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(54) Title: DISPLAY PANEL

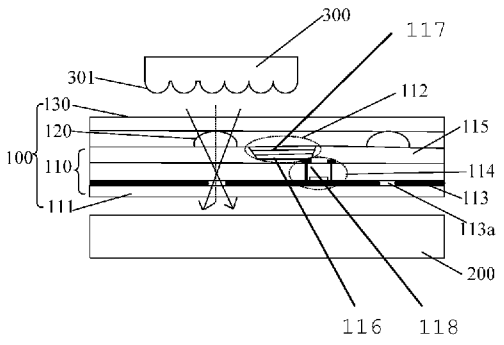

Fig. 1

(57) Abstract: A display panel (100). The display panel (100) may include a display substrate (110) and convergent lenses (120). The display substrate (110) may have pixel regions (P) and interval regions between the pixel regions (P). The display substrate (110) may include a light shielding layer (113) on a non-light exiting side of light emitting units (112) in the pixel regions (P). The light shielding layer (113) may have a plurality of light transmitting holes (113a) in the interval regions. The convergent lenses (120) may be on a side of the light shielding layer (113) toward the light emitting units (112) and at locations corresponding to the light transmitting holes (113a) respectively.

DISPLAY PANEL

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of the filing date of Chinese Patent Application No. 201710182796.0 filed on March 24, 2017, the disclosure of which is hereby incorporated by reference.

TECHNICAL FIELD

[0002] This invention relates to a display technology, and more particularly, to a display panel.

BACKGROUND

[0003] In recent years, smart phones have become more and more popular. A payment function in the smart phones provides great convenience to mobile phone users. The users can use mobile phones to pay for shopping or taking a taxi. Therefore, mobile phones having high security are needed to protect our property so that when the mobile phones are lost, they cannot be opened, and property and information in the mobile phones cannot be stolen. Fingerprint recognition came into being in response to the need of secure mobile phones. In the current mainstream technology, structures for fingerprint identification are mainly disposed outside a display area of a screen. For example, some structures for fingerprint identification are provided on a primary key (Home key) of a mobile phone, and can be opened by sliding or pressing. Some structures for fingerprint recognition are disposed on a back of a mobile phone. As such, when the phone is held in a hand of a user, fingerprints of the user's fingers on the back of the phone can be identified. Currently, there is no product where structures for fingerprint identification are disposed in a display area.

BRIEF SUMMARY

[0004] Accordingly, one example of the present disclosure is a display panel. The display panel may comprise a display substrate and convergent lenses. The display substrate may have pixel regions and interval regions between the pixel regions. The display substrate may comprise

a light shielding layer on a non-light exiting side of light emitting units in the pixel regions, and the light shielding layer may have a plurality of light transmitting holes in the interval regions. The convergent lenses may be on a side of the light shielding layer toward the light emitting units and at locations corresponding to the light transmitting holes respectively. A positive projection of each of the convergent lenses on the display substrate may cover a positive projection of one of the light transmitting holes on the display substrate respectively. Optical axes of the convergent lenses may pass through the corresponding light transmitting holes respectively. The optical axes of the convergent lenses may coincide with central axes of the corresponding light transmitting holes respectively. The light transmitting holes may be located at focal positions of the corresponding convergent lenses respectively.

[0005] The display panel may further include a cover plate opposite the display substrate, and the cover plate is on a light exiting side of the light emitting units and supported on the convergent lenses. The pixel regions may be arranged in a plurality of rows and columns, each of the pixel regions may have a same area, and each of the convergent lenses may be a part of a sphere. A radius of a bottom surface of each of the convergent lenses may be approximately between 7 μm and 12 μm, and a height of each of the convergent lenses may be approximately between 1 μm and 3 μm.

