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(54) **ORGANIC LIGHT-EMITTING DIODE DISPLAY AND METHOD OF MANUFACTURING THE SAME**

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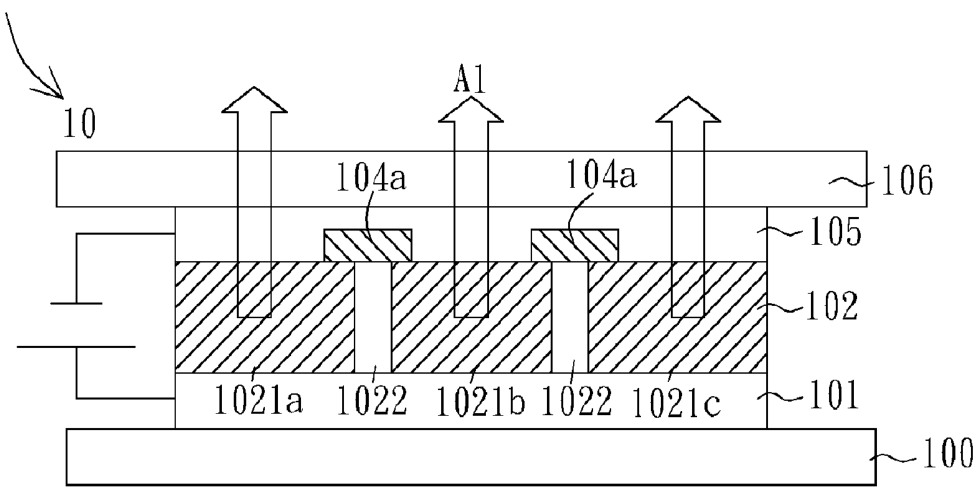
(57) **ABSTRACT**

An organic light-emitting diode display and method of manufacturing the same are provided in the present invention. The organic light-emitting diode display includes an anode layer and a cathode layer opposite to and spaced apart from each other, an organic light-emitting layer disposed between the anode layer and the cathode layer, wherein the organic light-emitting layer includes primary color regions and mixed color regions, and a color deviation protective layer disposed between the anode layer and the organic light-emitting layer or between the organic light-emitting layer and the cathode layer, and the color deviation protective layer is provided with insulating patterns corresponding to the mixed color regions to prevent light generation from the mixed color regions. The manufacturing method features the step of disposing a color deviation protective layer to prevent light generation from the mixed color regions of the organic light-emitting layer and solve conventional color deviation issue.



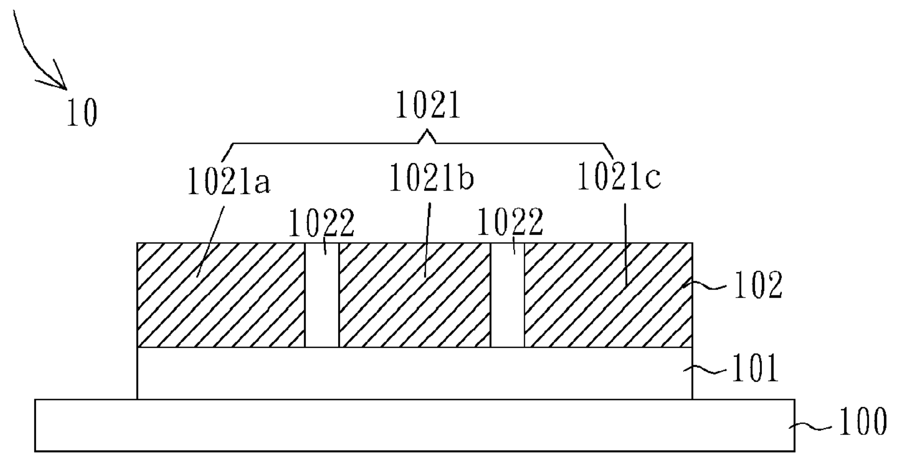
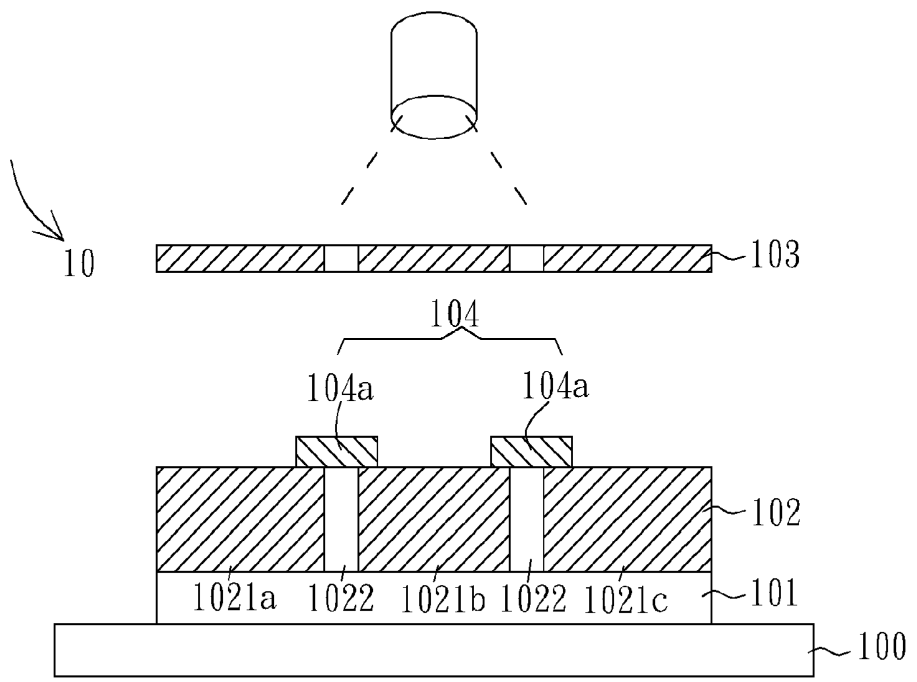

