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(54) **DISPLAY APPARATUS**

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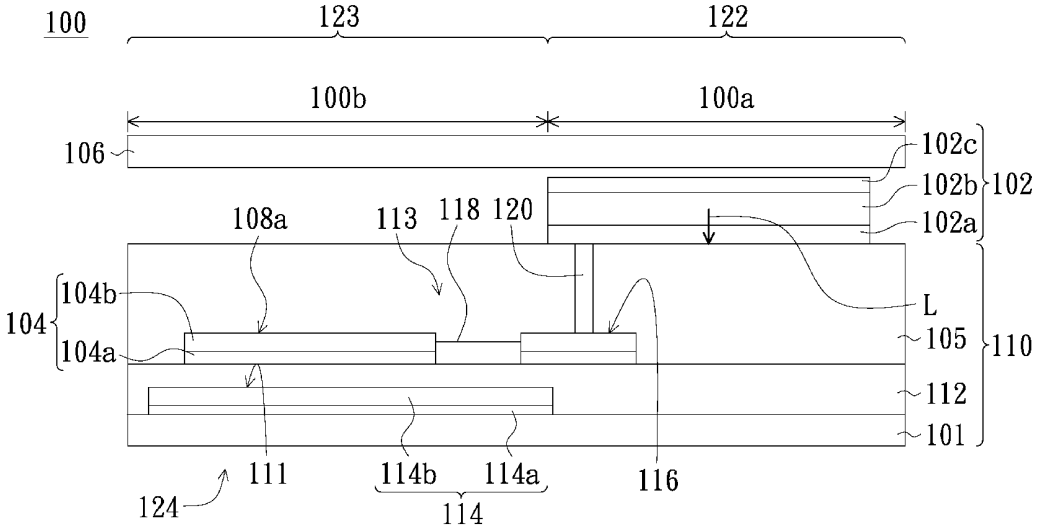
(57) **ABSTRACT**

A display apparatus includes a driving substrate and an organic light emitting diode device. The driving substrate includes a display area, a non-display area, a substrate and a transparent driving element. The transparent driving element is disposed in the non-display area to form a transparent region. The organic light emitting diode device is disposed over the driving substrate and located in the display area to form a non-transparent region.