[0006] In another embodiment, the pixel regions may be arranged in a plurality of columns, and in any two adjacent columns, an area of a pixel region in one column may be larger than an area of a pixel region in the other column. Each of the convergent lenses between the two adjacent columns of the pixel regions may be a part of an ellipsoid. A long axis of a bottom surface of each of the convergent lenses may be approximately between12 μm and 20 μm, a short axis thereof may be approximately between 6 μm and 12 μm, and a height of each of the convergent lenses may be approximately between 1 μm and 3μm. A refractive index of each of the convergent lenses may be approximately between 1.3 and 1.8. A diameter or length of each of the light transmitting holes may be approximately between 2 μm and 3 μm. The light-shielding layer may be made of a metallic or an opaque polyester material.

[0007] Another example of the present disclosure is a display apparatus. The display apparatus may comprise the display panel according to one embodiment of the present disclosure. The display apparatus may further comprise a fingerprint identification sensor. The fingerprint identification sensor may be on a side of the light shielding layer away from the light emitting units, and the fingerprint identification sensor is configured to collect and identify an image of fingerprint on a light exiting side of the display panel through the light transmitting holes when the display panel emits light

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0009] Fig. 1 is a schematic view of a display apparatus for fingerprint identification according to one embodiment of the present disclosure;

[0010] Fig. 2 is a schematic view of an arrangement of pixel regions in a display apparatus according to one embodiment of the present disclosure;

[0011] Fig. 3 is a schematic view of an arrangement of pixel regions in a display apparatus according to one embodiment of the present disclosure.

DETAILED DESCRIPTION

[0012] The present disclosure will be described in further detail with reference to the accompanying drawings and embodiments in order to provide a better understanding of the technical solutions of the present disclosure by those skilled in the art. Throughout the description of the invention, reference is made to Figs. 1-3. When referring to the figures, like structures and elements shown throughout are indicated with like reference numerals.

[0013] Fig. 1 shows a schematic view of a display apparatus for fingerprint identification according to one embodiment of the present disclosure. Fig. 2 shows a schematic view of a shape

of convergent lens and an arrangement of pixel regions in a display apparatus according to one embodiment of the present disclosure. Fig. 3 shows a schematic view a shape of convergent lens and an arrangement of pixel regions in a display apparatus according to another embodiment of the present disclosure. As shown in Figs. 1 to 3, the display apparatus includes a display panel 100 and a fingerprint identification sensor 200. The display panel 100 includes a display substrate 110. The display substrate 110 is divided into a plurality of pixel regions P and interval regions between two adjacent pixel regions P. A light emitting unit 112 is provided in each of the pixel regions P. The display panel 100 further includes a light shielding layer 113 provided on a non-light exiting side of the plurality of light emitting units 112. The light shielding layer 113 has a plurality of light transmitting holes 113a located in the interval regions respectively. Convergent lenses 120 are provided on a side of the light shielding layer 113 toward the light emitting units 112 and at locations corresponding to the light transmitting holes 113a respectively. The fingerprint identification sensor 200 is provided on a side of the light shielding layer 113 away from the light emitting units 112. The fingerprint identification sensor 200 is used to collect and identify an image of a fingerprint 301 located on a light exiting side of the display panel 100 through the light transmitting holes 113a when the display panel 100 emits light.

[0014] In one embodiment, the display substrate 110 may further include a base 111 and an array of thin film transistors 114 disposed on the base 111. The light emitting unit 112 may be an Organic Light-Emitting Diode unit (OLED) or a micro-LED provided on a side of the thin film transistor 114 away from the base 111. The light emitting unit 112 may comprise a first electrode 116, a second electrode 117 opposite the first electrode, and a light emitting function layer between the first electrode and the second electrode. The first electrode 116 is coupled to a drain 118 of the thin film transistor 114 . In one embodiment, the light emitting unit 112 may be a bottom light emission type. That is, the first electrode provided between the light-emitting function layer and the base is a transparent electrode and the second electrode is a non-transparent electrode. In another embodiment, the light emitting unit may be a top light emitting

type. That is, the first electrode is a non-transparent electrode and the second electrode is a transparent electrode.

