire substrate. The epitaxy layers **207** can be GaN layers.

The conductive photoresist **205** can be stripped off as needed in a prior art manner. It can be patterned by using a mask and then be stripped off. Alternatively, they can be kept on the receiving substrate **201** as a common electrode.

Alternatively, a new approach is proposed in FIG. **5**. As shown in FIG. **5**, the conductive photoresist **205** and the micro-LEDs **206** are exposed with ultraviolet light **209**. The metal electrodes **208** are not transparent for the ultraviolet light **209**.

In such a situation, the metal electrodes **208** act as a mask for the conductive photoresist. This is a kind of self-aligned photoresist exposure and auto masking by the metal electrodes. The exposing can be performed in a blanked manner, which is simple. The exposed conductive photoresist can be easily stripped off after the transfer. The processing of patterning can be omitted. This will simplify the processing of the transferring.

Optionally, the epitaxy layers **207** of the micro-LEDs **206** are transparent for at least one component of the ultraviolet light **209**. For example, the material of the epitaxy layers **207** is GaN, and is transparent for the components of the ultraviolet light **209** with wavelengths larger than 365 nm. In such a situation, the conductive photoresist under the epitaxy layers **207** can also be stripped off after transfer.

As shown in FIG. **5**, after being exposed with the ultraviolet **209**, the exposed portion of the conductive photoresist is modified to be suitable for stripping-off while the portions under the metal electrodes **208** are un-modified and will be kept after stripping-off.

It will be appreciated by a person skilled in the art that, although it is shown in FIG. **5** that the ultraviolet light **209** is irradiated via the carrier substrate **203**, this exposing process can also be performed after the carrier substrate **203** is separated from the receiving substrate **201**.

As shown in FIG. **6**, micro-LEDs **206** are selectively lifted-off from the carrier substrate **203** through laser lifting-off using a first laser **211**.

The epitaxy layers **207** are not transparent for the first laser **211**. The first laser will function at the interface between the carrier substrate **203** and the epitaxy layers **207** to lift off the selected micro-LEDs. For example, the first laser **211** has a wavelength of 193 nm, 248 nm or 308 nm. For example, an excimer laser can be used.

The conductive photoresist **205** will absorb some of the stress during the laser lifting-off so that the connection between the metal electrodes **208** and the electrodes **204** can be protected. As a result, the mechanical damage induced by the laser lifting-off is minimized due to the robust support on the micro-LEDs by the conductive photoresist. This will reduce the yield loss.

Optionally, as shown in FIG. **7**, the epitaxy layers **207** of the micro-LEDs **206** can be de-bonded from the conductive photoresist **205** by using a second laser **212**. For the second laser **212**, the metal electrodes **208** are not transparent and the epitaxy layers **207** are transparent. For example, the wavelength of the second laser **212** is larger than 365 nm, and the epitaxy layers **207** (GaN, for example) as well as the carrier substrate **203** (sapphire, for example) are transparent.

In such a manner, the epitaxy layers **207** are separated from the conductive photoresist **204** at the interface therebetween. So, it will be easy to separate the un-selected micro-LEDs from the receiving substrate **201**.

As shown in FIG. **8**, the carrier substrate **203** is separated from the receiving substrate **201**. The selected (lifted-off) micro-LEDs **206** are kept on the receiving substrate **201** and the metal electrodes **208** thereof are connected with the electrodes **204** via the un-modified conductive photoresist **210**.

The un-lifted-off micro-LEDs still have a strong bonding between the epitaxy layer **207** and the carrier substrate **203**. They will be separated from the receiving substrate **201** with the carrier substrate **203**.

As shown in FIG. **9**, the conductive photoresist **205** on the receiving substrate is stripped-off. The un-modified conductive photoresist **210** is left between the metal electrodes **208** and the electrodes **204**. For example, the conductive photoresist **205** can be stripped off by using a dry etching by using O_2 plasma, or RIE (Reactive Ion Etching) and so on, or by a wet etching by using developer or stripper with controlled time.

