



US009911795B2

(12) **United States Patent**
Hou et al.

(10) **Patent No.:** **US 9,911,795 B2**
(45) **Date of Patent:** **Mar. 6, 2018**

(54) **PIXEL UNIT AND METHOD OF
MANUFACTURING THE SAME, LIGHT
EMITTING DEVICE AND DISPLAY DEVICE**

(58) **Field of Classification Search**
CPC H01L 27/3246; H01L 51/0005
(Continued)

(71) Applicant: **BOE TECHNOLOGY GROUP CO.,
LTD.**, Beijing (CN)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Wenjun Hou**, Beijing (CN); **Ze Liu**,
Beijing (CN)

2005/0153468 A1 7/2005 Gupta et al.
2006/0238111 A1 10/2006 Shimizu et al.
(Continued)

(73) Assignee: **BOE TECHNOLOGY GROUP CO.,
LTD.**, Beijing (CN)

FOREIGN PATENT DOCUMENTS

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

CN 1446028 A 10/2003
CN 101529597 A 9/2009
(Continued)

(21) Appl. No.: **15/038,183**

OTHER PUBLICATIONS

(22) PCT Filed: **Oct. 20, 2015**

International Search Report dated Feb. 2, 2016 corresponding to
International application No. PCT/CN2015/092259.

(86) PCT No.: **PCT/CN2015/092259**

(Continued)

§ 371 (c)(1),

(2) Date: **May 20, 2016**

Primary Examiner — Fernando L Toledo

Assistant Examiner — Adam S Bowen

(87) PCT Pub. No.: **WO2016/074554**

(74) *Attorney, Agent, or Firm* — Nath, Goldberg &
Meyer; Joshua B. Goldberg; Annie J. Kock

PCT Pub. Date: **May 19, 2016**

(65) **Prior Publication Data**

US 2016/0293683 A1 Oct. 6, 2016

(30) **Foreign Application Priority Data**

Nov. 14, 2014 (CN) 2014 1 0646200

(57)

ABSTRACT

The present invention discloses a pixel unit, which comprises a pixel defining layer defining a pixel region, a first electrode within a central area of the pixel region, an organic-light-emitting-display-device functional layer formed within the pixel region and on the first electrode, and a second electrode formed on the organic-light-emitting-display-device functional layer, an area of a bottom plane of the organic-light-emitting-display-device functional layer being larger than that of an upper surface of the first electrode. The pixel defining layer comprises first and second pixel defining portions having ring-shaped structures, the first pixel defining portion has an inner side surface defining the pixel region, and the second pixel defining portion has an outer side surface in contact with the inner

(Continued)

(51) **Int. Cl.**

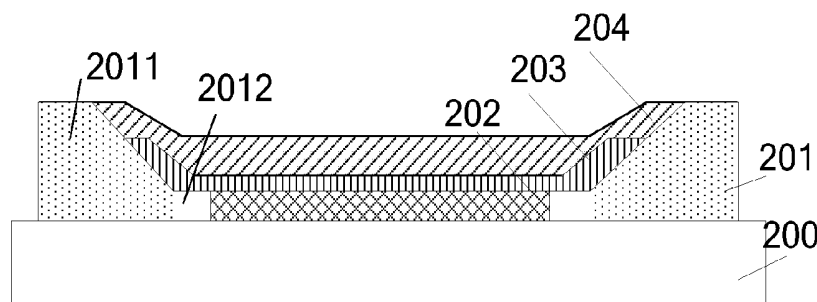
H01L 27/32 (2006.01)

H01L 51/56 (2006.01)

H01L 51/00 (2006.01)

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

CPC **H01L 27/3246** (2013.01); **H01L 51/001**
(2013.01); **H01L 51/0005** (2013.01); **H01L**
51/56 (2013.01); **H01L 2227/323** (2013.01)



side surface of the first pixel defining portion, and is disposed around the first electrode. The first pixel defining portion has a thickness greater than the second pixel defining portion.

20 Claims, 3 Drawing Sheets

(58) Field of Classification Search

USPC 257/40
See application file for complete search history.

(56) References Cited

U.S. PATENT DOCUMENTS

2009/0321725	A1	12/2009	Yoshida et al.	
2011/0008590	A1	1/2011	Goddard et al.	
2012/0176570	A1 *	7/2012	Yamazaki	 G02F 1/1334 349/86
2013/0001603	A1 *	1/2013	Lim	 H01L 51/5209 257/88
2013/0038203	A1 *	2/2013	Kim	 H01L 51/5215 313/504
2013/0321482	A1 *	12/2013	Goro	 G09G 5/10 345/690

FOREIGN PATENT DOCUMENTS

CN	101543135	A	9/2009
CN	101543136	A	9/2009
CN	101689559	A	3/2010
CN	102956669	A	3/2013
CN	103681765	A	3/2014
CN	104409647	A	3/2015
EP	1729358	A1	12/2006
JP	2005222776	A	8/2005

OTHER PUBLICATIONS

First Office Action dated May 3, 2016 corresponding to Chinese application No. 201410646200.4.

Second Office Action dated Oct. 10, 2016 corresponding to Chinese application No. 201410646200.4.

Written Opinion of the International Searching Authority dated Feb. 2, 2016 corresponding to International application No. PCT/CN2015/092259.