10
1021
1021a
1021b
1021c
1022
1022
102
101
100

FIG. 1


10
103
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104a
104a
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1021a
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FIG. 2

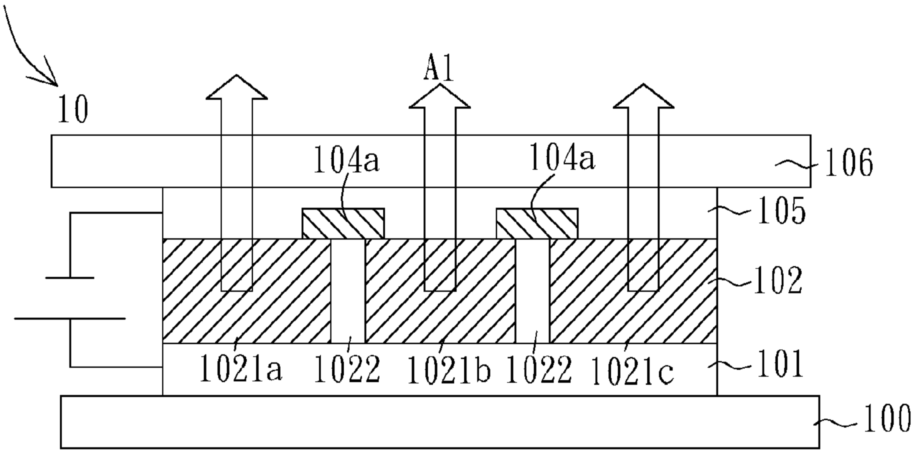
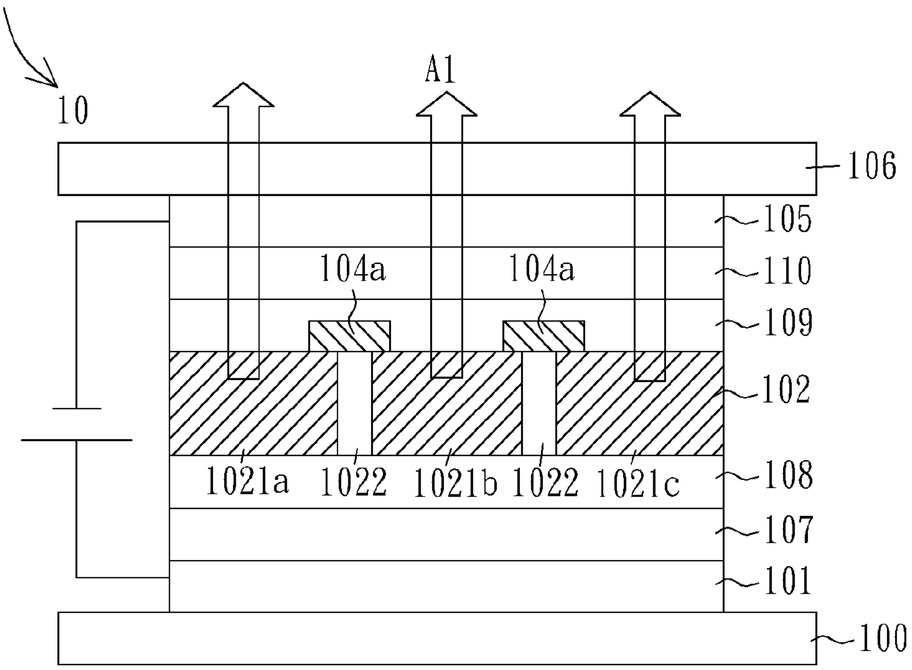

10
A1
104a
104a
106
105
102
1021a
1022
1021b
1022
1021c
101
100

FIG. 3


10
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1021a
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1021b
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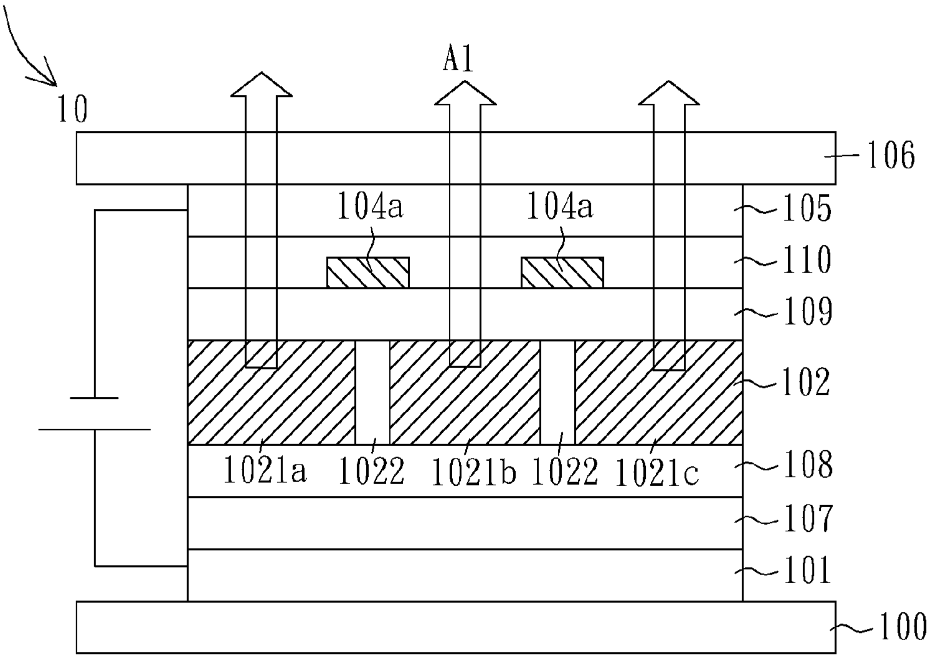
FIG. 4