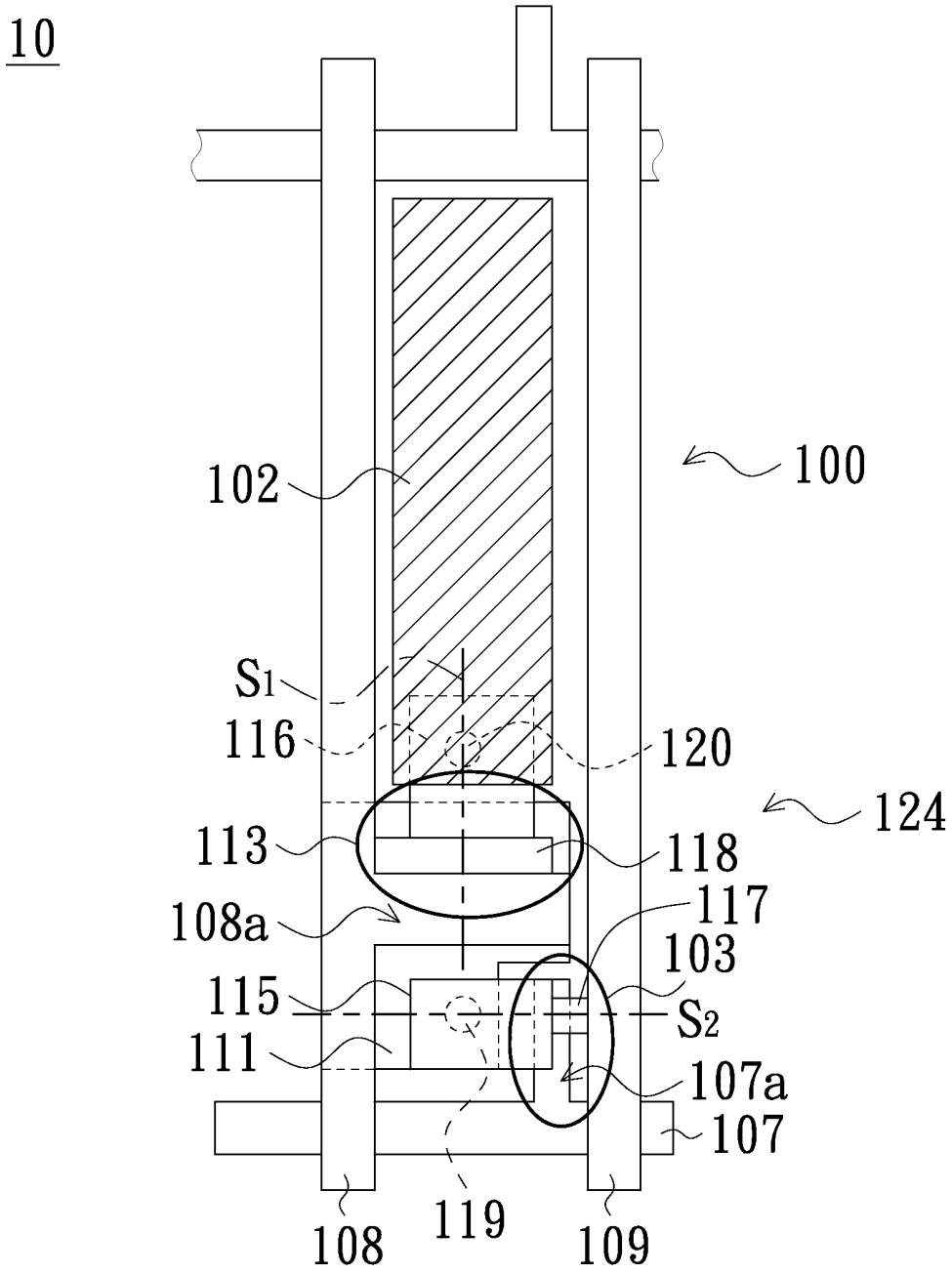

10
102
100
S1
116
120
124
113
118
108a
117
103
115
S2
111
107a