[0015] In one embodiment, a light emitting unit 112 has a light exiting side and a non-light exiting side. The light exiting side is a side where light from the light-emitting unit 112 is directed to. The non-light exiting side is a side opposite to the light exiting side. The light exiting side of the display panel is the light exiting side of the light emitting unit. For a light emitting unit 112 of a bottom light emission type, the non-light exiting side thereof is a side of the light-emitting unit 112 away from the base 111. For a light emitting unit 112 of a top light emission type, the non-light exiting side thereof is a side of the light-emitting unit 112 toward the base 111. In one embodiment of the present disclosure, the light emitting unit 112 may be a light emitting unit of a top light emission type. That is, the light shielding layer 113 is located on a side of the light emitting unit 112 toward the base 111. Convergent lenses 120 are provided on a side of the corresponding light transmitting holes 113a away from the base 111.

[0016] In a display apparatus according to one embodiment of the present disclosure, in a display state, when a user's finger 300 is placed on a display area of a display panel 100, light emitted by light emitting units 112 is reflected by a fingerprint 301. Then, the reflected light is converged by convergent lenses 120 and passes through light transmitting holes 113a to travel toward a fingerprint recognition sensor 200. Accordingly, the fingerprint recognition sensor 200 identifies an image of the fingerprint based on the light emitted from each of the light transmitting holes 113a. Provision of the light transmitting holes 113a can prevent stray light outside the display apparatus from entering the fingerprint recognition sensor 200 and influencing fingerprint recognition effect. Provision of the convergent lenses 120 makes the light reflected by the fingerprint 301 more concentrated, so that the recognition effect is better. As such, the embodiments of the present disclosure can realize fingerprint identification in a display area and achieve excellent fingerprint recognition effect. Moreover, since the light shielding layer 113 is provided on the non-light exiting side of the light emitting units 112 and the light transmitting holes 113a are provided in the interval regions between the pixel regions, normal display is not affected.

[0017] In order to make the fingerprint identification sensor 200 to identify a complete image of a fingerprint, distributions of the light emitting holes 113a and the convergent lenses 120 should satisfy the following: when a finger 300 is placed in a display area of a display panel 100, convergent lenses 120 in the area where the finger 300 is located should ensure that light reflected at each position of the finger 300 can pass through the convergent lenses 120 and the light transmitting holes 113a to reach the fingerprint identification sensor 200. In one embodiment, the fingerprint identification sensor 200 may include a photoelectric sensor and an image processor. The photoelectric sensor is used to convert the received light into electrical signals and then send the electrical signals to the image processor. The image processor calculates to obtain an image of a fingerprint corresponding to each of the convergent lenses based on the received electrical signals, and then integrates them into a complete image of the fingerprint.

[0018] In one embodiment, an optical axis of a convergent lens 120 passes through a corresponding light transmitting hole 113a. In another embodiment, an optical axis of a convergent lens 120 coincides with a central axis of a corresponding light transmitting hole 113a. The term “coincides with” herein means that the optical axis of a convergent lens 120 coincides exactly or wholly with the central axis of a corresponding light transmitting hole 113a; or that the optical axis of a convergent lens 120 is parallel with the central axis of a corresponding light transmitting hole 113a and passes through the corresponding light transmitting hole 113a; or that the optical axis of a convergent lens 120 intersects the central axis of a corresponding light transmitting hole 113a and an angle formed by the two intersecting axes is smaller than 5 degree. In another embodiment, the light transmitting hole 113a may be located at a focus position of the corresponding convergent lens 120, so that a light can pass through the light transmitting hole 113a as much as possible after the light is converged by the convergent lens 120, thereby improving the fingerprint recognition effect.