* cited by examiner

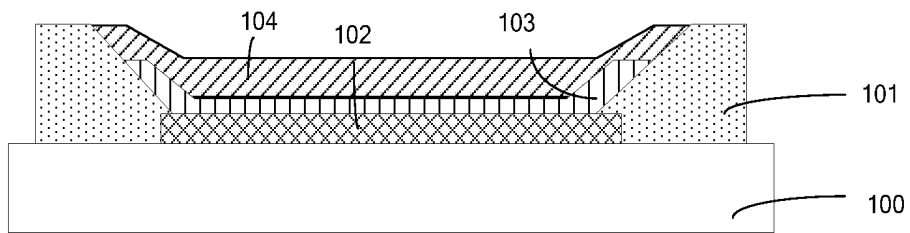


Fig. 1
(PRIOR ART)

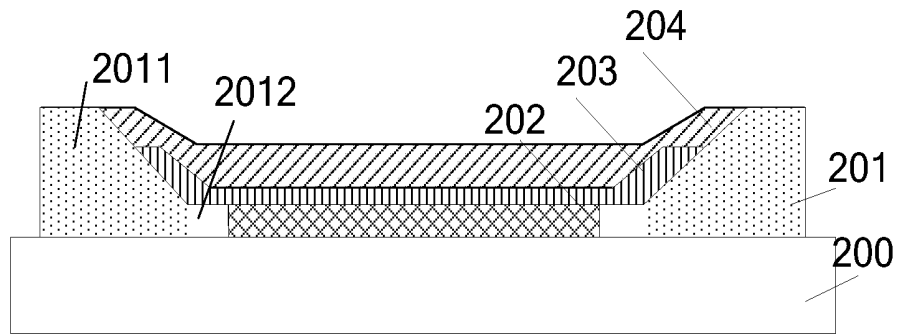


Fig. 2

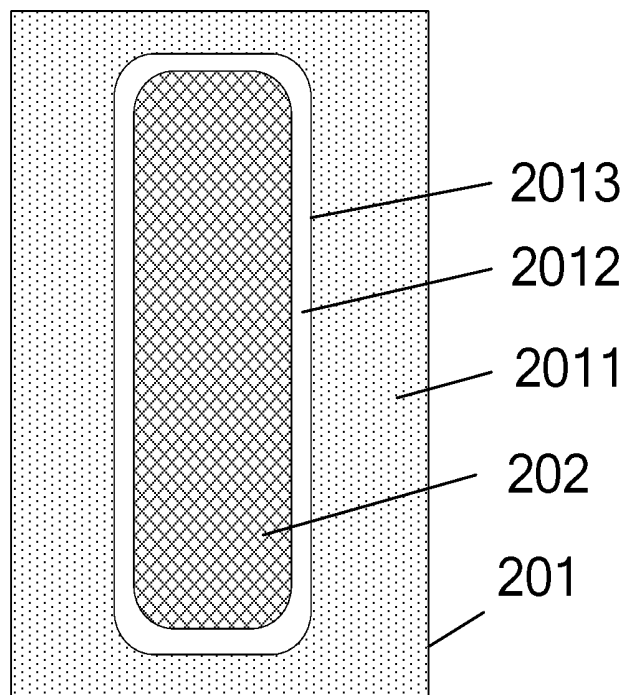


Fig. 3

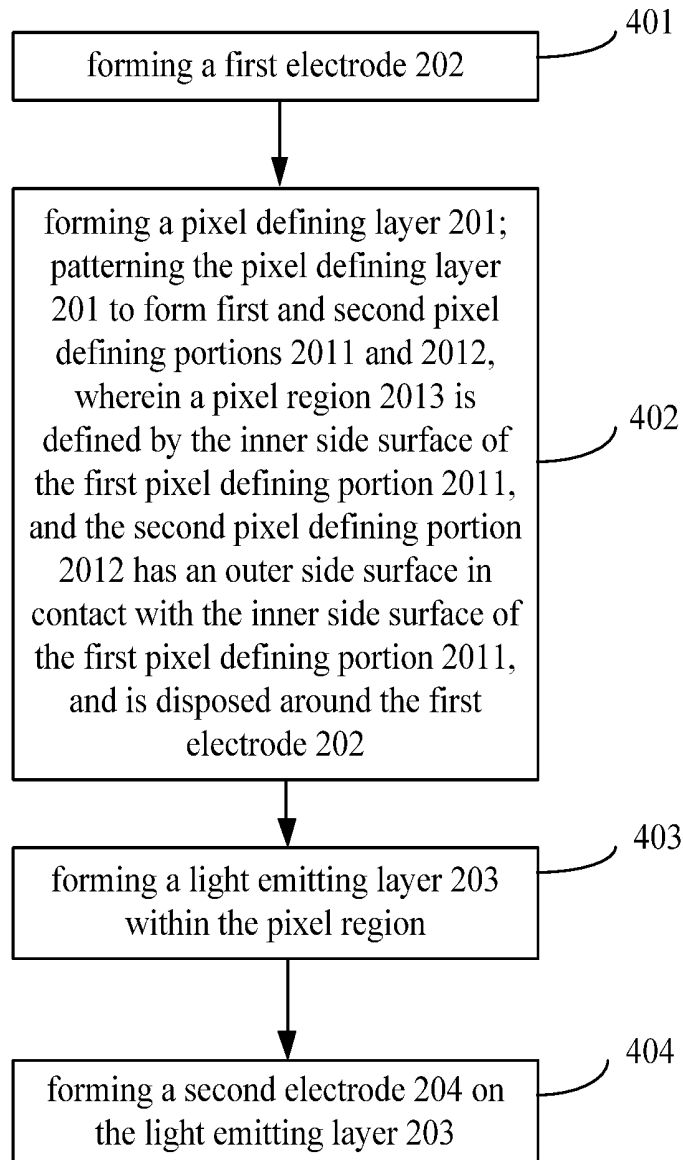


Fig. 4

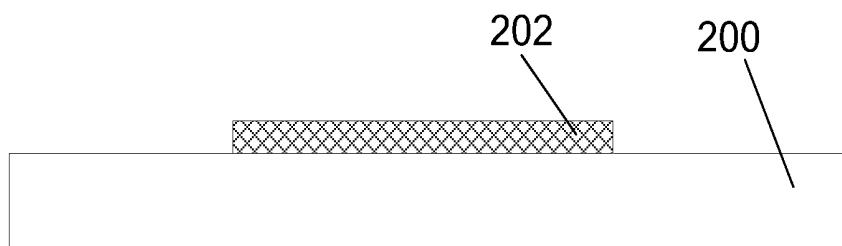


Fig. 5(A)

