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Lin et al.

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(54) **DISPLAY DEVICE AND METHOD FOR MAKING SAME**

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Related U.S. Application Data

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H01L 51/52	(2006.01)
H01L 51/00	(2006.01)
H01L 51/56	(2006.01)
H01L 51/50	(2006.01)
H01L 25/16	(2006.01)

(52) **U.S. Cl.**
CPC ***H01L 27/3218*** (2013.01); ***H01L 25/162*** (2013.01); ***H01L 27/3225*** (2013.01); ***H01L 27/3262*** (2013.01); ***H01L 51/0097*** (2013.01); ***H01L 51/502*** (2013.01); ***H01L 51/5036*** (2013.01); ***H01L 51/5206*** (2013.01); ***H01L 51/5221*** (2013.01); ***H01L 51/56*** (2013.01); *G09G 2300/0452* (2013.01); *H01L 51/52* (2013.01)

(58) **Field of Classification Search**
CPC H01L 27/3218; H01L 25/162; H01L 27/3262; H01L 27/3225; H01L 51/0097; H01L 51/5036; H01L 51/502; G09G 2300/0452
See application file for complete search history.

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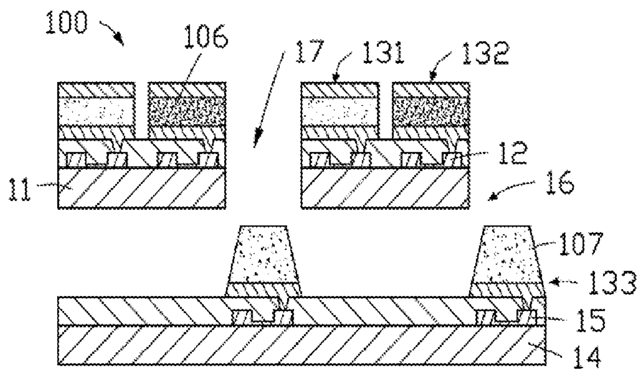
(57) **ABSTRACT**

A display device comprised of OLEDs and micro LEDs which allows for blue light degradation of the OLEDs includes a first substrate and a second substrate in a double-decked configuration. First light emitting elements are located and spaced on the first substrate and second light emitting elements are located and spaced on the second substrate, the light emitting elements on the lower deck being staggered so as not to be hidden by the light emitting elements on the upper deck. The upper deck has openings (or is transparent) therein to allow egress of light from the light emitting elements of the lower deck. The display device provides a solution for uneven display cause by degradation of pixels.