10
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104a
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1021a
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1021b
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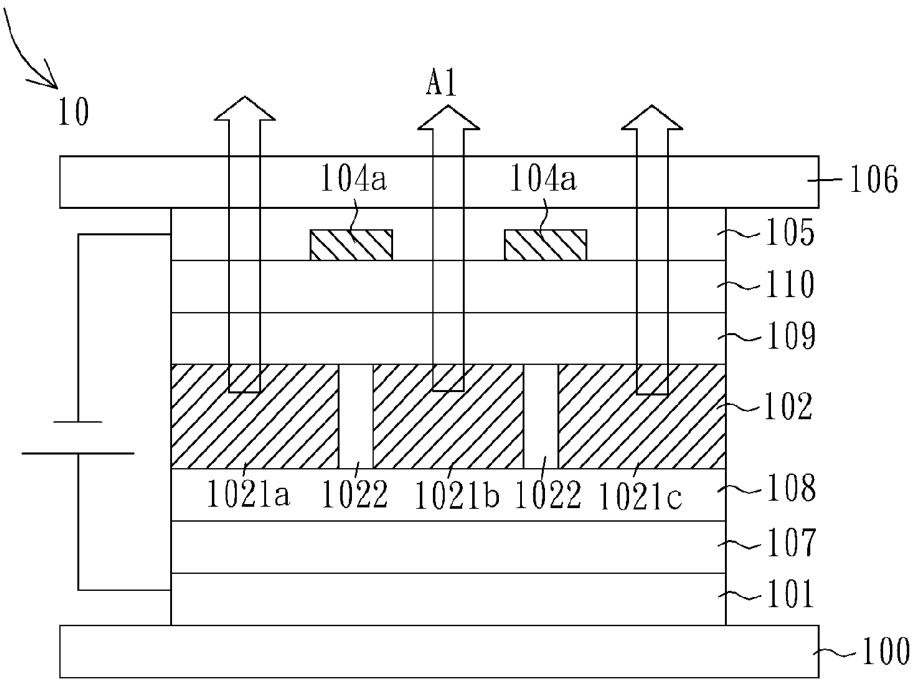
1021c
108
107
101
100

FIG. 5


10
A1
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104a
104a
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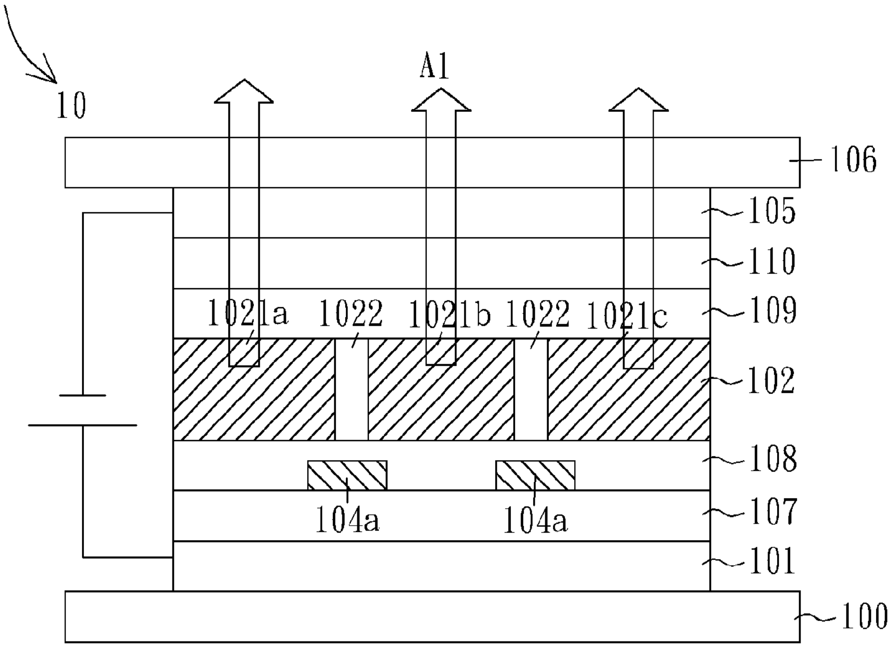
1021a
1022
1021b
1022
1021c
108
107
101
100