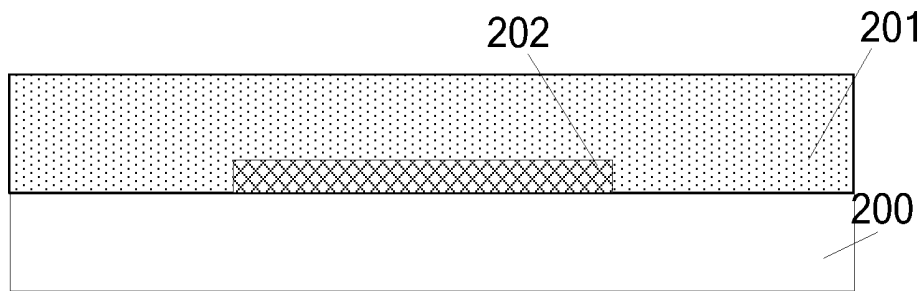


Fig. 5(B)

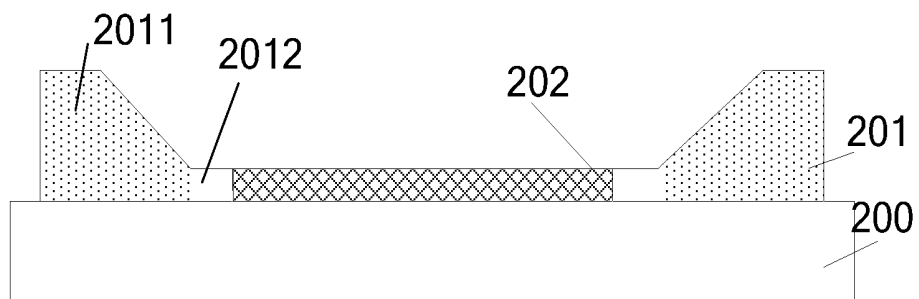


Fig. 5(C)

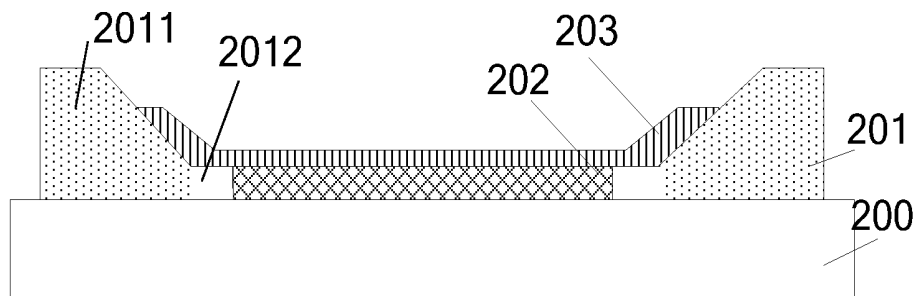


Fig. 5(D)

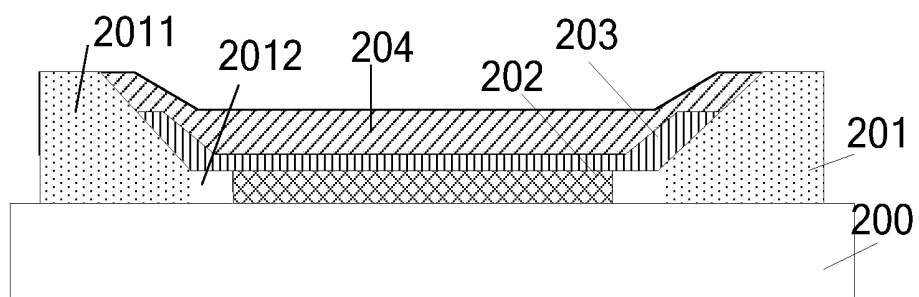


Fig. 5(E)

PIXEL UNIT AND METHOD OF MANUFACTURING THE SAME, LIGHT EMITTING DEVICE AND DISPLAY DEVICE

This is a National Phase Application filed under 35 U.S.C. 371 as a national stage of PCT/CN2015/092259, filed Oct. 20, 2015, an application claiming the benefit of Chinese Application No. 201410646200.4, filed Nov. 14, 2014, the content of each of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to the field of display technology, and specifically relates to a pixel unit and a method of manufacturing the same, a light emitting device and a display device.

BACKGROUND OF THE INVENTION

For an organic light-emitting device, light is emitted by an organic thin film formed of an organic light-emitting material. In conventional structures of a pixel unit, the luminance of the organic light-emitting device depends on the thickness of the organic thin film, and the entire organic light-emitting device has a uniform luminance when the organic thin film has a uniform thickness. In practice, however, the thickness of the organic thin film of the organic light-emitting device is not uniform due to the imperfection of the manufacture process.

For example, a solution process may be employed to form the organic thin film in the procedure of manufacturing the organic light-emitting device, which is applicable for a polymeric organic light-emitting material and a soluble-micromolecule organic light-emitting material and is characterized by the low cost for manufacture apparatus, thereby having a distinct advantage in massive production for large sizes. In the case of manufacturing a full-color organic light-emitting device, an inkjet printing technology, among the technologies of solution process, is generally used. In the inkjet printing technology, the solution is jetted into a pixel region accurately by a piezoelectric nozzle and then the solvent of the solution is removed by evaporation, such that the organic thin film is formed within the pixel region. However, due to the difference of the evaporation rate of the solvent at an edge area and at a central area of the pixel region, it is difficult to form an organic thin film having a uniform thickness within the pixel region.