15 Claims, 6 Drawing Sheets



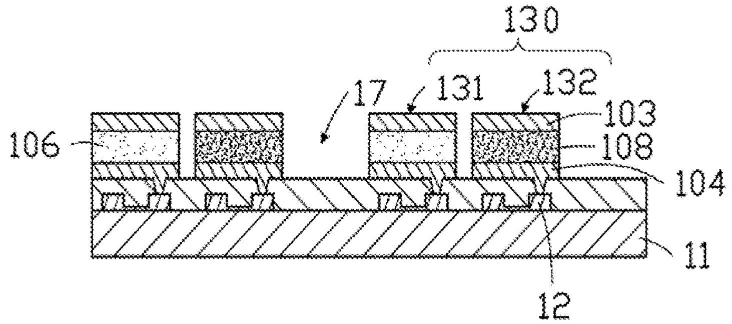


FIG. 1A

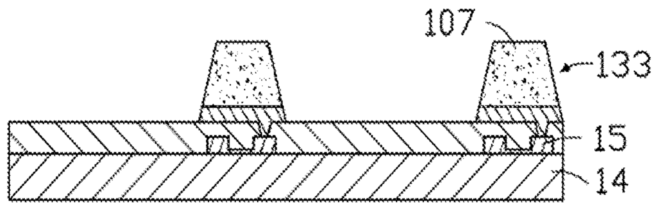


FIG. 1B

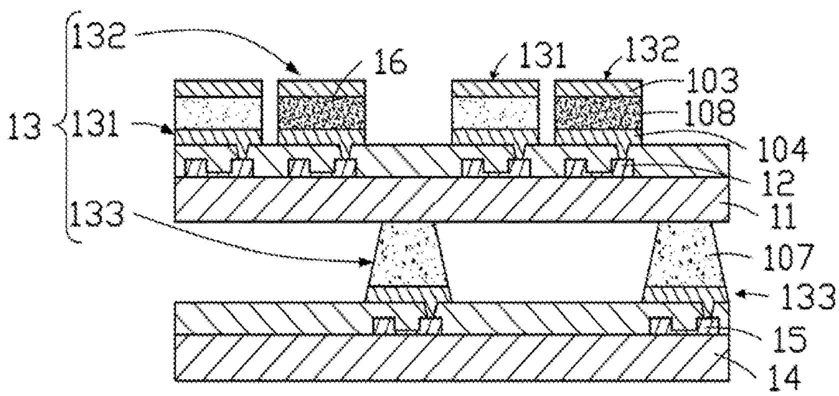


FIG. 1C

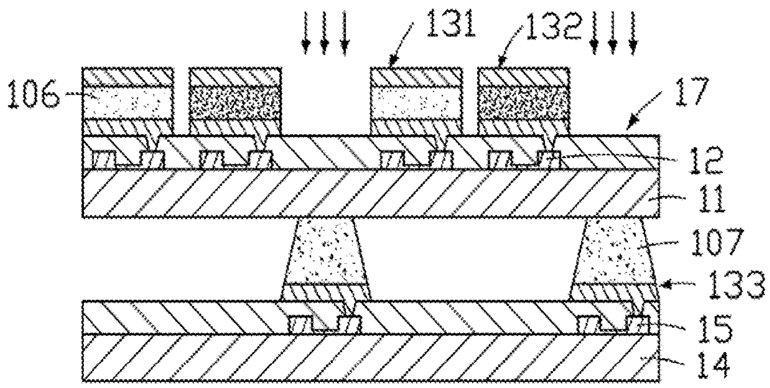

131
132
106
17
12
11
107
133
15
14

FIG. 1D

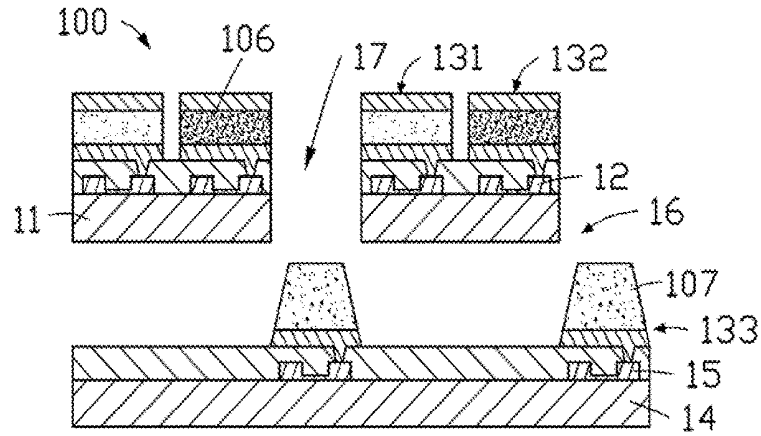

100
106
17
131
132
12
11
16
107
133
15
14

FIG. 1E

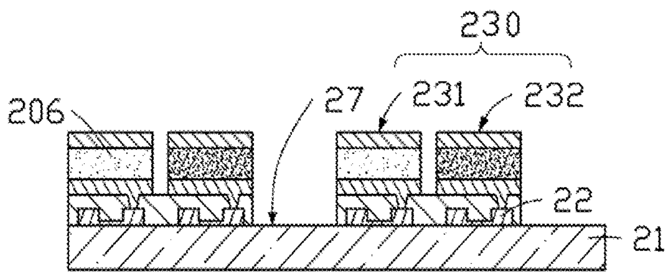


FIG. 2A

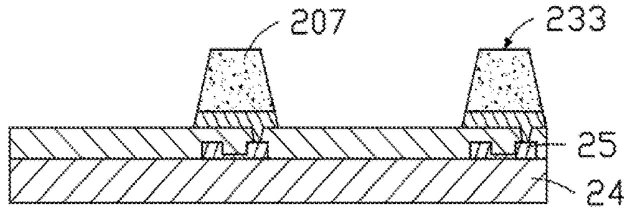


FIG. 2B

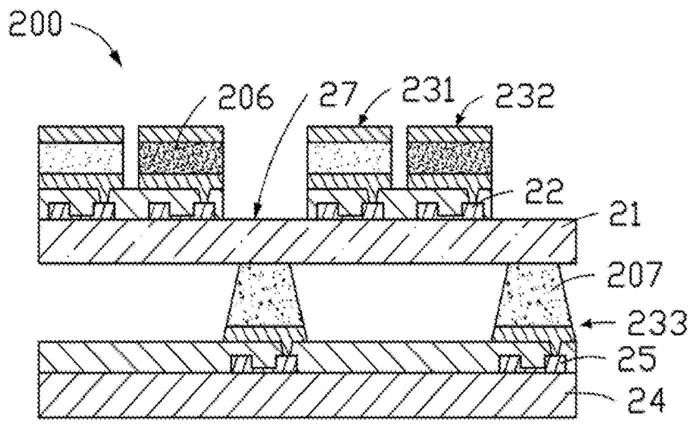


FIG. 2C

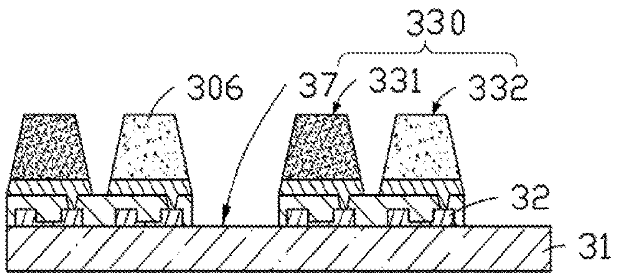


FIG. 3A

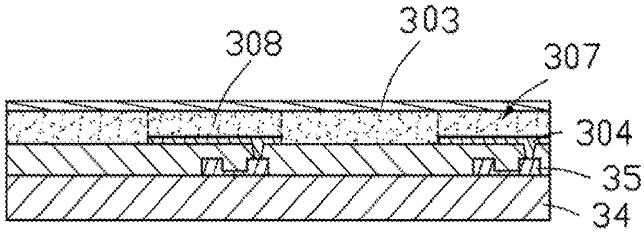


FIG. 3B

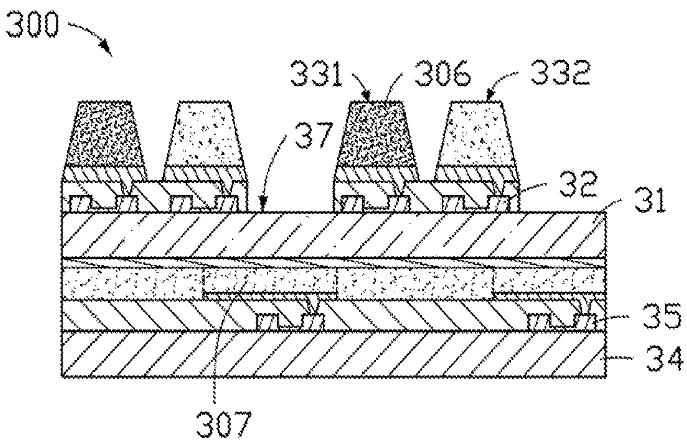


FIG. 3C

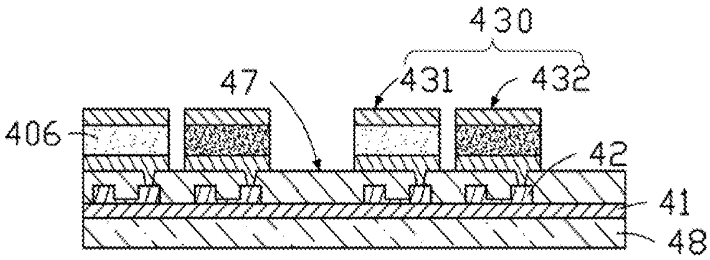


FIG. 4A

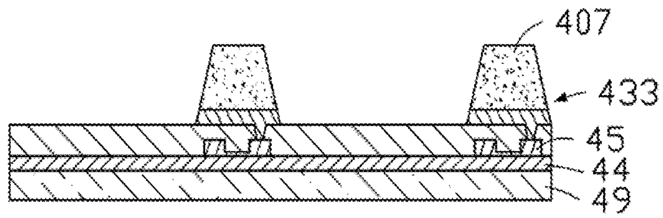


FIG. 4B

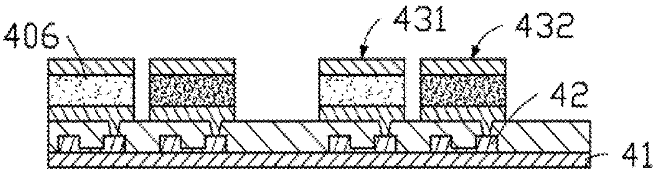


FIG. 4C

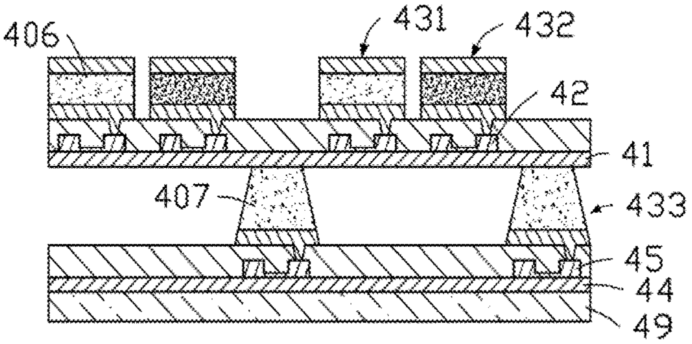


FIG. 4D

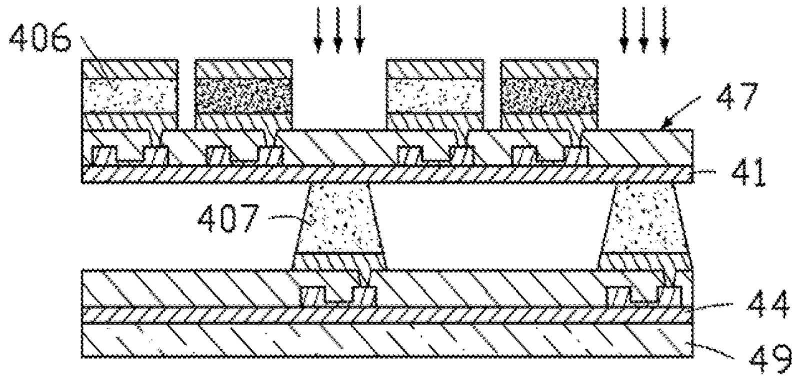


FIG. 4E

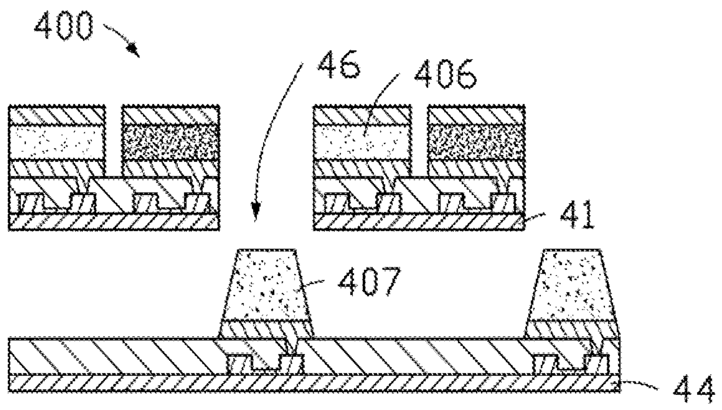


FIG. 4F

DISPLAY DEVICE AND METHOD FOR MAKING SAME

FIELD

The subject matter herein generally relates to a display panel and a method for making the display panel.

BACKGROUND

Organic light-emitting diode (OLED) has advantages of wide color range, thinness, and power efficiency. However, the blue sub-pixels in OLED may have degradation problems, which have not yet been effectively solved. The conventional processing method is to increase area of the blue sub-pixel, to ensure the display effect and prolong the life of the display device. However, in this method, the blue sub-pixels need to occupy a large area, which leads to a limit at pixel density.

Therefore, there is room for improvement in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

Implementations of the present technology will now be described, by way of example only, with reference to the attached figures.

FIG. **1**A through FIG. **1**E are cross-sectional views showing a method for making a display according to a first embodiment of the present disclosure.

FIG. **2**A through FIG. **2**C are cross-sectional views showing a method for making a display according to a second embodiment of the present disclosure.

FIG. **3**A through FIG. **3**C are cross-sectional views showing a method for making a display according to a third embodiment of the present disclosure.

FIG. **4**A through FIG. **4**F are cross-sectional views showing a method for making a display according to a fourth embodiment of the present disclosure.

