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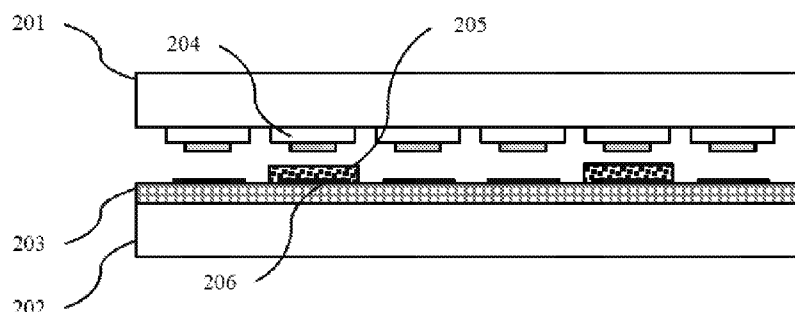


FIG. 2

(57) Abstract: It is disclosed a micro-LED transfer method, manufacturing method and display device. The method for transferring a micro-LED array (204) comprises: patterning conductive resist (205) on a receiving substrate (202) to cover electrodes (206) for the micro-LED array (204) to be transferred; bonding the micro-LED array (204) on a first substrate (201) with the receiving substrate (202) through the conductive resist (205), wherein the first substrate (201) is laser (207) transparent; irradiating laser (207) onto the micro-LED array (204) from a side of the first substrate (201) to lift-off the micro-LED array (204) from the first substrate (201). According to an embodiment, the performance of a micro-LED device may be improved.



MICRO-LED ARRAY TRANSFER METHOD, MANUFACTURING METHOD AND DISPLAY DEVICE

FIELD OF THE INVENTION

The present invention relates to a method for transferring a micro-LED array, a method
5 for manufacturing a display device and a 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. Currently, the micro-LED technology is starting development, and it is expected in the industry that a high-quality micro-LED product comes into the market.
10 High-quality micro-LED will have a deep affection on the conventional display products such as LCD/OLED that have already been put into the market.

In the process of manufacturing micro-LEDs, a micro-LED array is first formed on a growth substrate. Then, the micro-LED array is transferred to a receiving substrate, or is transferred to a receiving substrate via a carrier substrate. The receiving substrate is a display
15 screen, for example.

In the prior art, the micro-LED array can be transferred from one substrate to another substrate through laser lifting-off (LLO).

Fig. 1 shows a prior art example of transferring a micro-LED array from a first substrate 101 (a carrier substrate or a growth substrate) to a receiving substrate 102. As shown in Fig. 1, the
20 micro-LED array 104 is formed on the first substrate 101. The micro-LED array 104 is bonded onto the receiving substrate 102. For example, the micro-LED array 104 is bonded onto the anode 106 on top of a TFT (Thin Film Transistor) circuitry 103 formed in the receiving substrate 102 through solder bond 105. The first substrate 101 is laser-transparent. Laser 107 is irradiated from the side of the first substrate 101 onto the micro-LED array 104 to lift-off it.

25 Since the micro-LEDs in the micro-LED array are of a very small size, the bonding strength between the micro-LEDs and the receiving substrate is very low. Especially, when the resolution of the display device is improved and the micro-LEDs are getting smaller and smaller,

the yield loss during transfer is increased.

The bonding strength can be improved when the bonding temperature is elevated. However, the elevated bonding temperature will significantly degrade the bonding quality due to thermal mismatch of the micro-LEDs and the receiving substrate. In this regard, lowered bonding
5 temperature is preferred, especially, for a micro-LED transfer with a large area, where the bonding strength will be a key concern.

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

SUMMARY OF THE INVENTION

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

According to a first aspect of the present invention, there is provided a method for transferring a micro-LED array, comprising: patterning conductive resist on a receiving substrate to cover electrodes for the micro-LED array to be transferred; bonding the micro-LED array on a
15 first substrate with the receiving substrate through the conductive resist, wherein the first substrate is laser transparent; irradiating laser onto the micro-LED array from a side of the first substrate to lift-off the micro-LED array from the first substrate.

Alternatively or optionally, the method further comprises: cross-linking or curing the conductive resist after the micro-LED array is bonded with the receiving substrate and before the
20 micro-LED array is lifted-off.

Alternatively or optionally, the conductive resist is cross-linked or cured at a temperature lower than 200°C.