FIG. 1 shows a structure of a pixel unit in the prior art, the pixel unit including a substrate 100, a pixel defining layer 101, a pair of pixel electrodes 102 and 104, and an organic-light-emitting-display-device functional layer (i.e., an organic thin film) 103. A pixel region is defined by the pixel defining layer 101, the pixel electrode 102 is positioned within the pixel region, and the organic-light-emitting-display-device functional layer 103 is positioned on the pixel electrode 102. After preparing the organic-light-emitting-display-device functional layer 103 by the inkjet printing technology and the like, since the solvent at the edge area of the organic-light-emitting-display-device functional layer 103 has a higher vapor pressure than that of the solvent at the central area of the organic-light-emitting-display-device functional layer 103, the evaporation rate of the solvent at the edge area is faster than that of the solvent at the central area, such that the concentration of the solution at the edge area of the organic-light-emitting-display-device functional layer 103 is higher than that of the solution at the central area

thereof, and the solution at the central area may flow towards the edge area, which causes the thickness of the edge area of the organic-light-emitting-display-device functional layer 103 to be always greater than that of the central area. When a voltage is applied to the organic-light-emitting-display-device functional layer 103 by the pixel electrodes 102 and 104, both the edge area and the central area of the functional layer 103 may emit light, and the luminance of the central area of the pixel region is higher than that of the edge area of the pixel region due to the nonuniformity of the thickness of the functional layer 103, which causes the nonuniformity of the luminance of the organic light-emitting device.

In the prior art, the nonuniformity of the thickness of the organic thin film is decreased by using inkjet printing solutions which have different boiling points, adjusting the structure of the pixel defining layer, or performing surface treatment on the pixel defining layer. For example, in the European patent document EP1729358A1, the nonuniformity of the thickness of the organic thin film is decreased by the structure design of the pixel defining layer; and in the US patent publication document US 2011/0008590 A1, the shape and thickness of the organic thin film formed by the inkjet printing technology are controlled by using different high-boiling-point solutions. However, the nonuniformity of thickness of the organic thin film cannot be eliminated completely by the above technical solutions, and when using conventional structures of a pixel unit, the luminance of the central area of the pixel region in the light emitting device is higher than that of the edge area thereof due to the nonuniformity of thickness of the organic thin film.

SUMMARY OF THE INVENTION

In order to solve the above problems existing in the prior art, the present invention provides a pixel unit and a method of manufacturing the same, a light emitting device, and a display device.

According to a first aspect of the present invention, there is provided a pixel unit, which comprises a pixel defining layer defining a pixel region, a first electrode positioned within a central area of the pixel region, an organic-light-emitting-display-device functional layer formed within the pixel region and positioned on the first electrode, and a second electrode formed on the organic-light-emitting-display-device functional layer, wherein an area of a bottom plane of the organic-light-emitting-display-device functional layer is larger than that of an upper surface of the first electrode.

In the pixel unit according to the first aspect of the present invention, the pixel defining layer comprises first and second pixel defining portions having ring-shaped structures, respectively, the first pixel defining portion has an inner side surface defining the pixel region, and the second pixel defining portion has an outer side surface in contact with the inner side surface of the first pixel defining portion, and is disposed around the first electrode, wherein the organic-light-emitting-display-device functional layer is positioned on the first electrode and the second pixel defining portion.

In the pixel unit according to the first aspect of the present invention, the first pixel defining portion has a thickness greater than that of the second pixel defining portion.

In the pixel unit according to the first aspect of the present invention, the second pixel defining portion is in contact with the first electrode.

In the pixel unit according to the first aspect of the present invention, the first pixel defining portion has an inclined inner side surface.

In the pixel unit according to the first aspect of the present invention, the second pixel defining portion has a thickness equal to or greater than that of the first electrode.

In the pixel unit according to the first aspect of the present invention, the first pixel defining portion and the second pixel defining portion are formed integrally.

In the pixel unit according to the first aspect of the present invention, the thickness of the first electrode ranges from 10 nm to 400 nm.

In the pixel unit according to the first aspect of the present invention, the organic-light-emitting-display-device functional layer fits and is in contact with the inner side surface of the pixel defining layer.

According to a second aspect of the present invention, there is provided a light emitting device including the pixel unit according to the first aspect of the present invention.

According to a third aspect of the present invention, there is provided a display device including the light emitting device according to the second aspect of the present invention.

According to a fourth aspect of the present invention, there is provided a method of manufacturing a pixel unit, the method including steps of: forming a first electrode; forming a pixel defining layer and patterning the pixel defining layer, so as to define a pixel region and make the first electrode positioned within a central area of the pixel region; forming an organic-light-emitting-display-device functional layer on the first electrode, wherein a bottom plane of the organic-light-emitting-display-device functional layer has an area larger than that of an upper surface of the first electrode; and forming a second electrode on the organic-light-emitting-display-device functional layer.

In the method according to the fourth aspect of the present invention, the pixel defining layer includes first and second pixel defining portions having ring-shaped structures, respectively, the first pixel defining portion has an inner side surface defining the pixel region, the second pixel defining portion has an outer side surface in contact with the inner side surface of the first pixel defining portion and is disposed around the first electrode.

In the method according to the fourth aspect of the present invention, the first pixel defining portion has a thickness larger than that of the second pixel defining portion.