DETAILED DESCRIPTION

It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein may be practiced without these specific details. In other instances, methods, procedures, and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings are not necessarily to scale and the proportions of certain parts may be exaggerated to better illustrate details and features of the present disclosure.

The term "coupled" is defined as connected, whether directly or indirectly through intervening components, and is not necessarily limited to physical connections. The connection can be such that the objects are permanently connected or releasably connected. The term "comprising" when utilized, means "including, but not necessarily limited to"; it specifically indicates open-ended inclusion or membership in the so-described combination, group, series, and the like.

First Embodiment

As shown in FIG. **1**A through FIG. **1**E, a display device **100** comprises a plurality of organic light emitting diodes (OLEDs) and a plurality of micro light emitting diodes (micro-LEDs). The display device **100** is a hybrid display device. In this embodiment, a size of each Micro-LED is less than 50×50 μm. A method for making the display device **100** comprises the following steps.

Step **1**: as shown in FIG. **1**A, a first substrate **11** is provided and a plurality of first light emitting elements **106** are provided on the first substrate **11**. The first light emitting elements **106** are OLEDs.

In this embodiment, each first light emitting element **106** defines a pixel, the first light emitting elements **106** define a first pixel array on the first substrate **11**.

In this embodiment, the first pixel array comprises a plurality of first sub-pixels **131** and a plurality of second sub-pixels **132**. The first sub-pixels **131** and the second sub-pixels **132** emit light of different colors. In this embodiment, the first sub-pixels **131** emit red light and the second sub-pixels **132** emit green light.

A plurality of first thin film transistors **12** are formed on the first substrate **11**. The first thin film transistors **12** are located between the first substrate **11** and the first light emitting elements **106**. The first thin film transistors **12** control the first light emitting elements **106**.