Alternatively or optionally, the conductive resist is photo resist and includes at least one of GCM3060, carbon-particle-filled resist or epoxy, and metal-particle-filled resist or epoxy.

25 Alternatively or optionally, the specific contact conductivity of the conductive resist is larger than $1 \text{ S} \cdot \text{cm}^2$.

Alternatively or optionally, the micro-LED array is bonded with the receiving substrate at a temperature in a range of 50~150°C.

Alternatively or optionally, a patterned area of the conductive resist is larger than that of a corresponding electrode.

Alternatively or optionally, the conductive resist is photo-definable.

According to a second aspect of the present invention, there is provided a method for
5 manufacturing a display device, comprising transferring a micro-LED array from a first substrate to a receiving substrate of the display device by using the method for transferring a micro-LED array according to any embodiment.

According to a third aspect of the present invention, there is provided a display device
10 manufactured by using the method for manufacturing a display device according to any embodiment.

According to an embodiment, the performance of a micro-LED device may be improved.

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

BRIEF DISCRIPTION 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.

20 Fig. 1 shows a schematic diagram of a prior art example of transferring a micro-LED array through laser lifting-off.

Figs. 2-5 shows a schematic diagram of a process of transferring a micro-LED array from a first substrate to a receiving substrate according to an embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

25 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.

5 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
10 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.

In an embodiment, it is proposed to use conductive resist as bonding material
15 during a transfer of a micro-LED array.

Figs. 2-5 shows a schematic diagram of a process of transferring a micro-LED array from a first substrate to a receiving substrate according to an embodiment.

As shown in Fig. 2, conductive resist 205 is applied on a receiving substrate 202 and is patterned to cover electrodes 206 for the micro-LED array 204 to be transferred.

20 For example, the micro-LED array 204 is formed on a first substrate 201. The first substrate 201 is a growth substrate or a carrier substrate, and is laser transparent. For example, a TFT (Thin Film Transistor) circuitry 203 is formed in the receiving substrate 202, and the electrodes 206 are connected to the TFT circuitry 203.

For example, the conductive resist 205 is photo resist. It can include at least one of
25 GCM3060 (SU8 type conductive photo-epoxy), carbon-particle-filled resist or epoxy, and metal-particle-filled resist or epoxy. For example, the specific contact conductivity of the conductive resist is larger than $1 \text{ S} \cdot \text{cm}^2$, and preferably, larger than $10 \text{ S} \cdot \text{cm}^2$. Optionally, a specific contact resistivity of the conductive resist is $1 \times 10^{-3} \sim 1 \times 10^{-1} \text{ ohm} \cdot \text{cm}^2$, and the resistance for a $10 \mu\text{m}$ square electrode is about 1-100 kohms. The conductive resist is

electrically conductive for interconnection between electrodes on the receiving substrate and a p-metal of a micro-LED in the micro-LED array, for example.

In an example, a patterned area of the conductive resist 205 is larger than that of a corresponding electrode 206. For example, as shown in Fig. 2, the conductive resist 205 fully covers the electrode 206. In this manner, the bonding strength between a micro-LED of the array and a corresponding electrode will be improved. The yield loss during transfer can be decreased.

For example, the conductive resist is photo-definable. The conductive resist on the receiving substrate can be patterned through photolithography.

As shown in Fig. 3, the micro-LED array 205 on the first substrate 201 is bonded with the receiving substrate 202 through the conductive resist 205. The micro-LED array 205 may firstly be aligned with the electrodes 206 on the receiving substrate 202. The first substrate 201 may just include the micro-LED array or include several micro-LED arrays, such as red, green and blue micro-LED arrays, which will be transferred to the receiving substrate.

Since the conductive resist 205 fully covers the electrode 206, the contact area for bonding a micro-LED is increased and bonding strength is increased. In this manner, a performance of the micro-LED array during a transfer will be improved. In this embodiment, a robust bonding strength can be achieved by enlarged resist patterns hence. Here, more bonding surface between a micro-LED 204 and the receiving substrate 202 is obtained

In an example, the micro-LED array 205 is bonded with the receiving substrate 202 at a temperature in a range of 50~150°C. This temperature is relatively close to a room temperature. This temperature is preferable for bonding substrates of different coefficient of thermal expansion (CTE). The thermal mismatch of the micro-LEDs and the receiving substrate will be lowered at such a temperature range. This approach will decrease the thermal mismatch while providing a relatively strong bonding strength.