[0019] In order to ensure that a light converged by the convergent lens 120 can sufficiently pass through a light transmitting hole 113a, and simultaneously prevent external stray light from passing through the light transmitting hole 113a to influence fingerprint

recognition effect, a diameter of the light transmitting hole 113a may be approximately in a range between about 1.5 μm and about 3.5 μm, preferably between about 2 μm and about 3 μm. In one embodiment, the light transmitting hole 113a may have a cylindrical column shape. In another embodiment, the light transmitting hole 113a may have a square column shape. When a light transmitting hole 113a has a square column shape, a length of the light transmitting hole 113a is a length of a diagonal of the light transmitting hole 113a at a horizontal plane. That is, as a positive projection of the light transmitting hole on the display substrate has a rectangular shape, the length of the light transmitting hole is a length of a diagonal of the rectangular shape, which has a value approximately between about 1.5 μm and about 3.5 μm, preferably between about 2μm and about 3 μm.

[0020] In one embodiment, the display panel 100 further includes a cover plate 130 opposite the display substrate 110. The cover plate 130 is located on a light exiting side of the light emitting units 112 and supported by the convergent lenses 120. As described above, in one embodiment of the present disclosure, the light emitting units 112 are a top light emission type. Accordingly, the cover plate 130 is located on the light exiting side of the light emitting units 112. That is, the cover plate 130 is located on a side of the light emitting units 112 away from the substrate 111. The convergent lenses 120 can not only converge the light but also support the cover plate 130 to maintain structural stability of the display panel 100. As such, both fingerprint recognition in the display area and stability of the display panel 100 are achieved with a simple structure.

[0021] In one embodiment, the display substrate 110 further includes a pixel defining layer 115 disposed above the array of thin film transistors 114. The pixel defining layer 115 is formed with a plurality of grooves. The light emitting units 112 are disposed in the grooves. The convergent lenses 120 may be disposed on the pixel defining layer 115. A refractive index of the convergent lens 120 may be approximately between about 1.3 and about 1.8. In one embodiment, a refractive index of a convergent lens 120 is 1.7. A numerical range modified by "approximately" herein means that the upper and lower limits of the numerical range can vary by

10% thereof. A number modified by "about" herein means that the number can vary by 10% thereof.

[0022] The pixel regions P in the present disclosure may be arranged in different manners. An arrangement of pixel regions according to one embodiment of the present disclosure is shown in Fig. 2. In the embodiment, a plurality of pixel regions P is arranged in a plurality of rows and columns. An area of each of the pixel regions P is approximately the same. The convergent lens 120 may be a part of a sphere. A radius of a bottom surface of the convergent lens 120 is approximately between about 7 μm and about 12 μm, and a height of the convergent lens is approximately between about 1 μm and about 3 μm.

[0023] In one embodiment, when the pixel regions P are uniformly arranged as described above, the convergent lenses 120 are also arranged uniformly. When a finger 300 touches, each of the convergent lenses 120 in the corresponding area collects light reflected by a circular area on the finger 300. As such, it is more convenient for the fingerprint identification sensor 200 to acquire an entire image of a fingerprint based on the light reflected back from each circular area.

[0024] Fig. 3 shows an arrangement of pixel regions P according to one embodiment of the present disclosure. As shown in Fig. 3, a plurality of pixel regions P is arranged in a plurality of columns. In any two adjacent columns, an area of a pixel region P in one column is larger than that of a pixel region P in the other column. A convergent lens 120 located between the two adjacent columns of pixel regions P is a part of an ellipsoid. As shown in Fig. 3, an area of a blue pixel region B on the right column is approximately a sum of areas of a red pixel region R and a green pixel region G on the left column. A bottom surface of the convergent lens between the left column pixel region P and the right column pixel region P is elliptical to make full use of the interval region. For pixel regions P of the same column, areas of the pixel regions P may be the same. In one embodiment, the convergent lens 120 between the two adjacent pixel regions P may be a part of a sphere.

[0025] In one embodiment, when a convergent lens 120 is a part of an ellipsoid, a long axis of a bottom surface of the elliptical shape of the convergent lens 120 is approximately between about 12 μm and about 20 μm. A short axis thereof is approximately between about 6

μm and about 12 μm. A height of the convergent lens is approximately between about 1 μm and about 3μm.