As shown in FIG. **10**, the micro-LEDs of different colors can be transferred one color by one color. For example, the red micro-LEDs are first transferred by using the above processes, the green micro-LEDs are then transferred by using the above processes, and the blue micro-LEDs are finally transferred by using the above processes.

In another aspect of this disclosure, the transferring method can be used in a method for manufacturing a micro-LED display device. For example, the method can include: transferring micro-LEDs from a carrier substrate to a receiving substrate of the display device by using the method described above. The display device may a display screen or display panel, for example.

In still another aspect of this disclosure, a micro-LED display device manufactured by using the above method or manufacturing a micro-LED display device.

Although some specific embodiments of the present invention have been demonstrated in detail with examples, it should be understood by a person skilled in the art that the above examples are only intended to be illustrative but not to limit the scope of the present invention.

What is claimed is:

1. A method for transferring micro-LEDs, comprising:

coating conductive photoresist on a receiving substrate, wherein the conductive photoresist is positive-tone photoresist;

bonding a carrier substrate with the receiving substrate via the conductive photoresist, wherein metal electrodes of micro-LEDs on the carrier substrate are aligned with electrodes on the receiving substrate and are bonded with the electrodes on the receiving substrate via the conductive photoresist, and the carrier substrate is a transparent substrate;

selectively lifting-off micro-LEDs from the carrier substrate through laser lifting-off using a first laser; and

separating the carrier substrate from the receiving substrate.

2. The method according to claim **1**, further comprising:

exposing the conductive photoresist and the micro-LEDs with ultraviolet light, wherein the metal electrodes are not transparent for the ultraviolet light.

3. The method according to claim **1**, wherein the metal electrodes includes at least one of a P-metal electrode and a N-metal electrode.

4. The method according to claim **1**, further comprising:

de-bonding the epitaxy layers of the micro-LEDs from the conductive photoresist by using a second laser for which the metal electrodes are not transparent and the epitaxy layers are transparent.

5. The method according to claim **4**, wherein wavelength of the second laser is larger than 365 nm.

6. The method according to claim **2**, wherein the carrier substrate is a sapphire substrate and the epitaxy layers are GaN layers.

7. The method according to claim **1**, further comprising:

stripping off the conductive photoresist on the receiving substrate.

8. The method according to claim **1**, wherein the first laser has a wavelength of 193 nm, 248 nm or 308 nm.

9. A method for manufacturing a micro-LED display device, including: transferring micro-LEDs from a carrier substrate to a receiving substrate of the display device by using the method according to claim **1**.

10. A micro-LED display device manufactured by using the method according to claim **9**.

* * * * *

patsnap

专利名称(译)	微型LED转移方法，制造方法和显示装置		
公开(公告)号	US10388634	公开(公告)日	2019-08-20
申请号	US15/986812	申请日	2018-05-23
[标]申请(专利权)人(译)	歌尔声学股份有限公司		
申请(专利权)人(译)	歌尔声学，INC.		
当前申请(专利权)人(译)	歌尔声学，INC.		
[标]发明人	ZOU QUANBO		
发明人	ZOU, QUANBO		
IPC分类号	H01L21/00 H01L25/075 H01L33/62 H01L33/00		
CPC分类号	H01L25/0753 H01L33/0079 H01L33/62 H01L2933/0066 H01L33/007 H01L33/0075 H01L33/0093 H01L33/0095 H01L33/32 H01L2224/95		
其他公开文献	US20190096859A1		
外部链接	Espacenet		

摘要(译)

公开了一种微LED转移方法，制造方法和显示装置。该方法包括：在接收基板上涂覆导电光刻胶，其中导电光刻胶是正性光刻胶;通过导电光刻胶将载体基板与接收基板接合，其中载体基板上的微LED的金属电极与接收基板上的电极对齐，并通过导电光刻胶与接收基板上的电极接合，并且载体基材是透明基材;使用第一激光器通过激光剥离选择性地从载体基板上剥离微LED;将载体基板与接收基板分离。