107
108
119
109

FIG. 1A

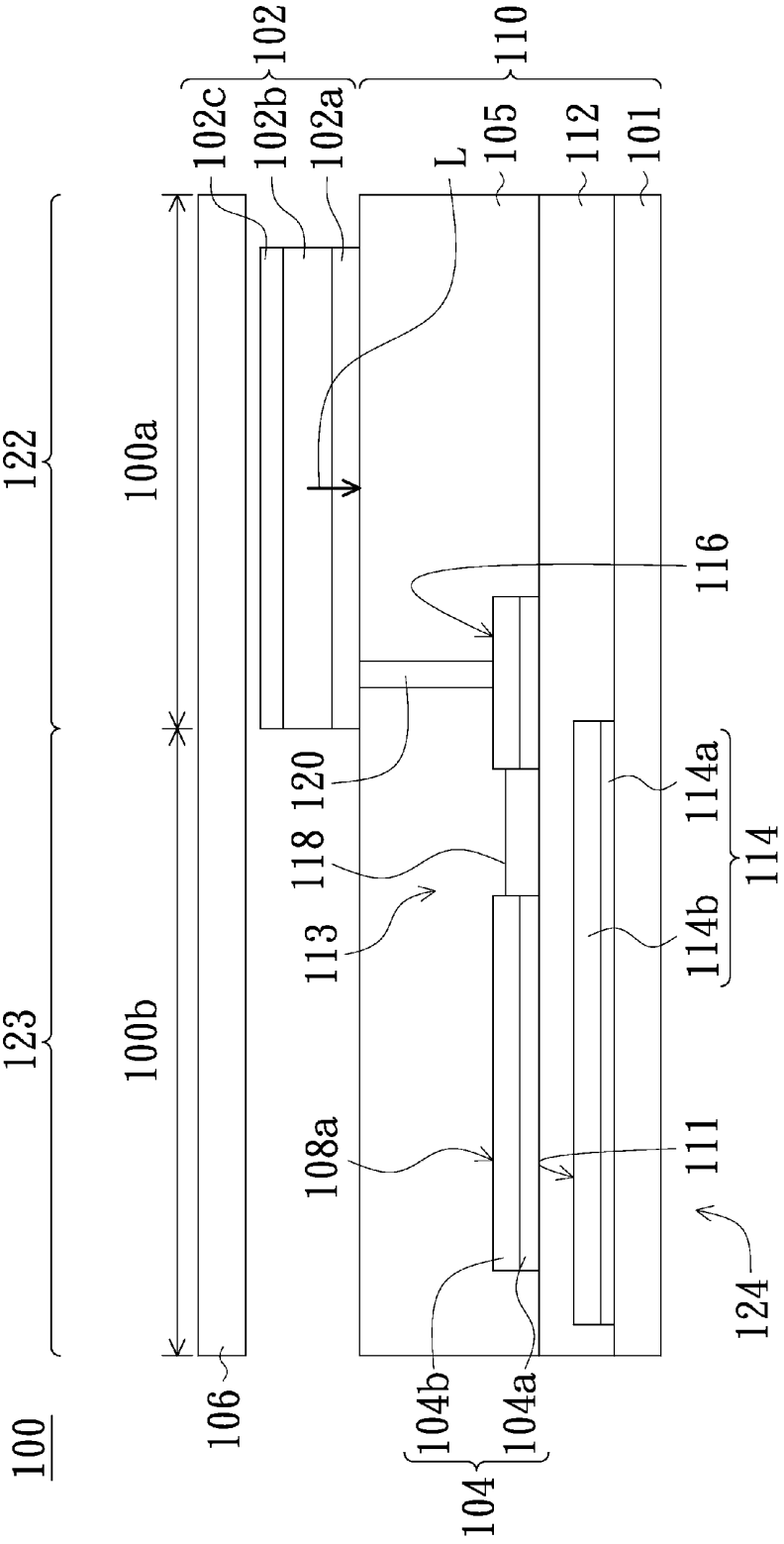
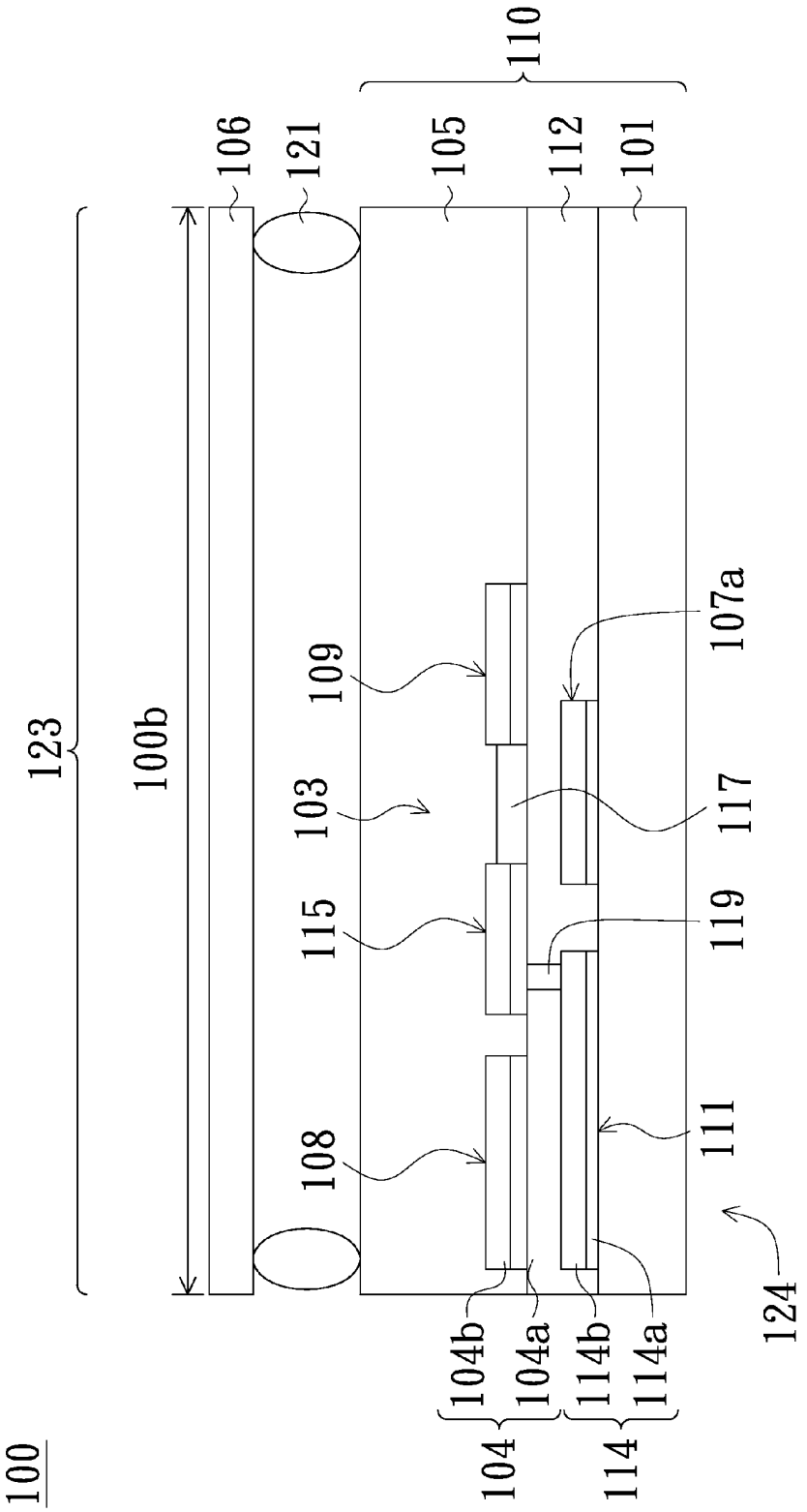