In the method according to the fourth aspect of the present invention, the step of forming the pixel defining layer specifically comprises: forming the pixel defining layer on the first electrode; performing, on the pixel defining layer on the first electrode, a photolithography process, such that an area of an exposure region is larger than that of the upper surface of the first electrode; and removing the material of the pixel defining layer positioned on the upper surface of the first electrode and thinning a side portion of the pixel defining layer, which is close to an edge of the first electrode, so as to form the first pixel defining portion and the second pixel defining portion.

In the method according to the fourth aspect of the present invention, the pixel defining layer is formed of an inorganic material, and the step of forming the pixel defining layer specifically comprises steps of:

forming, on the first electrode, a layer of inorganic material; exposing, by using a photoresist, and developing the inorganic material positioned on the first electrode, such that an area of an exposure region is larger than that of the upper surface of the first electrode; and removing the inorganic material positioned on the upper surface of the first electrode by dry etching, and thinning the side portion of the pixel

defining layer, which is close to an edge of the first electrode, so as to form the first pixel defining portion and the second pixel defining portion.

In the method according to the fourth aspect of the present invention, the pixel defining layer is formed of photoresist, and the step of forming the pixel defining layer specifically comprises:

forming, on the first electrode, a layer of photoresist; and exposing and developing the photoresist positioned on the first electrode, such that an area of an exposure region is larger than that of the upper surface of the first electrode, wherein the photoresist on the upper surface of the first electrode is over exposed, and an exposure amount is controlled when exposing the photoresist close to the edge of the first electrode, such that the developed photoresist has a thickness equal to or greater than that of the first electrode, so as to form the first pixel defining portion and the second pixel defining portion.

In the method according to the fourth aspect of the present invention, the organic-light-emitting-display-device functional layer is formed by a solution process or an evaporation process.

In the present invention, by the means of improving the structure of the pixel defining layer, the area of the upper surface of the first electrode is smaller than that of the bottom plane of the organic-light-emitting-display-device functional layer, thereby causing the first electrode not to be positioned under the edge area of the organic-light-emitting-display-device functional layer. Compared with the conventional technologies, even in the case that the thickness of the edge area of the organic-light-emitting-display-device functional layer is greater than that of the central area thereof, since the first electrode is not provided under the edge area of the organic-light-emitting-display-device functional layer, light is not emitted from the edge area of the organic-light-emitting-display-device functional layer when a voltage is applied to the thin film of the organic-light-emitting-display-device functional layer by the electrodes, thereby avoiding the nonuniformity of luminance of an organic light-emitting display device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a structural schematic diagram of a pixel unit in the prior art;

FIG. 2 is cross-sectional view illustrating a structure of a pixel unit according to an embodiment of the present invention;

FIG. 3 is plan schematic diagram of a pixel define layer and a first electrode in a pixel unit according to an embodiment of the present invention;

FIG. 4 is a flowchart of a method of manufacturing a pixel unit, according to an embodiment of the present invention; and

FIGS. 5(A) to 5(E) are cross-sectional views illustrating the method of manufacturing a pixel unit, according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

In order to make an object, a technical solution as well as advantages of the present invention more apparent, the present invention will be further described in detail below in conjunction with the specific embodiments and referring to the drawings.

FIG. 2 illustrates a cross-sectional structure of a pixel unit according to an embodiment of the present invention, and FIG. 3 illustrates a plan structure of a pixel defining layer and a first electrode in the pixel unit according to an embodiment of the present invention. As illustrated in FIGS. 2 and 3, the pixel unit includes a pixel defining layer **201**, a first electrode **202**, an organic-light-emitting-display-device functional layer **203** and a second electrode **204**. The pixel defining layer **201** may include first and second pixel defining portions **2011** and **2012** having ring-shaped structures, respectively, wherein a region defined by an inner side surface of the first pixel defining portion **2011** is a pixel region **2013** (shown in FIG. 3), an outer side surface of the second pixel defining portion **2012** is in contact with the inner side surface of the first pixel defining portion **2011**, and the first pixel defining portion **2011** has a thickness greater than that of the second pixel defining portion **2012**. The first electrode **202** is positioned within a central area of the pixel region **2013**, such that the second pixel defining portion **2012** is disposed around the first electrode **202**. The organic-light-emitting-display-device functional layer **203** is positioned on the first electrode **202** and the second pixel defining portion **2012**. The second electrode **204** is positioned on the organic-light-emitting-display-device functional layer **203**.

It can be seen from FIG. 2 that, in the pixel unit according to an embodiment of the present invention, an area of an upper surface of the first electrode **202** is smaller than that of a bottom plane of the organic-light-emitting-display-device functional layer **203**, in other words, the first electrode **202** is only positioned under a central area of the organic-light-emitting-display-device functional layer **203**. In this case, even if the thickness of the edge area of the organic-light-emitting-display-device functional layer **203** is greater than that of the central area thereof, since the first electrode is not provided under the edge area, light is not emitted from the thick edge area of the organic-light-emitting-display-device functional layer **203** when a voltage is applied to the organic-light-emitting-display-device functional layer **203** by the electrodes **202** and **204**, thereby avoiding the nonuniformity of luminance of an organic light-emitting display device.

Optionally, the pixel defining layer **201** may be made of an inorganic material such as SiO_2 , SiN_x or the like, and may also be made of an organic material such as a photoresist. The first pixel defining portion **2011** and the second pixel defining portion **2012** may be formed integrally.