In this embodiment, each first sub-pixel **131** or each second sub-pixel **132** corresponds to two first thin film transistors **12**. One of the first thin film transistors **12** is directly connected to the first light emitting elements **106** and is used as a driving transistor to drive the first light emitting elements **106** to emit light. The other first thin film transistor **12** is connected to a driving transistor and is used as a switching transistor to control the driving transistor to power on and off, and is electrically coupled to a scan line (not shown) and a data line (not shown).

In other embodiments, each first sub-pixel **131** or each second sub-pixel **132** may correspond to at least two first thin film transistors **12**, and each first sub-pixel **131** or each second sub-pixel **132** is controlled by the at least two first thin film transistors **12**.

In this embodiment, the first substrate **11** is provided with a plurality of light transmitting regions **17** to allow light to pass through. The first thin film transistors **12** and the first light-emitting elements **106** are located in such manner as to avoid the light transmitting regions **17**. The first thin film transistors **12** and the first light-emitting elements **106** thus do not block the light transmitting regions **17**. In this embodiment, the first substrate **11** may be opaque and may define a plurality of openings each extending through the substrate. Each opening forms a light transmitting region **17**. In other embodiments, the first substrate **11** may be transparent to allow light to pass through.

In this embodiment, each first sub-pixel **131** and adjacent second sub-pixel **132** define a group **130**. A light transmitting region **17** is located between adjacent groups **130**.

Each of the first light emitting elements **106** may be a conventional OLED. In this embodiment, each first light emitting element **106** includes a cathode electrode **103**, an anode electrode **104**, and a light emitting layer **108** sandwiched between the cathode electrode **103** and the anode electrode **104**. The light emitting layer **108** is a conventional OLED light-emitting layer including an organic electroluminescent material layer (EML) (not shown). The light-emitting layer **108** may also include an electron transport layer (ETL) (not shown) and an electron injection layer

(EIL) (not shown) located between the organic electroluminescent material layer and the cathode electrode **103**. A hole injection layer (HIL) (not shown) and a hole transport Layer (HTL) (not shown) are also located between the organic electroluminescent material layer and the anode electrode **104**.

Step **2**: as shown in FIG. **1**B, a second substrate **14** is provided and a plurality of second light emitting elements **107** are provided on the second substrate **14**. The second light emitting elements are Micro-LEDs.

In this embodiment, each second light emitting element **107** defines a pixel and the second light emitting elements **107** define a second pixel array on the second substrate **14**.

In this embodiment, the second pixel array comprises a plurality of third sub-pixels **133**. In this embodiment, the third sub-pixels **133** emit blue light. Micro-LEDs are used as sub-pixels emitting blue light, as a solution to the problem of the sub-pixels emitting blue light being easily degraded.

It can be understood that, in other embodiments, the first sub-pixels **131** may emit green light or blue light, the second sub-pixels **132** may emit red light or blue light, and the third sub-pixels **133** may emit red light or green light.

A plurality of second thin film transistors **15** are formed on the second substrate **14**, the second thin film transistors **15** are located between the second substrate **14** and the second light emitting elements **107**. The plurality of second thin film transistors **15** control the second light emitting elements **107**.

In this embodiment, each third sub-pixel **133** corresponds to two second thin film transistors **15**. One of the second thin film transistors **15** is directly connected to the second light emitting elements **107** and is used as a driving transistor to drive the second light emitting elements **107** to emit light. The other second thin film transistor **15** is connected to a driving transistor and is used as a switching transistor to control the driving transistor to power on and off, and is electrically coupled to a scan line (not shown) and a data line (not shown).

In other embodiments, each third sub-pixel **133** may correspond to at least two second thin film transistors **15**, each third sub-pixel **133** is controlled by at least two second thin film transistors **15**.

In this embodiment, the plurality of third sub-pixels **133** are spaced from each other. An area between two adjacent third sub-pixels **133** overlaps with one group **130** along a thickness direction of the display device **100**. In one embodiment, the area between two adjacent third sub-pixels **133** may be smaller than an area occupied by one group **130**. An area of each third sub-pixel **133** is larger than an area of the light transmitting region **17** for the sake of alignment tolerance, so that an overlapping area of the third sub-pixel **133** and the light transmitting region **17** will not be reduced through non-precise alignment.

In another embodiment, the area between two adjacent third sub-pixels **133** may be substantially the same as the area occupied by one group **130**.

Each of the second light emitting elements **107** may be a Micro-LED.

In an embodiment, each second light emitting element **107** comprises a P-type doped light-emitting material layer (not shown), an N-type doped light material layer (not shown), and an active layer (not shown) between the P-type doped light-emitting material layer and the N-type doped light material layer. Each P-type doped light-emitting material layer connects to a top electrode (not shown), and each N-type doped light-emitting material layer connects to a bottom electrode (not shown). The second light emitting element **107** emits light by adjusting voltages applied to the top electrode and the bottom electrode. It can be understood that the positions of the P-type doped light emitting material layer and the N-type doped light-emitting material layer may be exchanged.

It can be understood that, in other embodiment, each of the first light emitting elements **106** can be a micro-LED, and each of the second light emitting elements **107** can be an OLED.

Step **3**: as shown in FIG. **1**C, the first substrate **11** is laminated onto the second substrate **14**. The plurality of first light emitting elements **106**, the first substrate **11**, the plurality of second light emitting elements **107**, and the second substrate **14** are sequentially stacked in a thickness direction of the display device **100**. Each second light emitting element **107** is staggered from a first light emitting element **106** in the thickness direction.

In this embodiment, a projection of one second light emitting element **107** in the thickness direction at least partially overlaps with a projection of one light transmitting region **17** in the thickness direction.

In this embodiment, the first light emitting elements **106** are located on a side of the first substrate **11** away from the second substrate **14**; and the second light emitting elements **107** are located on the side of the second substrate **14** adjacent to the first substrate **11**.

In this embodiment, each group **130** and a third sub-pixel **133** form a pixel unit **13**. That is, in this embodiment, each pixel unit **13** comprises three sub-pixels emitting red light, green light, and blue light.

Step **4**: as shown in FIGS. **1**D and **1**E, the first substrate **11** is etched to form a plurality of openings **16** extending through the first substrate **11**. Each opening **16** forms a light transmitting region **17**.