The bonding of the micro-LED 205 with the receiving substrate 202 is performed prior to a resist hard baking or exposure. The conductive resist 205 is soft and/or compressible during the bonding.

As shown in Fig. 4, laser 207 is irradiated onto the micro-LED array 205 from a side of the first substrate 201 to lift-off the micro-LED array 205 from the first substrate 201.

For example, the conductive resist 205 can be cross-linked or cured after the micro-LED array is bonded with the receiving substrate and before the micro-LED array is lifted-off. The cross-linking or curing can be performed by light exposure or elevating temperature. In this approach, the bonding strength during a transfer will be increased. For example, the
5 conductive resist is cross-linked or cured at a temperature lower than 200°C; preferably lower than 1°C; further preferably, lower than 100°C; and even further preferable, lower than 50°C..

As shown in Fig. 5, the micro-LED array 204 is separated from the first substrate 201 and is transferred onto the receiving substrate 202.

In a case where several micro-LED arrays, such as red, blue and green micro-LED
10 arrays, are to be transferred to a receiving substrate, the above processes may be repeated.

In another embodiment, an embodiment includes a method for manufacturing a display device. The manufacturing method comprises transferring a micro-LED array from a first substrate to a receiving substrate of the display device by using the method for transferring a micro-LED array according to an embodiment as above. The display device can be a display
15 panel, a display screen and so on.

In another embodiment, another embodiment includes a display device manufactured by using the method for manufacturing a display device according to an embodiment as above.

In another embodiment, another embodiment can further include an electronic apparatus. The electronic apparatus contains a display device as above. For example, the
20 electronic apparatus can be a mobile phone, a pad computer and so on.

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.

CLAIMS

What is claimed is:

1. A method for transferring a micro-LED array, comprising:

5 patterning conductive resist on a receiving substrate to cover electrodes for the micro-LED array to be transferred;

bonding the micro-LED array on a first substrate with the receiving substrate through the conductive resist, wherein the first substrate is laser transparent;

10 irradiating laser onto the micro-LED array from a side of the first substrate to lift-off the micro-LED array from the first substrate.

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

cross-linking or curing the conductive resist after the micro-LED array is bonded with the receiving substrate and before the micro-LED array is lifted-off.

15 3. The method according to claim 2, wherein the conductive resist is cross-linked or cured at a temperature lower than 200°C.

20 4. The method according to any of claims 1-3, wherein the conductive resist is photo resist and includes at least one of GCM3060, carbon-particle-filled resist or epoxy, and metal-particle-filled resist or epoxy.

5. The method according to any of claims 1-4, wherein the specific contact conductivity of the conductive resist is larger than $1 \text{ S} \cdot \text{cm}^2$.

25 6. The method according to any of claims 1-5, wherein the micro-LED array is bonded with the receiving substrate at a temperature in a range of 50~150°C.

7. The method according to any of claims 1-6, wherein a patterned area of the conductive resist is larger than that of a corresponding electrode.

8. The method according to any of claims 1-7, wherein the conductive resist is
5 photo-definable.

9. A method for manufacturing a display device, comprising transferring a micro-LED array from a first substrate to a receiving substrate of the display device by using the method for transferring a micro-LED array according to any of claims 1-8.

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10. A display device manufactured by using the method for manufacturing a display device according to claim 9.

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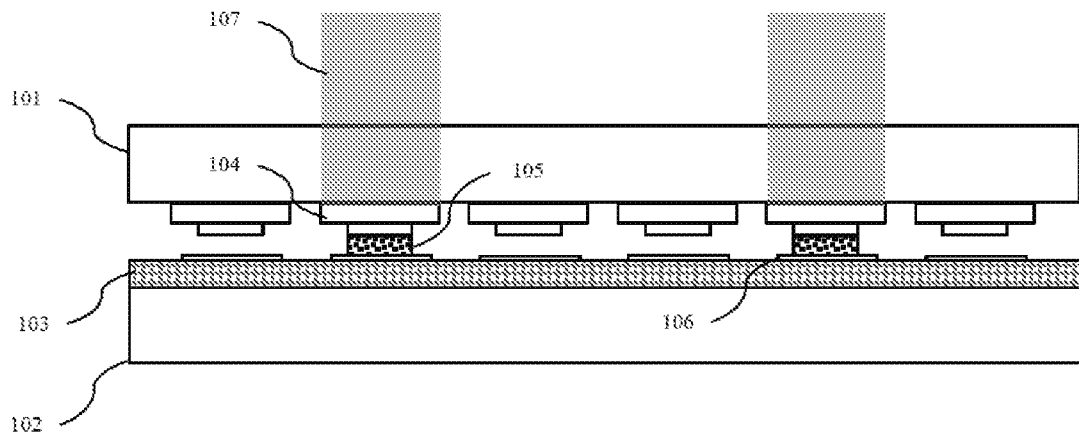