100
122
123
100a
100b
102
102c
102b
102a
110
L
105
112
101
116
120
118
113
114a
114
114b
108a
111
124
106
104b
104a
104

FIG. 1B


100
123
100b
106
121
110
105
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103
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108
107a
117
119
111
124
104b
104a
114b
114a
104
114

FIG. 1C

# DISPLAY APPARATUS

## FIELD OF THE INVENTION

**[0001]** The present invention relates to an electroluminescent display unit and its applications, and more particularly to a transparent electroluminescent display unit of a transparent display apparatus and its applications.

## BACKGROUND OF THE INVENTION

**[0002]** Since a transparent display apparatus itself contains a certain degree of light transmission, in addition to the original display function, the background behind the screen thus can be revealed. Such that, a transparent display apparatus can be applied to large-scale commercial demonstration and decoration of glass curtain walls, vehicle windows and shop windows. In terms of some design and performance aspects, the transparent display apparatus can show functions that many existing display technologies are difficult to achieve, hence it can be expected that the transparent display apparatus will replace parts of the existing display apparatuses in the future, and can be extensively applied to consumer electronic products, such as smart phones, notebook computers and portable electronic components.

**[0003]** An organic light emitting diode having advantages of simple processes, light, thin, flexible, colorful and a transparent self-luminous layer, has gradually become the main light source for producing the transparent display apparatus. In order to balance the injection carriers, transparent material of indium tin oxide (InSnO) with high work function is adopted by traditional organic light emitting diodes serving as the bottom anode electrodes. In addition, transparent or translucent material, mainly composed of InSnO, may be used to replacing the traditional metal layer to form a cathode electrode for purpose of enhancing its optical transmission property.

**[0004]** However, the cathode electrode mainly composed of transparent InSnO is difficult to be combined with the organic light emitting layer, such that the mass production technologies are still unable to be established. Moreover, traditional transparent display apparatus can simultaneously show images on both front side and back side. But this may bother the users who attach importance to privacy and don't want to show the contents displayed from the back side of the display apparatus.

**[0005]** Therefore, it is necessary to provide a transparent display apparatus with simple process, performing the functions of displaying images and revealing the background, as well as simultaneously taking the privacy of users into account.

## SUMMARY OF THE INVENTION

**[0006]** One aspect of the present invention is to provide a display apparatus, wherein the display apparatus includes a driving substrate and an organic light emitting diode device. The driving substrate includes a display area, a non-display area, a substrate and a transparent driving element. The transparent driving element is disposed in the non-display area to form a transparent region. The organic light emitting diode device is disposed over the driving substrate and located in the display area to form a non-transparent region.

**[0007]** According to the aforementioned embodiments, a display apparatus including a driving substrate and an organic light emitting diode device is provided, wherein a transparent driving element is formed in a non-display area of the driving substrate by adopting chromium molybdenum (MoCr) thin layer and an InSnO layer to form conductive wires and electrodes of transparent thin film transistors (TFTs) involved in the transparent driving element, as well as by applying transparent oxide semiconductor material to form channel layers of the TFTs. Simultaneously, an organic light emitting diodes having an opaque cathode metal layer is adopted serving as a single-side light source and disposed in a display area of the driving substrate. As a result, the display apparatus can be essentially divided into a transparent area and a non-transparent area.