FIG. 6


10
A1
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1021a
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1021b
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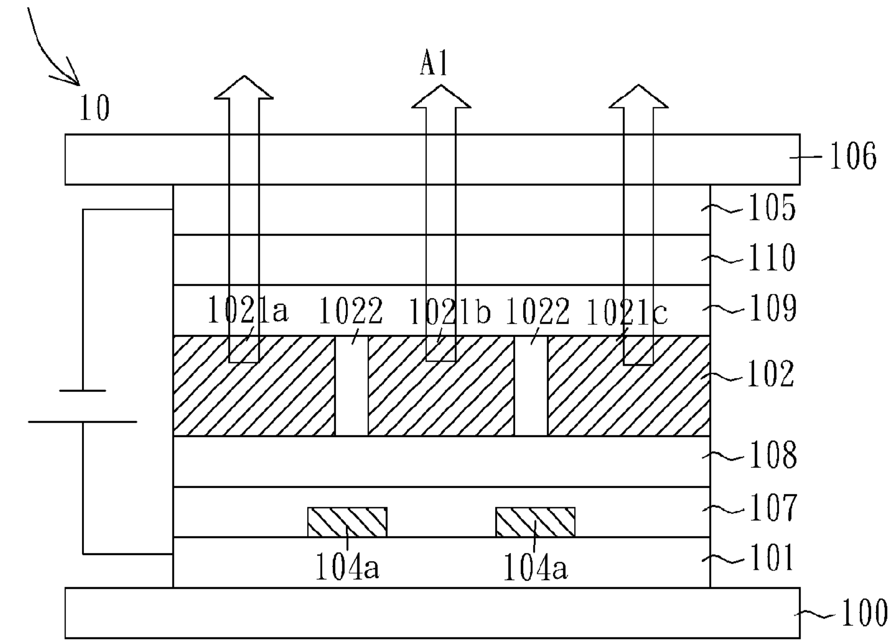
1021c
102
108
104a
104a
107
101
100

FIG. 7


10
A1
106
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1021a
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1021b
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1021c
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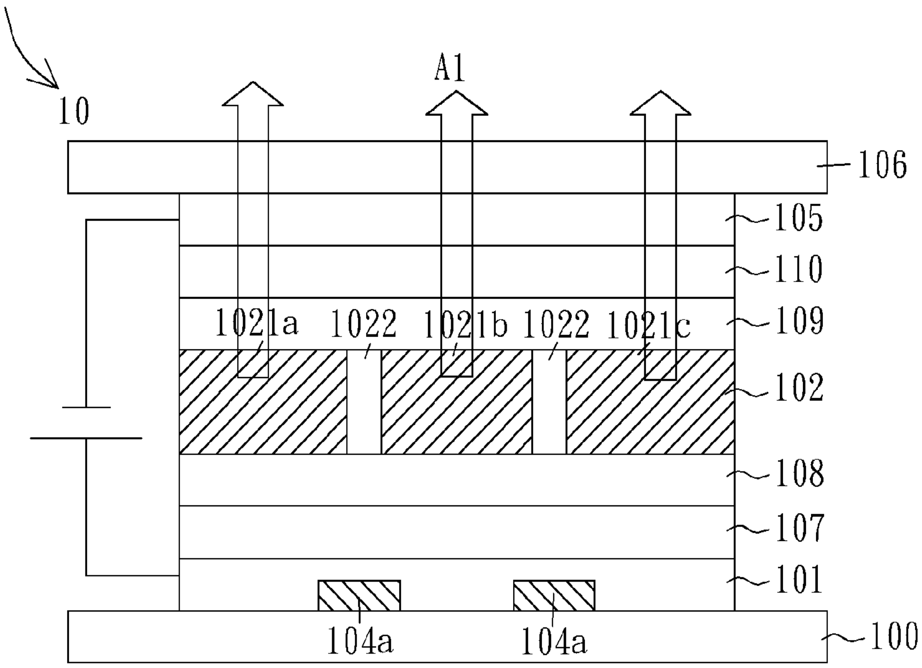
107
104a
104a
101
100

FIG. 8


10
A1
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1021a
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1021b
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1021c
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107
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104a
104a
100

FIG. 9

ORGANIC LIGHT-EMITTING DIODE DISPLAY AND METHOD OF MANUFACTURING THE SAME

BACKGROUND OF THE INVENTION

[0001] This Application claims priority of China Patent Application No. CN 201310409844.7, filed on Sep. 9, 2013, and the entirety of which is incorporated by reference herein.

[0002] 1. Field of the Invention

[0003] The present invention generally relates to a display, and more particularly, to an organic light-emitting diode (OLED) display and method of manufacturing the same.

[0004] 2. Description of the Prior Art

[0005] The organic light-emitting diode (OLED) display is always considered as being among the most competitive technology in next display generation, with the advantages of self-luminous (does not need a backlight unit), fast response, and low operating voltage.

[0006] A standard OLED display is self-luminous with an organic material layer formed of organic materials. When a current is applied on the organic material layer, the organic material in the organic material layer emits light. With different organic materials, the OLED display may emit light with different colors, to fulfill the requirement of full color display.