Optionally, the pixel defining layer **201** may be formed on a substrate **200**. The substrate may be a glass substrate or an array substrate provided with an array circuit. The pixel defining layer **201** may include the first pixel defining portion **2011** and the second pixel defining portion **2012**, the first and second pixel defining portions have ring-shaped structures, respectively, the inner side surface of the first pixel defining portion **2011** is in contact with the outer side surface of the second pixel defining portion **2012**, and the thickness of the first pixel defining portion **2011** is greater than that of the second pixel defining portion **2012**. That is, the second pixel defining portion **2012** is formed at the edge area of the pixel region **2013**, which is defined by the inner side surface of the first pixel defining portion **2011**, and the first electrode **202** is formed at the central area of the pixel region **2013**, such that the second pixel defining portion **2012** is disposed around the first electrode **202**. It can be seen that the area of the pixel region **2013**, which is defined by the inner side surface of the first pixel defining portion **2011**, is larger than that of a region in which the first

electrode **202** is formed. In FIG. 2, the second pixel defining portion **2012** is in contact with the first electrode **202**, but the embodiments of the present invention are not limited thereto, and the second pixel defining portion **2012** may also be spaced apart from the first electrode **202**.

FIG. 2 illustrates that the first pixel defining portion **2011** has a thickness gradually changed, that is, the first pixel defining portion **2011** has an inclined inner side surface which is connected to the upper surfaces of the first and second pixel defining portions **2011** and **2012**, but the embodiments of the present invention are not limited thereto. The first pixel defining portion **2011** may also have a constant thickness, that is, the first pixel defining portion **2011** may have a vertical inner side surface.

FIG. 2 illustrates that the organic-light-emitting-display-device functional layer **203** fits and is in contact with an inner side surface of the first pixel defining portion **2011**, but the embodiments of the present invention are not limited thereto. Other layer(s) may be interposed between the organic-light-emitting-display-device functional layer **203** and the first pixel defining portion **2011**.

Optionally, the thickness of the second pixel defining portion **2012** is equal to or greater than that of the first electrode **202**, and it is preferable that the second pixel defining portion **2012** and the first electrode **202** have the same thickness. The thickness of the first electrode **202** may range from 10 nm to 400 nm.

The first electrode **202** and the second electrode **204** constitute a pair of pixel electrodes. The first electrode **202** may be an anode or a cathode. In the case that the first electrode **202** is an anode, the material thereof may include a transparent conductive material or a translucent conductive material, such as ITO, Ag, NiO, Al or graphene. In the case that the first electrode **202** is a cathode, preferably, the material thereof may include a metal or a combination of metals having a low work function, such as one of Al, Mg, Ca, Ba, Na, Li, K and Ag, or any combination of Al, Mg, Ca, Ba, Na, Li, K and Ag.

Optionally, when viewed in a plan view, a shape of the first electrode **202** may include a parallelogram shape, such as a rectangle shape, a square shape or a diamond shape, or an ellipse shape. Depending on the requirements in practice applications, the first electrode **202** may also include any other shape, for example, a quadrangle having any specific shape.

Optionally, the organic-light-emitting-display-device functional layer **203** may include one or more layers of a hole injection layer, a hole transmission layer, a light emitting layer, a hole barrier layer, an electron barrier layer, an electron transmission layer and an electron injection layer.

The second electrode **204** has a polarity opposite to that of the first electrode **202**, that is, the first electrode **202** is one of the anode and the cathode, and the second electrode **204** is the other thereof. In the case that the second electrode **204** is a cathode, the material thereof may include a metal or a combination of metals having a low work function, such as one of Al, Mg, Ca, Ba, Na, Li, K and Ag, or any combination of Al, Mg, Ca, Ba, Na, Li, K and Ag. In the case that the second electrode **204** is an anode, the material thereof may include a transparent conductive material or a translucent conductive material, such as ITO, Ag, NiO, Al or graphene.

In the pixel unit according to the embodiments of the present invention, the organic-light-emitting-display-device functional layer **203** is positioned on the first electrode **202** and the second pixel defining portion **2012**, and the area of the bottom plane of the organic-light-emitting-display-device functional layer **203** is larger than that of the upper

surface of the first electrode **202**. Therefore, in the case that the thickness of the edge area of the organic-light-emitting-display-device functional layer **203** is greater than that of the central area of the organic-light-emitting-display-device functional layer **203**, since the first electrode **202** is not disposed under the edge area, light may not be emitted from the edge area of the organic-light-emitting-display-device functional layer **203** when a voltage is applied to the organic-light-emitting-display-device functional layer **203** by the electrodes **202** and **204**, thereby avoiding the non-uniformity of luminance of an organic light-emitting display device.

Optionally, the pixel unit may be an organic light-emitting diode (OLED) unit.

The embodiments of the present invention further include a display panel comprising the above pixel unit. The display panel may be an OLED display panel.

FIG. 4 illustrates a flowchart of a method of manufacturing a pixel unit, according to an embodiment of the present invention. FIGS. 5(A) to 5(E) are cross-sectional views illustrating the method of manufacturing a pixel unit, according to an embodiment of the present invention.

As illustrated in FIG. 4, the method of manufacturing a pixel unit according to an embodiment of the present invention may include a step **401**, a step **402**, a step **403** and a step **404**.

In the step **401**, as illustrated in FIG. 5(A), a first electrode **202** is formed.

In the step **402**, as illustrated in FIG. 5(B), a pixel defining layer **201** is formed. Then, the pixel defining layer **201** is patterned to form a first pixel defining portion **2011** and a second pixel defining portion **2012**, wherein a pixel region is defined by an inner side surface of the first pixel defining portion **2011**, an outer side surface of the second pixel defining portion **2012** is in contact with the inner side surface of the first pixel defining portion **2011**, and the second pixel defining portion **2012** is disposed around the first electrode **202**, as illustrated in FIG. 5(C). The second pixel defining portion **2012** has a thickness equal to or slightly greater than that of the first electrode **202**. Optionally, the second pixel defining portion **2012** is in contact with the first electrode **202**.