In this embodiment, the positions of the first substrate **11** corresponding to the second light-emitting elements **107** are etched to form the plurality of openings **16** extending through the first substrate **11**, so that the light from the second light-emitting elements **107** can pass through the openings **16**. That is, the light from the second light emitting elements **107** can pass through the light transmitting regions **17**.

In this embodiment, the first substrate **11** is an opaque material. The first substrate **11** can be etched by laser to form openings **16**. In other embodiment, a plasma etching may also be used. The OLED should not have contact with water vapor, thus any suitable dry etching method may be adopted.

It can be understood that, in other embodiment, the first substrate **11** may be etched to form the openings **16** extending through the first substrate **11** in the step **1**, and step **4** may be omitted.

In this embodiment, the method for making the display device **100** further comprises forming a protective layer (not shown) to cover the first light emitting elements **106** and the second light emitting elements **107**.

The display device **100** according to the first embodiment can be made by the above described steps. As shown in FIG. **1**E, the display device **100** of the first embodiment comprises: a first substrate **11** and a second substrate **14**. A plurality of first light emitting elements **106** with a space between each is on the first substrate **11** and a plurality of second light emitting elements **107** with a space between each is on the second substrate **14**. The plurality of first light emitting elements **106**, the first substrate **11**, the plurality of second light emitting elements **107**, and the second substrate **14** are sequentially stacked in the thickness direction of the display device **100**. In the thickness direction, each of the second light emitting elements **107** is staggered from a first light emitting element **106**. The first substrate **11** is provided with a plurality of light transmitting regions **17** to allow light output through the light transmitting regions **17**. Each of the plurality of first light emitting elements **106** is an organic light emitting diode, each of the plurality of second light emitting elements **107** is a micro light emitting diode. Conversely, each of the plurality of second light emitting elements **107** can be an organic light emitting diode, and each of the plurality of first light emitting elements **106** can be an inorganic micro light emitting diode.

In this embodiment, each of the first light emitting elements **106** is an OLED, each of the second light emitting element **107** is a micro-LED. The first substrate **11** defines a plurality of openings **16** each extending through the first substrate **11**. Each opening **16** forms one light transmitting region **17**.

Second Embodiment

As shown in FIG. **2**A through FIG. **2**C, a display device **200** comprises a plurality of OLEDs and a plurality of micro-LEDs. The display device **200** is a hybrid display device. A method for making the display device **200** comprises the following steps.

Step **1**: as shown in FIG. **2**A, a first substrate **21** is provided, and a plurality of first light emitting elements **206** are provided on the first substrate **21**. The first light emitting elements **206** are OLEDs.

In this embodiment, each first light emitting element **206** defines a pixel, and the first light emitting elements **206** define a first pixel array on the first substrate **21**.

In this embodiment, the first pixel array comprises a plurality of first sub-pixels **131** and a plurality of second sub-pixels **232**. The first sub-pixels **231** and the second sub-pixels **232** emit light of different colors. In this embodiment, the first sub-pixels **231** emit red light and the second sub-pixels **232** emit green light.

A plurality of first thin film transistors **22** are formed on the first substrate **21**. the first thin film transistors **22** are located between the first substrate **21** and the first light emitting elements **206**. The first thin film transistors **22** control the first light emitting elements **206**.

In this embodiment, the first substrate **21** is a transparent substrate, and light can pass through the first substrate **21**.

In this embodiment, the first substrate **21** is provided with a plurality of light transmitting regions **27** to allow light pass through. The first thin film transistors **22** and the first light-emitting elements **206** are located so as to avoid the light transmitting regions **27**. The first thin film transistors **22** and the first light-emitting elements **206** thus do not block the light transmitting regions **27**.

In this embodiment, each first sub-pixel **231** and one adjacent second sub-pixel **232** define a group **230**. Each light transmitting region **27** is located between adjacent groups **230**.

Step **2**: as shown in FIG. **2**B, a second substrate **24** is provided and a plurality of second light emitting elements **207** is on the second substrate **24**. The second light emitting elements are micro-LEDs.

In this embodiment, each second light emitting element **207** defines a pixel, and the second light emitting elements **207** define a second pixel array on the second substrate **24**. The second pixel array comprises a plurality of third sub-pixels **233**, and the third sub-pixels **233** emit blue light.

A plurality of second thin film transistors **25** are formed on the second substrate **24**, the second thin film transistors **25** are located between the second substrate **24** and the second light emitting elements **207**. The second thin film transistors **25** control the second light emitting elements **207**.

In this embodiment, the third sub-pixels **233** are spaced from each other. An area between two adjacent third sub-pixels **233** overlaps with one group **230** along a thickness direction of the display device **200**. In one embodiment, the area between two adjacent third sub-pixels **233** may be smaller than an area occupied by one group **230**. An area of each third sub-pixel **233** is larger than an area of the light transmitting region **27**. An overlapping area of the third sub-pixel **233** and the transmitting region **17** will not be reduced though the first substrate **11** and the second substrate **14** are not aligned accurately. In other embodiments, the area between two adjacent third sub-pixels **233** may be substantially the same as the area occupied by one group **230**.

It can be understood that, in other embodiments, each of the first light emitting elements **206** can be a micro-LED, and each of the second light emitting elements **207** can be an OLED.

Step **3**: as shown in FIG. **2**C, the first substrate **21** is laminated on the second substrate **24**. The plurality of first light emitting elements **206**, the first substrate **21**, the plurality of second light emitting elements **207**, and the second substrate **24** are sequentially stacked in a thickness direction of the display device **200**. Each second light emitting element **207** is staggered from a first light emitting element **206** in the thickness direction.

In this embodiment, a projection of one second light emitting element **207** in the thickness direction at least partially overlaps with a projection of one light transmitting region **27** in the thickness direction.

In this embodiment, the first substrate **21** is transparent to allow light to pass through, and the first substrate **21** does not need to be etched. The light from the second light emitting elements **207** passes through the light transmitting regions **27**.