FIG. 1

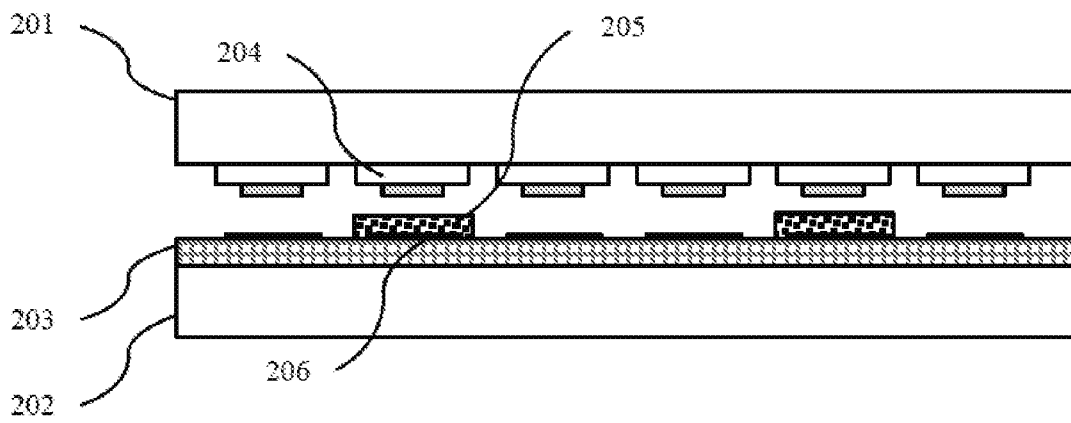


FIG. 2

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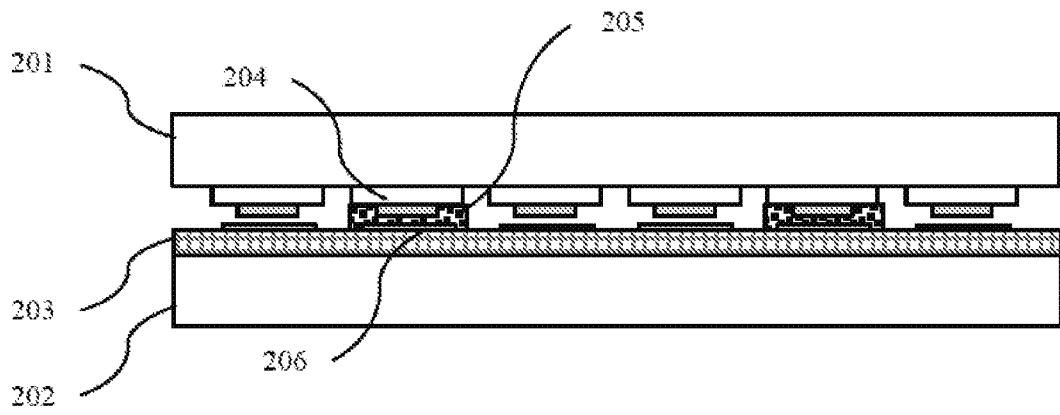