Optionally, the step **402** may specifically comprise the following steps: forming, on a substrate **200** provided with the first electrode **202**, the pixel defining layer; performing a photolithography process on the pixel defining layer, such that an area of an exposure region is larger than that of the upper surface of the first electrode **202**; and removing the material of the pixel defining layer positioned on the upper surface of the first electrode **202** and thinning a side portion of the pixel defining layer, which is close to an edge of the first electrode **202**, so as to form the first pixel defining portion **2011** and the second pixel defining portion **2012**.

Optionally, the pixel defining layer **201** may be made of an inorganic material such as SiO_2 , SiN_x or the like, and may also be made of an organic material such as a photoresist and the like.

In the case that the pixel defining layer **201** is made of an inorganic material, the step **402** may further comprise: forming, on the substrate provided with the first electrode, a layer of inorganic material by using a technology such as chemical vapor deposition, the layer of inorganic material may have a thickness ranging from 100 nm to 400 nm, which is greater than the thickness of the first electrode **202**. Next, a photoresist is spin coated on the layer of inorganic material and is exposed and developed, where the exposure area of the photoresist is larger than that of the upper surface of the

first electrode **202**. Thereafter, the layer of inorganic material is dry etched to remove the inorganic material positioned on the upper surface of the first electrode **202**, and a side portion of the layer of inorganic material close to an edge of the first electrode **202** is thinned, such that the thickness of the inorganic material close to the edge of the first electrode **202** is equal to or slightly greater than that of the first electrode **202**, and then the remaining photoresist is removed, so as to form the first pixel defining portion **2011** and the second pixel defining portion **2012**.

In the case that the pixel defining layer **201** is made of an organic material, the step **402** may further comprise: coating, on the substrate provided with the first electrode, an organic photoresist material by coating processes such as slit coating, spin coating and the like, to form an organic thin film having a thickness ranging from 100 nm to 2000 nm, wherein the thickness of the organic photoresist material is greater than that of the first electrode **202**. Thereafter, the organic photoresist material is exposed and developed, and the exposure area of the photoresist is larger than that of the upper surface of the first electrode **202**. When performing the exposure, the photoresist positioned on the upper surface of the first electrode **202** is over exposed to be removed completely, while the exposure amount for exposing the photoresist close to the edge portion of the first electrode **202** is controlled such that the developed photoresist has a thickness equal to or slightly greater than that of the first electrode **202**, thereby eventually forming the first pixel defining portion **2011** and the second pixel defining portion **2012**.

In the step **403**, an organic-light-emitting-display-device functional layer **203** is formed on the first electrode **202** and the second pixel defining portion **2012**, and the organic-light-emitting-display-device functional layer **203** fits and is in contact with the inner side surface of the first pixel defining portion **2011**, as illustrated in FIG. 5(D).

Optionally, in the step **403**, the organic-light-emitting-display-device functional layer **203** may be formed by a solution process and/or an evaporation process. As an example, the formation of the organic-light-emitting-display-device functional layer **203** may specifically include: forming a hole injection layer, a hole transmission layer, a light emitting layer and the like within the pixel region **2013**, respectively, by using the inkjet printing technology, and forming an electron transmission layer, an electron injection layer and the like by using the evaporation process.

In the step **404**, a second electrode **204** is formed on the organic-light-emitting-display-device functional layer **203**, as illustrated in FIG. 5(E).

The method of manufacturing the pixel unit according to the embodiments of the present invention is particularly applicable to the manufacture of the pixel unit by the solution process. Compared with the conventional technologies, the pixel unit manufactured by the method according to the embodiments of the present invention has a first electrode, of which the upper surface has an area smaller than that of the pixel region defined by the pixel defining layer. As such, even in the case that the thickness of the edge area of the organic-light-emitting-display-device functional layer is greater than that of the central area thereof, since the first electrode is not provided under an edge area of the thin film of the organic-light-emitting-display-device functional layer, light is not emitted from the edge area of the organic-light-emitting-display-device functional layer when a voltage is applied to the thin film of the organic-light-emitting-

display-device functional layer by the electrodes, thereby avoiding the nonuniformity of luminance of an organic light-emitting display device.

The objects, the technical solutions and the advantageous effects of the present invention are further explained in detail in the above-mentioned specific embodiments, and it should be understood that the above are merely specific embodiments of the present invention which are not intended to limit the present invention thereto. Any variation, equivalent alternation and improvement within the spirit and essence of the present invention shall fall into the protection scope of the present invention.

What is claimed is:

1. A pixel unit, comprising:

a pixel defining layer that defines a pixel region;

a first electrode positioned within a central area of the pixel region;

an organic-light-emitting-display-device functional layer, which is formed within the pixel region and positioned on the first electrode; and

a second electrode formed on the organic-light-emitting-display-device functional layer,

wherein an area of a bottom plane of the organic-light-emitting-display-device functional layer is larger than that of an upper surface of the first electrode, and

wherein the pixel defining layer is configured to contact with a side surface of the first electrode and not contact with remaining surfaces of the first electrode.

2. The pixel unit according to claim 1, wherein the pixel defining layer comprises first and second pixel defining portions having ring-shaped structures, respectively, the first pixel defining portion has an inner side surface defining the pixel region, and the second pixel defining portion has an outer side surface in contact with the inner side surface of the first pixel defining portion, and is disposed around the first electrode, wherein the organic-light-emitting-display-device functional layer is positioned on the first electrode and the second pixel defining portion.

3. The pixel unit according to claim 2, wherein the first pixel defining portion has a thickness greater than that of the second pixel defining portion.