The display device **200** of the second embodiment can be made by the above described steps. As shown in FIG. **2**C, the display device **200** of the second embodiment comprises a first substrate **21** and a second substrate **24**. A plurality of first light emitting elements **206** spaced apart is on the first substrate **21** and a plurality of second light emitting elements **207** spaced apart is on the second substrate **24**. The plurality of first light emitting elements **206**, the first substrate **21**, the plurality of second light emitting elements **207**, and the second substrate **24** are sequentially stacked in the thickness direction of the display device **200**. In the thickness direction, the second light emitting elements **207** are staggered from a first light emitting elements **206**. The first substrate **21** is provided with a plurality of light transmitting regions **27** to allow light output through the light transmitting regions **27**. Each of the plurality of first light emitting elements **206** is an organic light emitting diode, each of the plurality of second light emitting elements **207** is a micro light emitting diode. Conversely, each of the plurality of second light emitting elements **207** can be an organic light emitting diode, and each of the plurality of first light emitting elements **206** can be a micro light emitting diode.

In this embodiment, each of the first light emitting elements **106** is an OLED, each of the second light emitting element **107** is a micro-LED. The first substrate **21** is transparent.

Third Embodiment

As shown in FIGS. **3**A through **3**C, a display device **300** comprises a plurality of OLEDs and a plurality of Micro-

LEDs. The display device **300** is a hybrid display device. A method for making the display device **300** comprises the following.

Step **1**: As shown in FIG. **3**A, a first substrate **31** is provided, and a plurality of first light emitting elements **306** are provided on the first substrate **31**. The first light emitting elements **306** are Micro-LEDs.

In this embodiment, each first light emitting element **306** defines a pixel, and the plurality of first light emitting elements **306** define a first pixel array on the first substrate **31**.

In this embodiment, the first pixel array comprises a plurality of first sub-pixels **131** and a plurality of second sub-pixels **332**, the first sub-pixels **331** and the second sub-pixels **332** emit light of different color. In this embodiment, the first sub-pixels **331** emit green light and the second sub-pixels **332** emit blue light.

A plurality of first thin film transistors **32** are formed on the first substrate **31**. The first thin film transistors **32** are located between the first substrate **31** and the first light emitting elements **306**. The first thin film transistors **32** control the first light emitting elements **306**.

In this embodiment, the first substrate **31** is transparent, and light can pass through the first substrate **31**.

In this embodiment, the first substrate **31** is provided with a plurality of light transmitting regions **37** to allow light to pass through. The first thin film transistors **32** and the first light-emitting elements **306** are located so as to avoid the light transmitting regions **37**. The first thin film transistors **32** and the first light-emitting elements **306** thus do not block the light transmitting regions **37**.

In this embodiment, each first sub-pixel **331** and an adjacent second sub-pixel **332** define a group **330**, and each light transmitting region **37** is located between two adjacent groups **330**.

Step **2**: as shown in FIG. **3**B, a second substrate **34** is provided and a plurality of second light emitting elements **307** are on the second substrate **34**. The second light emitting elements are OLEDs.

In this embodiment, each second light emitting element **307** defines a pixel, the second light emitting elements **307** define a second pixel array on the second substrate **34**.

In this embodiment, the second pixel array comprises a plurality of third sub-pixels **333**.

A plurality of second thin film transistors **35** are formed on the second substrate **34**, the second thin film transistors **35** are located between the second substrate **34** and the second light emitting elements **307**. The second thin film transistors **35** control the second light emitting elements **307**.

Each second light emitting element **307** includes a light emitting layer **308**, a cathode electrode **303**, and an anode electrode **304**. The cathode electrode **303** and the anode electrode **304** are located on opposite sides of the light emitting layer **308**. Two second light emitting elements **307** (or at least two) share a single light emitting layer **308**. In this embodiment, all the second light emitting elements **307** share a single light emitting layer **308**.

In one embodiment, at least two adjacent second light emitting elements share a single anode electrode **304**. In one embodiment, at least two adjacent second light emitting elements share a single cathode electrode **303**.

In this embodiment, all the second light emitting elements **307** share a single cathode electrode **303**, and the anode electrodes **304** are spaced apart.

The plurality of second thin film transistors **35** only drive the portions of the single cathode electrode **303** which are overlapped with the anode electrodes **304**, to emit light.

In this embodiment, the third sub-pixels **33** emit red light.

Step **3**: as shown in FIG. **3**C, the first substrate **31** is laminated on the second substrate **34**. The first light emitting elements **306**, the first substrate **31**, the second light emitting elements **307**, and the second substrate **34** are sequentially stacked in a thickness direction of the display device **300**. Each second light emitting elements **307** is staggered from the first light emitting elements **306** in the thickness direction.

In this embodiment, a projection of one second light emitting element **307** in the thickness direction at least partially overlaps with a projection of one light transmitting region **37** in the thickness direction.

In this embodiment, the first substrate **31** is transparent to allow light to pass through, and the first substrate **31** does not need to be etched. The light from the second light emitting elements **307** passes through the light transmitting regions **37**.

In one embodiment, an area between two adjacent second light emitting layers **307** may be smaller than an area occupied by one group **330**, and an area of each second light emitting layer **307** is larger than an area of the light transmitting region **37**. In other embodiments, the area between two adjacent second light emitting layers **307** may be substantially the same as the area occupied by one group **330**.

The display device **300** of the third embodiment can be made by the above steps. As shown in FIG. **3**C, the display device **300** of the third embodiment comprises: a first substrate **31** and a second substrate **34**. A plurality of first light emitting elements **306** spaced apart are on the first substrate **31** and the plurality of second light emitting elements **307** spaced apart are on the second substrate **34**. The plurality of first light emitting elements **306**, the first substrate **31**, the plurality of second light emitting elements **307**, and the second substrate **34** are sequentially stacked in the thickness direction of the display device **300**. In the thickness direction, the second light emitting elements **307** are staggered from the first light emitting elements **306**. The first substrate **31** is provided with a plurality of light transmitting regions **37** to allow light from the second light emitting elements to pass through the light transmitting regions **37**. Each first light emitting element **306** is an organic light emitting diode, and each second light emitting element **307** is a micro light emitting diodes, or the converse may be true.

In this embodiment, each of the first light emitting elements **306** is a micro-LED and each of the second light emitting elements **307** is an OLED. The first substrate **21** is transparent. Each second light emitting element **307** includes a light emitting layer **308**, a cathode electrode **303**, and an anode electrode **304**. The cathode electrode **303** and the anode electrode **304** are located on opposite sides of the light emitting layer **308**. At least two second light emitting elements **307** share a single light emitting layer **308**.

In one embodiment, at least two second light emitting elements **307** share a single cathode electrode **303**. In one embodiment, at least two second light emitting elements **307** share a single anode electrode **304**.