[0007] Currently, an evaporation tool is utilized to form the organic material layer with red(R), green(G) and blue(B) colors in the manufacture of the OLED displays. The evaporation tool has a tension mask with openings to define pixel areas on the organic material layer. During the evaporation process, the organic material with one of the R, G, B colors is first deposited on a pixel area through the openings of the tension mask. The tension mask is then moved to other pixel area and forms the organic materials with other color (ex. G and B) through the same openings. Since the organic material would leave residue on the tension mask near the openings during the evaporation process, the weight of the organic materials would cause the deformation of the tension mask and change the original shape of the openings on the tension mask, so that the openings of the tension mask can't be precisely aligned in the process and results in mixed color regions on the organic material layer. That is, a pixel area is formed with stacked different colors, thereby causing the color deviation issue.

BRIEF SUMMARY OF THE DISCLOURE

[0008] In view of the above-mentioned issue, an approach of disposing a color deviation protective layer in the organic light-emitting diode (OLED) display is utilized in the present invention to prevent the mixed color regions of the organic light-emitting layer from emitting light, thereby solving the conventional color deviation issue.

[0009] An OLED display is provided in the present invention, including an anode layer and a cathode layer opposite to and spaced apart from each other, an organic light-emitting layer disposed between the anode layer and the cathode layer, wherein the organic light-emitting layer includes primary color regions and mixed color regions, and a color deviation protective layer disposed between the anode layer and the organic light-emitting layer or between the organic light-emitting layer and the cathode layer, and the color deviation protective layer is provided with insulating patterns corresponding to the mixed color regions, wherein the insulating patterns is used to prevent the corresponding mixed color regions from emitting light.

[0010] A method of manufacturing an OLED display is provided in the present invention, including the steps of disposing an anode layer and a cathode layer opposite to and spaced apart from each other, disposing an organic light-emitting layer between the cathode layer and the anode layer, wherein the organic light-emitting layer includes primary color regions and mixed color regions, and disposing an color deviation protective layer between the anode layer and the organic light-emitting layer or between the organic light-emitting layer and the cathode layer, and the color deviation protective layer is provided with insulating patterns corresponding to the mixed color regions, wherein the insulating pattern is used to prevent the mixing color regions from emitting light.

[0011] The approach of disposing a color deviation protective layer in the OLED display is utilized in the present invention to prevent the mixed color regions of the organic light-emitting layer from emitting light, thereby solving the conventional color deviation issue and significantly increase the production yield.

[0012] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIGS. **1-4** are cross-sectional views schematically showing a process flow of an OLED display in accordance with one preferred embodiment of the present invention; and

[0014] FIGS. **5-9** are cross-sectional views schematically showing a variety of types of the OLED display of the present invention.

[0015] It should be noted that all the figures are diagrammatic. Relative dimensions and proportions of parts of the drawings have been shown exaggerated or reduced in size, for the sake of clarity and convenience in the drawings. The same reference signs are generally used to refer to corresponding or similar features in modified and different embodiments.

Description of the Exemplary Embodiments

[0016] In the following detailed description of the present invention, reference is made to the accompanying drawings which form a part hereof and is shown by way of illustration and specific embodiments in which the invention may be practiced. These embodiments are described in sufficient details to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims. Besides, the terms "on" or "under" ("above" or "below") referred in the following embodiments are used to describe relative positions between components rather than limiting the scope of the present invention.

[0017] Several embodiments are provided hereinafter accompanying the figures to describe the skill of the present invention, wherein FIGS. **1-4** are cross-sectional views schematically showing a process flow of manufacturing an OLED display according to one preferred embodiment of the present invention, and FIGS. **5-9** are cross-sectional views schematically showing a variety of types of the OLED display of the present invention.

[0018] The method of manufacturing an OLED display in the present invention includes the steps of disposing an anode layer and a cathode layer opposite to and spaced apart from each other, disposing an organic light-emitting layer between the cathode layer and the anode layer, wherein the organic light-emitting layer includes primary color regions and mixed color regions, and disposing a color deviation protective layer between the anode layer and the organic light-emitting layer or between the organic light-emitting layer and the cathode layer, and the color deviation protective layer is provided with insulating patterns corresponding to the mixed color regions to prevent light generation from the mixed color regions.

[0019] In one embodiment, an upper substrate and a lower substrate are further provided before the organic light-emitting layer is disposed, and the anode layer and the cathode layer are disposed between the upper substrate and the lower substrate.

[0020] The flow of manufacturing the OLED display will be explained in detail in the following embodiments with reference to the accompanying figures.

[0021] Please note that, in this embodiment, the OLED display is top-emitting display, which means the light of the OLED display is emitted out from the upper substrate. In other embodiments, the OLED display can be bottom-emitting display, in other words, the light of OLED display is emitted out from the lower substrate.

[0022] Please refer to FIG. **1**. In the beginning, a lower substrate **100** is provided as a base for all components, for example, the lower substrate **100** may be a transparent glass plate or plastic plate or other material which may support the components, in addition, the lower substrate **100** may be a reinforced plate. An anode layer **101** is then formed above or on the upper surface of the lower substrate **100** by evaporation or sputtering process. The material of the anode layer **101** may be transparent conducting oxide (TCO), such as indium tin oxide (ITO), zinc oxide (ZnO), Al:ZnO (AZO), or opaque metals, such as Ni, Au, Mo, or Pt, etc.