4. The pixel unit according to claim 2, wherein the second pixel defining portion is in contact with the first electrode.

5. The pixel unit according to claim 2, wherein the first pixel defining portion has an inclined inner side surface.

6. The pixel unit according to claim 2, wherein the second pixel defining portion has a thickness equal to or greater than that of the first electrode.

7. The pixel unit according to claim 2, wherein the first pixel defining portion and the second pixel defining portion are formed integrally.

8. The pixel unit according to claim 6, wherein the thickness of the first electrode ranges from 10 nm to 400 nm.

9. A light emitting device, comprising the pixel unit according to claim 1.

10. A display device, comprising the light emitting device according to claim 9.

11. A method of manufacturing a pixel unit, comprising steps of:

forming a first electrode;

forming a pixel defining layer and patterning the pixel defining layer, so as to define a pixel region and make the first electrode positioned within a central area of the pixel region;

forming an organic-light-emitting-display-device functional layer on the first electrode, wherein a bottom plane of the organic-light-emitting-display-device

functional layer has an area larger than that of an upper surface of the first electrode; and

forming a second electrode on the organic-light-emitting-display-device functional layer,

wherein the pixel defining layer is formed to contact with a side surface of the first electrode and not contact with remaining surfaces of the first electrode.

12. The method according to claim 11, wherein

the pixel defining layer includes first and second pixel defining portions having ring-shaped structures, respectively, the first pixel defining portion has an inner side surface defining the pixel region, the second pixel defining portion has an outer side surface in contact with the inner side surface of the first pixel defining portion, and is disposed around the first electrode.

13. The method according to claim 12, wherein the first pixel defining portion has a thickness greater than that of the second pixel defining portion.

14. The method according to claim 12, wherein the step of forming the pixel defining layer comprises:

forming the pixel defining layer on the first electrode;

performing, on the pixel defining layer on the first electrode, a photolithography process, such that an area of an exposure region is larger than that of the upper surface of the first electrode; and

removing the material of the pixel defining layer positioned on the upper surface of the first electrode, and thinning a side portion of the pixel defining layer, which is close to an edge of the first electrode, so as to form the first pixel defining portion and the second pixel defining portion.

15. The method according to claim 14, wherein the pixel defining layer is formed of an inorganic material, and the step of forming the pixel defining layer comprises:

forming, on the first electrode, a layer of inorganic material;

exposing, by using photoresist, and developing the inorganic material positioned on the first electrode, such that an area of an exposure region is larger than that of the upper surface of the first electrode; and

removing the inorganic material positioned on the upper surface of the first electrode by dry etching, and thinning the side portion of the pixel defining layer, which is close to an edge of the first electrode, so as to form the first pixel defining portion and the second pixel defining portion.

16. The method according to claim 14, wherein the pixel defining layer is formed of a photoresist, and the step of forming the pixel defining layer comprises steps of:

forming, on the first electrode, a layer of photoresist; and exposing and developing the photoresist positioned on the first electrode, such that an area of an exposure region is larger than that of the upper surface of the first electrode, wherein the photoresist on the upper surface of the first electrode is over exposed, and an exposure amount is controlled when exposing the photoresist close to the edge of the first electrode, such that the developed photoresist has a thickness equal to or greater than that of the first electrode, so as to form the first pixel defining portion and the second pixel defining portion.

17. The method according to claim 11, wherein the organic-light-emitting-display-device functional layer is formed by a solution process or an evaporation process.

18. The method according to claim 13, wherein the step of forming the pixel defining layer comprises:
forming the pixel defining layer on the first electrode;
performing, on the pixel defining layer on the first electrode, a photolithography process, such that an area of an exposure region is larger than that of the upper surface of the first electrode; and
removing the material of the pixel defining layer positioned on the upper surface of the first electrode, and thinning a side portion of the pixel defining layer, which is close to an edge of the first electrode, so as to form the first pixel defining portion and the second pixel defining portion.

19. The pixel unit of claim 1, wherein the second electrode is at a side of the organic-light-emitting-display-device functional layer distal to the first electrode.

20. The pixel unit of claim 2, wherein each of the organic-light-emitting-display-device functional layer and the second electrode is configured to contact with the inner side surface of the first pixel defining portion.

* * * * *

专利名称(译)	像素单元及其制造方法，发光装置和显示装置		
公开(公告)号	US9911795	公开(公告)日	2018-03-06
申请号	US15/038183	申请日	2015-10-20
[标]申请(专利权)人(译)	京东方科技集团股份有限公司		
申请(专利权)人(译)	京东方科技集团股份有限公司.		
当前申请(专利权)人(译)	京东方科技集团股份有限公司.		
[标]发明人	HOU WENJUN LIU ZE		
发明人	HOU, WENJUN LIU, ZE		
IPC分类号	H01L27/32 H01L51/00 H01L51/56		
CPC分类号	H01L27/3246 H01L51/001 H01L51/56 H01L51/0005 H01L2227/323		
优先权	201410646200.4 2014-11-14 CN		
其他公开文献	US20160293683A1		
外部链接	Espacenet USPTO		

摘要(译)

本发明公开了一种像素单元，包括限定像素区域的像素限定层，位于像素区域中心区域内的第一电极，形成于像素区域内部的有机发光显示装置功能层第一电极和形成在有机发光显示装置功能层上的第二电极，有机发光显示装置功能层的底平面的面积大于上表面的面积第一个电极。像素限定层包括具有环形结构的第一和第二像素限定部分，第一像素限定部分具有限定像素区域的内侧表面，第二像素限定部分具有与内侧表面接触的外侧表面第一像素限定部分的第一像素限定部分，并且设置在第一电极周围。第一像素限定部分的厚度大于第二像素限定部分的厚度。