[0026] A material of the light-shielding layer 13 of the present disclosure is not particularly limited here. In one embodiment, it may be made of a metallic material or an opaque polyester material.

[0027] In the display apparatus described above, in a display mode, when a user's finger is placed in a display area of a display panel, light emitted by the light emitting unit is reflected by a fingerprint. The reflected light is then converged by convergent lenses, passes through light transmitting holes, and travels toward a fingerprint recognition sensor. The fingerprint recognition sensor identifies a fingerprint image based on the light emitted from each of the light transmitting holes. Provision of the light transmitting holes can prevent stray light outside the display apparatus from entering the fingerprint recognition sensor and influence the fingerprint recognition effect. Provision of the convergent lens makes the light reflected by the fingerprint more concentrated. As such, the recognition effect is better.

[0028] The descriptions of the various embodiments of the present disclosure have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the embodiments disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the described embodiments. The terminology used herein was chosen to best explain the principles of the embodiments, the practical application or technical improvement over technologies found in the marketplace, or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

[0029] Description of symbols in the drawings:

100: display panel

110: display substrate

111: base

112: light-emitting unit

113: light shielding layer

113a: light transmitting hole

114: thin-film transistor

115: pixel defining layer

116: first electrode

117: second electrode

118: drain of thin film transistor

120: convergent lens

130: cover plate

200: fingerprint recognition sensor

300: finger

301: fingerprint

P: pixel region

R: red pixel region

G: green pixel region

B: blue pixel region

CLAIMS

What is claimed is:

1. A display panel comprising:

a display substrate and convergent lenses, the display substrate having pixel regions and interval regions between the pixel regions,

wherein the display substrate comprises a light shielding layer on a non-light exiting side of light emitting units in the pixel regions, the light shielding layer having a plurality of light transmitting holes in the interval regions, and

the convergent lenses are on a side of the light shielding layer toward the light emitting units and at locations corresponding to the light transmitting holes respectively.

2. The display panel according to claim 1, wherein a positive projection of each of the convergent lenses on the display substrate covers a positive projection of one of the light transmitting holes on the display substrate respectively.

3. The display panel according to claim 1 or claim 2, wherein optical axes of the convergent lenses pass through the corresponding light transmitting holes respectively.

4. The display panel according to claim 3, wherein the optical axes of the convergent lenses coincide with central axes of the corresponding light transmitting holes respectively.

5. The display panel according to claim 4, wherein the light transmitting holes are located at focal positions of the corresponding convergent lenses respectively.

6. The display panel according to any one of the claims 1-5, wherein the display panel further includes a cover plate opposite the display substrate, and the cover plate is on a light exiting side of the light emitting units and supported on the convergent lenses.

7. The display panel according to any one of claims 1-6, wherein the pixel regions are arranged in a plurality of rows and columns, each of the pixel regions has a same area, and each of the convergent lenses is a part of a sphere.

8. The display panel according to claim 7, wherein a radius of a bottom surface of each of the convergent lenses is approximately between 7 μm and 12 μm, and a height of each of the convergent lenses is approximately between 1 μm and 3 μm.

9. The display panel according to any one of claims 1-6, wherein the pixel regions are arranged in a plurality of columns, and in any two adjacent columns, an area of a pixel region in one column is larger than an area of a pixel region in the other column, and

each of the convergent lenses between the two adjacent columns of the pixel regions is a part of an ellipsoid.

10. The display panel according to claim 9, wherein a long axis of a bottom surface of each of the convergent lenses is approximately between12 μm and 20 μm, a short axis thereof is approximately between 6 μm and 12 μm, and a height of each of the convergent lenses is approximately between 1 μm and 3μm.

11. The display panel according to any one of claims 1-10, wherein a refractive index of each of the convergent lenses is approximately between 1.3 and 1.8.

12. The display panel according to any one of claims 1-11, wherein a diameter or length of each of the light transmitting holes is approximately between 2 μm and 3 μm.