[0023] After the anode layer **101** is formed, an organic light-emitting layer (EML) **102** is formed on the anode layer **101**. The organic light-emitting layer **102** includes primary color regions **1021**, for example, red primary color regions **1021***a*, green primary color regions **1021***b* and blue primary color regions **1021***c*. The material of primary color regions **1021** of the organic light-emitting layer **102** may be different depending on the colors of the primary color regions **1021**, for example, uses red dyes of DCM(4-(Dicyanomethylene)-2-methyl-6-(4-dimethylaminostyryl)-4H-pyran),DCM-2, or DCJTB(4-(Dicyanomethylene)-2-tert-butyl-6-(1,1,7,7-tetra methyljulolidin-4-yl-vinyl)-4H-pyran) for red primary color region **1021***a*, uses green dyes of Alq((8-hydroxyquinoline) aluminum), Alq3(tris-(8-hydroxyquinoline)aluminum), or DMQA(N,N'-Dimethyl-quinacridone) for green primary color regions, and uses anthracene, Alq2, BCzVBi(4,4"-bis (9-ethyl-3-carbazovinylene)-1,1"-biphenyl), Perylene, OXD (oxadiazole), DPVB(Bis(2,2-diphenylvinyl)benzene) for blue primary color regions. The organic light-emitting layer **102** may be formed by using a conventional evaporation tool and corresponding tension mask to deposit red, green and blue color emitting materials to respectively form red primary color regions **1021***a*, green primary color regions **1021***b* and blue primary color regions **1021***c*. Since the organic material would leave residue on the tension mask near the openings during the evaporation process, the weight of the organic materials would cause the deformation of the tension mask and change the original shape of the openings on the tension mask, so that the openings of the tension mask can't be precisely aligned in the process and results in mixed color regions **1022** on the organic material layer **102**.

[0024] Please refer to FIG. **2**, a mask **103** is disposed above or below (disposed above in this embodiment) the organic light-emitting layer **102** after the organic light-emitting layer **102** is formed. An evaporation process or sputtering process is then performed through the mask **103** to form color deviation protective layer **104** on the organic light-emitting layer **102**, wherein the color deviation protective layer **104** is provided with insulating patterns **104***a* corresponding to the mixed color regions **1022**. The material of the insulating pattern **104***a* may be silicon dioxide or photoresist.

[0025] If the material of the insulating pattern **104***a* is photoresist, a photoresist layer is first coated and the photolithographic process and etching process (including the steps of UV exposure and development, etc) are then performed to pattern the photoresist layer and form the insulating patterns **104***a*. Alternatively, the photoresist layer may be formed first by sputtering process on the organic light-emitting layer **102**, then the photolithographic and etching processes are performed to pattern the photoresist layer and form the insulating patterns **104***a*.

[0026] In one preferred embodiment, the insulating patterns **104***a* may be formed of silicon dioxide. In addition, the insulating patterns **104***a* may be formed by using the same photolithographic and etching processes, and thus is not repeatedly described herein.

[0027] Please refer to FIG. **3**, a cathode layer **105** is then formed on the color deviation protective layer **104**. The function of the cathode layer **105** is to generate electrons, thus metal materials with low work function are generally utilized, such as alkali, alkaline earth or lanthanide materials with low work function. Afterward, an upper substrate **106** is provided on the cathode layer **105** to protect the whole components. The upper substrate **106** may be a transparent glass plate, plastic plate or other material which may support the components. The main process of making the structure of the OLED display **10** is therefore completed.

[0028] As shown in FIG. **3**, when a current is applied, holes generated from the anode layer **101** and electrons generated from the cathode layer **105** would combine in the organic light-emitting layer **102** to generate photons and emit light from the organic light-emitting layer **102**. However, in the present invention, the holes generated from the anode layer **101** and the electrons generated from the cathode layer **105** can not combine in the mixed color regions **1022** to form photons due to the insulating patterns **104***a* disposed on corresponding mixed color regions **1022**, thereby inhibiting light emitted from the mixed color regions **1022** and preventing the color deviation issue.

[0029] It should be noted that the direction of light emitted from the OLED display may be different depending on the selected materials of the anode layer **101** and the cathode layer **105**.

[0030] In one embodiment, the anode layer **101** may be an aluminum layer with a thickness of 150 nm to 200 nm or a gold layer with a thickness of 100 nm to 150 nm, and the cathode layer **105** may be an aluminum layer with a thickness of 0.1 nm to 20 nm, a silver layer with a thickness of 0.1 nm to 20 nm, or an ITO layer or IZO layer with a thickness of 20 nm to 100 nm. In this embodiment, the anode layer **101** is light-reflective type, and the cathode layer **105** is light-transparent type. The light of the OLED display **10** is emitted upward along the direction Al and to the upper substrate **106**.

[0031] In another embodiment, the anode layer **101** may be ITO layer or IZO layer with a thickness of 50 nm to 300 nm, and the cathode layer **105** may be an aluminum layer with a thickness of 150 μm to 200 μm. In this embodiment, the anode layer **101** is light-transparent type, and the cathode layer **105** is light-reflective type. The light may be emitted downwardly from the OLED display **10** to the lower substrate **100**.

[0032] In the embodiment above, the color deviation protective layer **104** is disposed between the cathode layer **105** and the organic light-emitting layer **102**. In other embodiments, the color deviation protective layer **104** may be disposed between the anode layer **101** and the organic light-emitting layer **102**.

[0033] In the above embodiment, other layer structures may be added to the OLED display **10** to improve the emitting efficiency of the OLED display.