FIG. 3

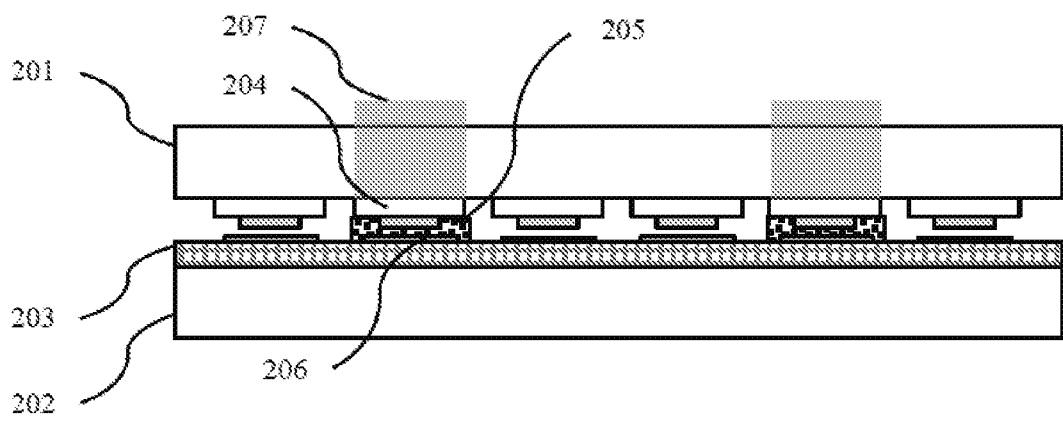


FIG. 4

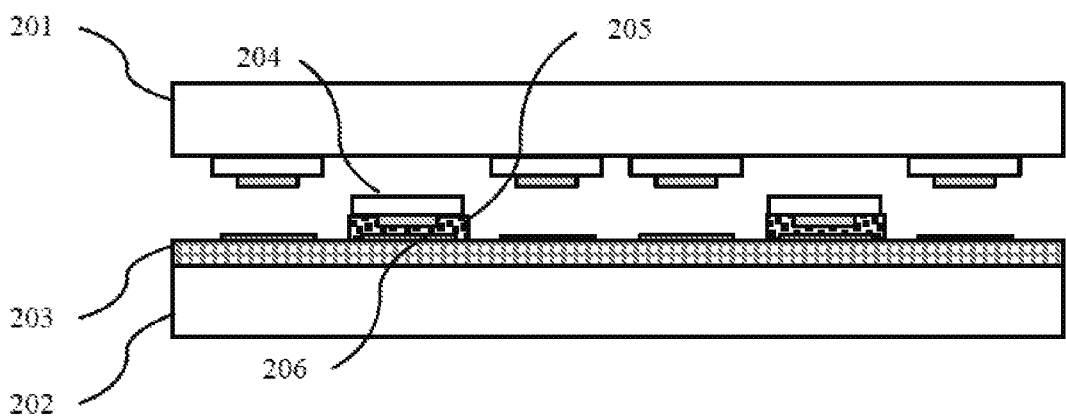


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/081063

A. CLASSIFICATION OF SUBJECT MATTER		
H01L 33/00(2010.01)i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
H01L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
CNPAT,CNKI,WPI,EPODOC: micro LED, mled, μ LED, transfer+, laser, display, lift off, detach+, resist+		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016155892 A1 (SCT TECHNOLOGY LTD.) 02 June 2016 (2016-06-02) description, paragraphs[0003]-[0006], [0082]-[0088], [0090], figures 14-17, 19	1-10
X	CN 105493297 A (GOERTEK INC.) 13 April 2016 (2016-04-13) description, paragraphs [0083]-[0099], figures 3-4	1-10
X	WO 2016183845 A1 (GOERTEK INC.) 24 November 2016 (2016-11-24) description, page 6 line 23-page 14 line 9, figures 1-4	1-10
A	WO 2016060677 A1 (INTEL CORPORATION) 21 April 2016 (2016-04-21) the whole document	1-10
A	WO 2011072373 A1 (COOLEGE LIGHTING INC.) 23 June 2011 (2011-06-23) the whole document	1-10
A	CN 106058010 A (SHENZHEN CHINA STAR OPTOELECTRONICS TECHNOLOGY CO., LTD.) 26 October 2016 (2016-10-26) the whole document	1-10
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
26 December 2017		18 January 2018
Name and mailing address of the ISA/CN		Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2017/081063

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2016155892	A1	02 June 2016	US	9698134	B2	04 July 2017
				CN	206134683	U	26 April 2017
				US	2017062400	A1	02 March 2017
				CN	107026124	A	08 August 2017
CN	105493297	A	13 April 2016	WO	2016183844	A1	24 November 2016
				US	2017338199	A1	23 November 2017
WO	2016183845	A1	24 November 2016	US	2017338374	A1	23 November 2017
WO	2016060677	A1	21 April 2016	CN	106716611	A	24 May 2017
				JP	2017533453	A	09 November 2017
				EP	3207563	A1	23 August 2017
				KR	20170041912	A	17 April 2017
				US	2017278733	A1	28 September 2017
WO	2011072373	A1	23 June 2011	US	2011151588	A1	23 June 2011
CN	106058010	A	26 October 2016	None			