13. The display panel according to any one of claims 1-12, wherein the light-shielding layer is made of a metallic or an opaque polyester material.

14. A display apparatus comprising:

the display panel according to any one of claims 1-13,

a fingerprint identification sensor ,

wherein the fingerprint identification sensor is on a side of the light shielding layer away from the light emitting units, and the fingerprint identification sensor is configured to collect and identify an image of fingerprint on a light exiting side of the display panel through the light transmitting holes when the display panel emits light.

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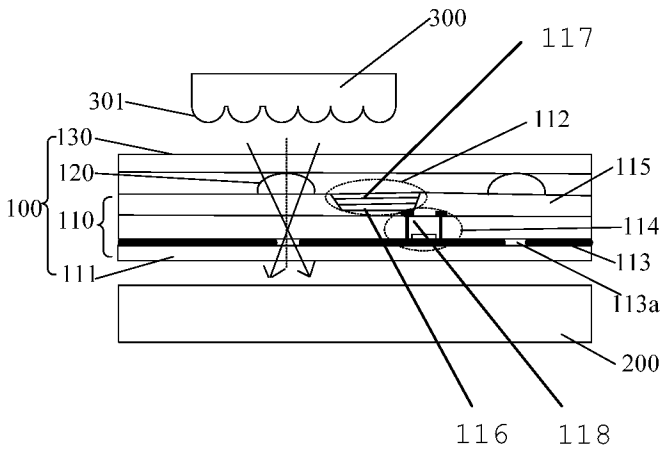

Fig. 1

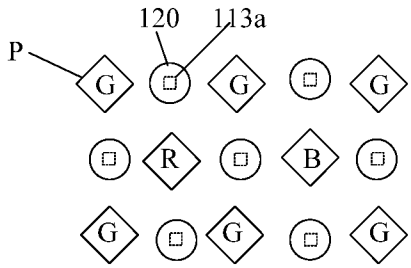

Fig. 2

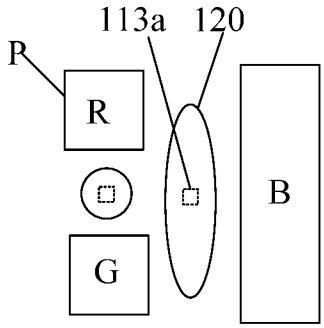

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/105495

A. CLASSIFICATION OF SUBJECT MATTER

H01L 27/32(2006.01)i; G06K 9/00(2006.01)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)

H01L27/-; G06K9/-

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)

EPODOC, WPI, CNKI, CNPAT: fingerprint+, oled, display+, pixel, substrate?, light, shield+, hole?, convergent, lens, sensor +, layer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 106847872 A (BOE TECHNOLOGY GROUP CO., LTD. ET AL.) 13 June 2017 (2017-06-13) description, paragraphs [0025]-[0037], figures1-3	1-14
Y	CN 106298859 A (BOE TECHNOLOGY GROUP CO., LTD.) 04 January 2017 (2017-01-04) description, paragraphs [0029]-[0036], figures1-3	1-14
Y	CN 106022324 A (BOE TECHNOLOGY GROUP CO., LTD.) 12 October 2016 (2016-10-12) description, paragraphs [0038]-[0050], figures1-5	1-14
A	CN 105373772 A (BOE TECHNOLOGY GROUP CO., LTD. ET AL.) 02 March 2016 (2016-03-02) the whole document	1-14
A	CN 106295580 A (GUANGDONG OPPO MOBILE COMMUNICATION CO., LTD.) 04 January 2017 (2017-01-04) the whole document	1-14

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 December 2017	**11 January 2018**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	Authorized officer **LIU,Yuan**
Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)62414457**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/105495

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 105336751 A (SHANGHAI LUOJI TECHNOLOGY CO., LTD.) 17 February 2016 (2016-02-17) the whole document	1-14
A	WO 2016154378 A1 (CRESSPUTI RES L.L.C.) 29 September 2016 (2016-09-29) the whole document	1-14

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/105495

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