[0034] Please refer to FIG. **4**. In this embodiment, the anode layer **101** is formed on the lower substrate **100**. A hole injection layer **107** is formed on the anode layer **101**. The hole injection layer **107** may be formed of the material with the highest occupied molecular orbital (HOMO) energy level and the material with work function matching the anode layer **101**, such as CuPc (copper phthalocyanine), TiOPc, m-MTDATA(4,4',4"-tris(3-methylphenylphenylamino)triphenylamine), 2-TNATA (4,4'A"-tris(2-naphthylphenylamino) triphenylamine) or PEDOT-PSS (poly(3,4-ethylene dioxythiophene)-poly(styrenesulfonate)), etc. The hole injection layer **107** may be formed through the process such as evaporation, spin coating, or blade coating, etc. The function of the hole injection layer **107** is to increase the charge injection so as to increase the emitting efficiency of the OLED display **10**.

[0035] After the hole injection layer **107** is formed, a hole transport layer (HTL) **108** is formed on the hole injection layer **107** by the process such as evaporation, spin coating or blade coating, etc. The hole transport layer **108** may be formed of thin film materials with high hole mobility and high thermal stability, for example, NPB (naphtha-phenylene benzidine), TPD(N,N'-diphenyl-N,N'-di(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine), or PVK (poly(9-vinyl carbazole)), etc. The function of the hole transport layer **108** is to increase the hole transport rate, so as to increase the emitting efficiency of the OLED display **10**.

[0036] After the hole transport layer **108** is formed, the organic light-emitting layer **102** is formed on the hole transport layer **108**. The organic light-emitting layer **102** is provided with primary color regions **1021** and mixed color regions **1022**. A color deviation protective layer **104** (not shown in FIG. **4**) is then formed on the organic light-emitting layer **102**, wherein the color deviation protective layer **104** is provided with insulating patterns **104*a*** corresponding to the mixed color regions **1022**. An electron transport layer (ETL) **109** may be then formed on the color deviation protective layer **104**. The function of electron transport layer **109** is to facilitate the transportation of the injected electrons from the cathode layer **105** to the organic light-emitting layer **102**, so as to inhibit the transition of the holes to the cathode layer **105**. For this reason, the material of electron transport layer **109** must have high electron mobility with enough barrier level to block the hole, such as the materials of PBD(2-(4-biphenyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole), OXD, TAZ(3-(biphenyl4-yl)-4-phenyl-5-(4-tert-butylphenyl)-4H-1,2,4-triazole) or Alq3, formed on the color deviation protective layer **104** by evaporation, spin coating or blade coating, etc.

[0037] An electron injection layer (EIL) **110** is formed on the electron transport layer **109** to facilitate the electron injection, which may be formed of the material with lowest unoccupied molecular orbital (LUMO) energy level and the material with work function matching the cathode layer **105**, such as LiF, LiO_3, $LiBO_2$, etc. A cathode layer **105** is then formed on the electron injection layer **110**, and an upper substrate **106** is finally provided on the cathode layer **105** to protect the whole components, such as a transparent glass plate or plastic or other materials which may support the components. The main process of making the structure of the OLED display **10** is therefore completed.

[0038] In one embodiment, the main structure of the OLED display **10** is shown in FIG. **3**. The anode layer **101** of the OLED display is light-reflective type, while the cathode layer **110** is light-transparent type, thus the light emitted from the OLED display **10** would travel upward through the upper substrate **106** along the direction Al. The whole stack structure from bottom up includes the lower substrate **100**, the anode layer **101**, the organic light-emitting layer **102** with primary color regions **1021** and mixed color regions **1022**, the color deviation protective layer **104** with insulating patterns **104*a*** corresponding to the mixed color regions **1022**, the cathode layer **105** and the upper substrate **106**.

[0039] In another embodiment, the main structure of the OLED display **10** is shown like FIG. **4**. The anode layer **101** of the OLED display is light-reflective type, while the cathode layer **110** is light-transparent type, thus the light emitted from the OLED display **10** would travel upward through the upper substrate **106** along the direction Al. The whole stack structure from bottom up includes the lower substrate **100**, the anode layer **101**, the hole transport layer **108**, the organic light-emitting layer **102** with primary color regions **1021** and mixed color regions **1022**, the color deviation protective layer **104** with insulating patterns **104*a*** corresponding to the mixed color regions **1022**, the electron transport layer **109**, the electron injection layer **110**, the cathode layer **105** and the upper substrate **106**.

[0040] The structure shown in the above embodiment is merely an exemplary configuration of the present invention. In another embodiment, the color deviation protective layer **104** may be disposed in different positions depending on the light-emitting directions of the OLED display **10**, as long as it corresponds to the mixed color regions **1022**. Please refer to FIGS. **5-9**, which are cross-sectional views schematically showing a variety of types of the OLED display **10** of the present invention.

[0041] In one embodiment, the color deviation protective layer **104** may be disposed between the electron transport layer **109** and the electron injection layer **110** (FIG. **5**), between the electron injection layer **110** and the cathode layer **105** (FIG. **6**), between the hole transport layer **108** and the hole injection layer **107** (FIG. **7**), between the hole injection layer **107** and the anode layer **101** (FIG. **8**), or between the anode layer **101** and the lower substrate **100** (FIG. **9**), to achieve the function of inhibiting the combination of holes and electrons in the mixed color regions **1022** and preventing the color deviation issue.