Fourth Embodiment

As shown in FIG. **4**A through FIG. **4**F, a display device **400** comprises OLEDs and micro-LEDs. The display device

400 is a hybrid display device. A method for making the display device 400 comprises the following steps.

Step 1: as shown in FIG. 4A, a first supporting substrate 48 and a first substrate 41 are provided, the first supporting substrate 48 supports the first substrate 41. First light emitting elements 406 are provided on the first substrate 41, and the first light emitting elements 406 are OLEDs.

In this embodiment, each first light emitting element 406 defines a pixel, the first light emitting elements 406 define a first pixel array on the first substrate 41.

In this embodiment, the first pixel array comprises a plurality of first sub-pixels 431 and a plurality of second sub-pixels 432, the first sub-pixels 431 and the second sub-pixels 432 emitting light of different color. In this embodiment, the first sub-pixels 431 emit red light and the second sub-pixels 432 emit green light.

A plurality of first thin film transistors 42 are formed on the first substrate 41, the first thin film transistors 42 are located between the first substrate 11 and the first light emitting elements 406. The first thin film transistors 42 control the first light emitting elements 406.

In this embodiment, the first substrate 41 is flexible, but first supporting substrate 48 is rigid. The first supporting substrate 48 supports the first substrate 41.

In this embodiment, the first substrate 41 is provided with a plurality of light transmitting regions 47 to allow light to pass through. The first thin film transistors 42 and the first light-emitting elements 406 are located so as to avoid the light transmitting regions 47. The first thin film transistors 42 and the first light-emitting elements 406 thus do not block the light transmitting regions 47. In this embodiment, light transmittance of the first substrate 41 is not limited.

In this embodiment, each first sub-pixel 431 and an adjacent second sub-pixel 432 define a group 430, and each light transmitting region 47 is located between two adjacent groups 430.

Step 2: as shown in FIG. 4B, a second supporting substrate 49 and a second substrate 44 are provided, the second supporting substrate 49 supporting the second substrate 44. Second light emitting elements 407 are provided on the second substrate 44, the second light emitting elements 407 are micro-LEDs.

In this embodiment, the second substrate 44 is flexible, but the second supporting substrate 49 is rigid, and the second supporting substrate 49 supports the second substrate 44.

In this embodiment, the first substrate 41 and the second substrate 44 are polymide films (PI film), and the first supporting substrate 48 and the second supporting substrate 49 can be made of glass.

In this embodiment, each second light emitting element 407 defines a pixel, the second light emitting elements 407 define a second pixel array on the second substrate 44.

In this embodiment, the second pixel array comprises a plurality of third sub-pixels 433, the third sub-pixels 433 emit blue light.

Second thin film transistors 45 are formed on the second substrate 44, the second thin film transistors 45 are located between the second substrate 44 and the second light emitting elements 407. The second thin film transistors 45 are used to control the second light emitting elements 407.

In this embodiment, the third sub-pixels 433 are spaced apart. An area between two adjacent third sub-pixels 433 overlaps one group 430 along a thickness direction of the display device 400. In one embodiment, the area between two adjacent third sub-pixels 433 may be smaller than an area occupied by one group 430, and an area of each third sub-pixel 433 is larger than an area of the light transmitting region 47. An overlapping area of the third sub-pixel 133 and the light transmitting region 47 will then not be reduced through misalignment of the first substrate 41 and the second substrate 44. In other embodiment, the area between two adjacent third sub-pixels 433 may be substantially the same as the area occupied by one group 430.

It can be understood that, in other embodiment, each first light emitting element 406 can be a micro-LED, and each second light emitting element 407 can be an OLED.

Step 3: as shown in FIG. 4C, the first supporting substrate 48 can be peeled off.

In this embodiment, a method of peeling off can be mechanical peeling off or peeling off by laser. In the laser process, laser is directed from the first supporting substrate 48 side to the interface between the first supporting substrate 48 and the first substrate 41, leaving the material at the interface in a molten state, to make the first supporting substrate 48 easier to peel.

Step 4: as shown in FIG. 4D, the first substrate 41 is laminated onto the second substrate 44. The first light emitting elements 406, the first substrate 41, the second light emitting elements 407, and the second substrate 44 are sequentially stacked in the thickness direction of the display device 400. Each second light emitting element 407 is staggered from each first light emitting element 406 in the thickness direction.

In this embodiment, a projection of one second light emitting element 407 in the thickness direction at least partially overlaps with a projection of one light transmitting region 47 in the thickness direction.

Step 5: As shown in FIG. 4E, the first substrate 41 is etched to form openings 46 each extending through the first substrate 41. Each opening 16 forms one light transmitting region 47.

In this embodiment, positions on the first substrate 41 which correspond to the second light-emitting elements 407 are etched to form the openings 46 each extending through the first substrate 41. The light from the second light-emitting elements 407 can pass through the openings 46.

Step 5: As shown in FIG. 4F, the second supporting substrate 49 is peeled off.

In this embodiment, the flexible first substrate 41 and the flexible second substrate 44 are respectively supported by the rigid first supporting substrate 48 and the rigid second supporting substrate 49. The first supporting substrate 48 and the second supporting substrate 49 can then be removed, thereby a flexible display device 400 is made.

The display device 400 of the fourth embodiment can be made by the above described steps. As shown in FIG. 4F, the display device 400 of the fourth embodiment comprises: a first substrate 31 and a second substrate 44. First light emitting elements 406 spaced apart are on the first substrate 41 and second light emitting elements 407 spaced apart are on the second substrate 44. The plurality of first light emitting elements 406, the first substrate 41, the plurality of second light emitting elements 407, and the second substrate 44 are sequentially stacked in the thickness direction of the display device 400. In the thickness direction, the second light emitting elements 407 are staggered from the first light emitting elements 406. The first substrate 41 is provided with a plurality of light transmitting regions 47 to allow light from the second light emitting elements to pass through. Each first light emitting element 406 is an organic light emitting diode, and each second light emitting elements 407 is a micro light emitting diode, or the converse can apply.

In this embodiment, each of the first light emitting elements **406** is an OLED, each of the second light emitting elements **407** is a micro-LED. A plurality of openings **46**, each of which extends through the first substrate **11**, forms one light transmitting region **47**. Both the first substrate **41** and the second substrate **44** are flexible.