**[0008]** Because of the transparent area (which composed of the transparent driving element and the channel layers) allowing light passing there through, the background behind the screen thus can be revealed from the transparent area. Besides, since the image may be masked by the opaque cathode metal layer, thus the displayed images may not be observed from the back side of the display apparatus. Therefore, the privacy of users can be taken into account while the display apparatus performs the functions of image displaying and revealing the background behind the screen. Moreover, because the cathode metal layer which is competent to be easily combined with the organic light emitting layer of the organic light emitting diode is adopted, hence the display apparatus with the same elements is suitable for mass production.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** FIG. **1**A is a schematic top-view for illustrating a portion of a transparent display apparatus in accordance with an embodiment of the present invention;

**[0010]** FIG. **1**B is a cross-sectional view depicted along a section line S**1** to illustrate a portion of the electroluminescent display unit as shown in FIG. **1**A; and

**[0011]** FIG. **1**C is a cross-sectional view depicted along a section line S**2** to illustrate a portion of the electroluminescent display unit as shown in FIG. **1**A.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

**[0012]** The present invention will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of preferred embodiments of this invention are presented herein for purpose of illustration and description only. It is not intended to be exhaustive or to be limited to the precise form disclosed.

**[0013]** The present invention is to provide a transparent display apparatus including the functions of displaying image, revealing the background behind the screen and taking the privacy of users into account. In order to make the objects aforementioned and other purposes, features and advantages of the present invention to be more easily understood, the transparent electroluminescence display apparatus **10** is described as a preferred embodiment.

**[0014]** FIG. **1**A is a schematic top-view for illustrating a portion of a transparent display apparatus **10** in accordance with an embodiment of the present invention. Typically, the transparent display apparatus **10** is constituted by a plurality of transparent electroluminescent display unit **100**. However, for the convenience of description, only one single electroluminescence display unit **100** is depicted in FIG. **1**A. FIG. **1**B is a cross-sectional view depicted along a section line Si to

illustrate a portion of the electroluminescent display unit **100** as shown in FIG. **1**A; and FIG. **1**C is a cross-sectional view depicted along a section line S**2** to illustrate a portion of the electroluminescent display unit **100** as shown in FIG. **1**A.

**[0015]** Each transparent electroluminescent display unit **100** includes a driving substrate **110** and an organic light emitting diode device **102**. The driving substrate **110** can be divided into a display area **122** and a non-display area **123**; and the driving substrate **110** includes a substrate **101** and at least one transparent driving element **124** disposed in the non-display area **123**, wherein the transparent driving element **124** includes a plurality transparent TFTs, such as transparent TFTs **103** and **113**, and a plurality transparent circuit layers, such as transparent circuit layers **104** and **114**.

**[0016]** The transparent TFTs **103** and **113** and the transparent circuit layers **104** and **114** are disposed over the substrate **101** and covered with a passivation layer **105**. The organic light emitting diode device **102** is disposed over the passivation layer **105**. The passivation layer **105** and the organic light emitting diode device **102** are all covered with a protection layer **106**. In order to keep the passivation layer **105** separated from the protection layer **106** for a constant distance, some spacers **121**, for example, may be inserted between the passivation layer **105** and the protection layer **106**.

**[0017]** The substrate **101** may be a semiconductor substrate (e.g. silicon substrate), or a flexible plasticized substrate. The passivation layer **105** and the protection **106** both are constituted by transparent materials. In other embodiment of the present invention, the material of the passivation layer **105** and the protection **106** may be a semiconductor material, such as silicon dioxide, silicon nitride and silicon oxynitride, plastic material, or other suitable transparent dielectric materials.