[0042] In the present invention, the shape of the color deviation protective layer **104** is not limited to squares as shown in the figures. Rhombus, trapezoid, and funnel-shape are within the scope of the present invention, as long as the color deviation protective layer **104** can completely block the mixed color regions **1022**.

[0043] It should be noted that the light-emitting direction, whether upwardly or downwardly, of the OLED display **10** are not limited in the present invention, and the position of the color deviation protective layer **104** is not limited by the light-emitting direction of the OLED display **10**. The only requirement is the color deviation protective layer **104** being disposed between the anode layer **101** and the cathode layer **105** to inhibit the combination of holes and electrons and the light generation in the mixed color regions **1022** of the organic light-emitting layer **102**, so as to prevent the color deviation issue and significantly increase the production yield.

[0044] Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. An organic light-emitting diode display, comprising:
- an anode layer;
- a cathode layer opposite to and spaced apart from said anode layer;
- an organic light-emitting layer disposed between said anode layer and said cathode layer, wherein said organic light-emitting layer comprises primary color regions and mixed color regions; and
- an color deviation protective layer disposed between said anode layer and said organic light-emitting layer or between said organic light-emitting layer and said cathode layer, and said color deviation protective layer is provided with insulating patterns corresponding to said mixed color regions, wherein said insulating patterns are used to prevent the light generation from said corresponding mixed color regions.

2. The organic light-emitting diode display according to claim **1**, wherein said organic light-emitting diode display further comprises:
- an upper substrate and a lower substrate, wherein said cathode layer and said anode layer are disposed between said upper substrate and said lower substrate.

3. The organic light-emitting diode display according to claim **2**, wherein said anode layer is light-reflective type and said cathode is light-transparent type, and the light of said organic light-emitting diode display is emitted out from said upper substrate.

4. The organic light-emitting diode display according to claim **3**, wherein said light-reflective type anode layer is an aluminum layer with a thickness of 150 nm to 200 nm or a gold layer with a thickness of 100 nm to 150 nm, and said light-transparent type cathode layer is an aluminum layer with a thickness of 0.1 nm to 20 nm, or an indium tin oxide (ITO) layer or indium zinc oxide (IZO) layer with a thickness of 20 nm to 100 nm.

5. The organic light-emitting diode display according to claim **2**, wherein said anode layer is light-transparent type and said cathode layer is light-reflective type, and the light of said organic light-emitting diode display is emitted out from said lower substrate.

6. The organic light-emitting diode display according to claim **5**, wherein said light-transparent type anode layer is an indium tin oxide (ITO) layer or an indium zinc oxide (IZO) layer with a thickness of 50 nm to 300 nm, and said light-reflective type cathode layer is an aluminum layer with a thickness of 150 μm to 200 μm.

7. The organic light-emitting diode display according to claim **1**, wherein the material of said insulating pattern is photoresist or silicon dioxide.

8. A method of manufacturing an organic light-emitting diode display, comprising:
- disposing an anode layer;
- disposing a cathode layer, wherein said anode layer and said cathode layer are opposite to and spaced apart from each other;
- disposing an organic light-emitting layer between said cathode layer and said anode layer, wherein said organic light-emitting layer comprises primary color regions and mixed color regions; and
- disposing an color deviation protective layer between said anode layer and said organic light-emitting layer or between said organic light-emitting layer and said cathode layer, and said color deviation protective layer is provided with insulating patterns corresponding to said mixed color regions, wherein said insulating pattern is used to prevent light generation from said mixed color regions.

9. The method of manufacturing an organic light-emitting diode display according to claim **8**, further comprising providing an upper substrate and a lower substrate, wherein said cathode layer and said anode layer are disposed between said upper substrate and said lower substrate.

10. The method of manufacturing an organic light-emitting diode display according to claim **9**, wherein said anode layer is light-reflective type and said cathode layer is light-transparent type, and the light of said organic light-emitting diode display is emitted out from said upper substrate.

11. The method of manufacturing an organic light-emitting diode display according to claim **9**, wherein said anode layer is light-transparent type and said cathode is light-reflective type, and the light of said organic light-emitting diode display is emitted out from said lower substrate.

12. The method of manufacturing an organic light-emitting diode display according to claim **8**, wherein the material of said insulating pattern is photoresist or silicon dioxide.

13. The method of manufacturing an organic light-emitting diode display according to claim **8**, wherein the step of forming said insulating patterns comprises:
- coating a photoresist layer; and
- patterning said photoresist layer by a photolithographic process and an etching process to form said insulating patterns.

14. The method of manufacturing an organic light-emitting diode display according to claim **8**, wherein the step of forming said insulating patterns comprises:
- evaporating or sputtering silicon dioxide to form said insulating patterns.

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专利名称(译)	有机发光二极管显示器及其制造方法		
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摘要(译)

在本发明中提供了一种有机发光二极管显示器及其制造方法。有机发光二极管显示器包括相对且彼此间隔开的阳极层和阴极层，设置在阳极层和阴极层之间的有机发光层，其中有机发光层包括原色区域和混色区域，以及设置在阳极层和有机发光层之间或有机发光层和阴极层之间的颜色偏差保护层，并且颜色偏差保护层设置有对应于的颜色偏差保护层。混合颜色区域以防止混合颜色区域产生光。该制造方法的特征在于设置颜色偏差保护层以防止从有机发光层的混合颜色区域产生光并解决传统颜色偏差问题的步骤。