It is to be understood, even though information and advantages of the present embodiments have been set forth in the foregoing description, together with details of the structures and functions of the present embodiments, the disclosure is illustrative only; changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the present embodiments to the full extent indicated by the plain meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A display device, comprising:

a first substrate;

a second substrate;

a plurality of first light emitting elements on the first substrate and spaced apart from each other; and

a plurality of second light emitting elements on the second substrate and spaced apart from each other;

the plurality of first light emitting elements, the first substrate, the plurality of second light emitting elements, and the second substrate sequentially stacked in a thickness direction of the display device;

each of the plurality of second light emitting elements staggered from the plurality of first light emitting elements in the thickness direction;

the first substrate provided with a plurality of light transmitting regions to allow light from the plurality of second light emitting elements pass through;

wherein each of the plurality of first light emitting elements is an organic light emitting diode, each of the plurality of second light emitting elements is a micro light emitting diode; or

each of the plurality of second light emitting element is an organic light emitting diode, each of the plurality of first light emitting elements is a micro light emitting diode.

2. The display device of claim **1**, wherein the substrate defines a plurality of openings each extending through the first substrate, each of the plurality of openings forms one of the plurality of light transmitting regions.

3. The display device of claim **1**, wherein the first substrate is transparent to form the plurality of light transmitting regions.

4. The display device of claim **1**, wherein

each of the plurality of second light emitting element are organic light emitting diodes;

each of the plurality second light emitting elements comprises a light emitting layer, a cathode electrode, and a anode electrode; the cathode electrode and the anode electrode are on opposite sides of the light emitting layer;

at least two adjacent of the plurality of second light emitting elements share a single light emitting layer.

5. The display device of claim **4**, wherein at least two adjacent of the plurality of second light emitting elements share a single cathode electrode.

6. The display device of claim **4**, wherein at least two adjacent of the plurality of second light emitting elements share a single anode electrode.

7. The display device of claim **1**, wherein the first substrate is flexible.

8. A method for making the display panel, comprising:

providing a first substrate with a plurality of light transmitting regions;

providing a plurality of first light emitting elements on the first substrate;

providing a second substrate;

providing a plurality of second light emitting elements on the second substrate;

assembling the first substrate and the second substrate to make the plurality of first light emitting elements, the first substrate, the plurality of second light emitting elements, and the second substrate be sequentially stacked in a thickness direction of the display device;

each of the plurality of second light emitting elements staggered from the plurality of first light emitting elements in the thickness direction; and

wherein each of the plurality of first light emitting elements is an organic light emitting diode, each of the plurality of second light emitting elements is a micro light emitting diode; or

each of the plurality of second light emitting element is an organic light emitting diode, each of the plurality of first light emitting elements is a micro light emitting diode.

9. The method of claim **8**, wherein further comprising etching the first substrate to form a plurality of openings each extending through the first substrate, each of the plurality of openings forms one of the plurality of light transmitting regions.

10. The method of claim **8**, wherein the first substrate is transparent.

11. The method of claim **8**, wherein

each of the plurality of second light emitting element are organic light emitting diodes;

each of the plurality second light emitting elements comprises a light emitting layer, a cathode electrode, and a anode electrode; the cathode electrode and the anode electrode are on opposite sides of the light emitting layer;

at least two adjacent of the plurality of second light emitting elements share a single light emitting layer.

12. The display device of claim **11**, wherein at least two adjacent of the plurality of second light emitting elements share a single cathode electrode.

13. The display device of claim **11**, wherein at least two adjacent of the plurality of second light emitting elements share a single anode electrode.

14. The method of claim **8**, wherein both the first substrate and the second substrate are flexible substrates, the method further comprises:

providing a first supporting substrate and a second supporting substrate, the first substrate supported by the first supporting substrate, and the second substrate supported by the second supporting substrate;

before assembling the first substrate and the second substrate, peeling off the first supporting substrate from the first substrate;

after peeling off the first supporting substrate, peeling off the second supporting substrate.

15. The method of claim **14**, wherein a method of peeling off is mechanically peeling off or laser peeling off.

* * * * *

patsnap

专利名称(译)	显示装置及其制造方法		
公开(公告)号	[US10424622](US10424622)	公开(公告)日	2019-09-24
申请号	US16/027325	申请日	2018-07-04
[标]申请(专利权)人(译)	鸿海精密工业股份有限公司		
申请(专利权)人(译)	鸿海精密工业股份有限公司.		
当前申请(专利权)人(译)	鸿海精密工业股份有限公司.		
[标]发明人	LIN CHANG TING CHANG WEI CHIH CHEN YING CHIEH LAI CHUNG WEN HUANG CHUN CHIEH WANG WEI LI LU PO YI CHEN JEN JIE WU I WEI		
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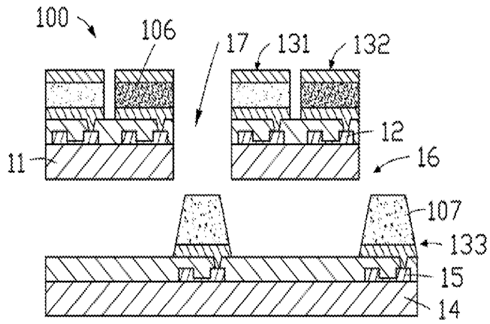
IPC分类号	H01L27/32 H01L25/16 H01L51/50 H01L51/56 H01L51/00 H01L51/52		
CPC分类号	H01L51/502 H01L27/3218 H01L51/5036 H01L51/5221 H01L51/56 H01L51/0097 H01L25/162 H01L27/3262 H01L51/5206 H01L27/3225 H01L51/52 G09G2300/0452 H01L27/3211 H01L27/3244 H01L2227/323 H01L2227/326 H01L25/0753		
优先权	62/529002 2017-07-06 US		
其他公开文献	US20190013365A1		
外部链接	Espacenet		

摘要(译)

由OLED和微型LED组成的显示装置允许OLED的蓝光降解，该显示装置包括双层构造的第一基板和第二基板。第一发光元件位于第一基板上并隔开，第二发光元件位于第二基板上并隔开，下甲板上的发光元件交错排列，以免被上端的发光元件隐藏甲板。上平台在其中具有开口（或透明），以允许光从下平台的发光元件流出。该显示装置提供了一种解决方案，用于解决由于像素退化而导致的显示不均匀。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