**[0018]** In one embodiment of the present invention, the electroluminescent display unit **100** includes at least two transparent circuit layers **104** and **114** which are sequentially stacked over the substrate **101** but not coplanar with etch other, wherein the two transparent circuit layers **104** and **114** are isolated from each other by an inner dielectric layer**112** disposed there between. Besides, the two transparent circuit layers **104** and **114** are respectively electrical connected to the transparent thin film TFTs **103** and **113**. The transparent circuit layer **104** preferably is a patterned conductive layer stacked by at least one chromium molybdenum (MoCr) thin layer **104***a* and at least one indium tin oxide (InSnO) layer **104***b*. The transparent circuit layer **114** is also a patterned conductive layer stacked by at least one MoCr thin layer **114***a* and at least one ITO layer **114***b*. The inner dielectric layer **112** is also constituted by transparent dielectric material, such as silicon dioxide, silicon nitride, silicon oxynitride, or other transparent dielectric material.

**[0019]** The transparent circuit layer **114** can be divided into a transparent scan line **107** and a transparent capacitance line (Cs line) **111**; the transparent circuit layer **104** can be divided into a transparent date line **109**, a transparent power supply line **108**, and transparent electrodes **115** and **116**. In the present embodiment, an extension part **107***a* of the transparent scan line **107**, a portion of the transparent date line **109** and a portion of the transparent electrode **115** are overlapped, so as to constitute a transistor **103**; and likewise, an extension part **108***a* of the transparent power supply line **108**, a portion of the Cs line **111** and a portion of the transparent electrode **116** are overlapped so as to constitute a transistor **113** (see FIG. **1**A). In addition, a capacitor (not shown) used to assist the operation of the transistor **113** may be constituted by the overlap of the Cs line **111** and another part of the transparent power supply line **108**.

**[0020]** The transparent TFT **103** includes a transparent gate electrode constituted by the extension part **107***a* of the transparent scan line **107**, a transparent source electrode constituted by a portion of the transparent date line **109**, a transparent drain electrode constituted by a portion of the transparent electrode **115**, a gate insulator layer constituted by a portion of the inner dielectric layer **112**, and a semiconductor channel layer **117** (see FIG. **1**C). The transparent TFT **113** includes a transparent gate electrode constituted by a portion of the transparent capacitance line **111**, a transparent source electrode constituted by the extension part **108***a* of the power supply line **108**, a transparent drain electrode constituted by a portion of the transparent electrode **116**, a gate insulator layer constituted by a portion of the inner dielectric layer **112**, and a semiconductor channel layer **118** (see FIG. **1**B).

**[0021]** Furthermore, the aforementioned drain electrode (the transparent electrode **115**) of the transparent TFT **103** is electrically connected to the transparent Cs line **111** by the interconnection line **119** penetrating through the inner dielectric layer **112**; and the drain electrode (the transparent electrode **116**) of the transparent TFT **113** is electrically connected to the organic light emitting diode device **102** by the interconnection line **120** penetrating through the passivation layer **105**. The luminescence of the organic light emitting diode device **102** can be controlled by turning on or off the transparent TFT **103** and **113**.

**[0022]** It is worth noting that both of the semiconductor channel layers **117** and **118** are made of transparent oxide semiconductor material including indium, gallium, zinc, or any combinations thereof. In some embodiments of the present invention, the oxide semiconductor material is selected from a group consisting of indium oxide (InO), gallium oxide (GaO), zinc oxide (ZnO), indium gallium zinc oxide (InGaZnO), gallium zinc oxide (GaZnO), indium gallium oxide (InGaO) and indium zinc oxide (InZnO). In the present embodiment, the preferred material used to constitute the semiconductor channel layers **117** and **118** is amorphous InGaZnO (a-IGZO).

**[0023]** The organic light emitting diode device **102** which is disposed in the display area **122** of the driving substrate **110** includes an anode layer constituted by a transparent electrode **102***a*, an organic electroluminescent layer **102***b* and a cathode layer constituted by an opaque metal layer **102***c*. The transparent electrode **102***a* (the anode layer) is formed over the passivation layer **105** and electrically connected to the drain electrode (the transparent electrode **116**) of transparent TFT **113** by the interconnection line **120**. The organic electroluminescent layer **102***b* is formed over the transparent electrode **102***a* by vapor deposition or roller printing (roll to roll). The opaque metal layer **102***c* is formed over the organic electroluminescent layer **102***b*.

**[0024]** In one embodiment of the present invention, the transparent electrode **102***a* is preferably, but not limited, made of ITO; the preferred material of the opaque metal layer **102***c* is preferably, but not limited, made of aluminum. Light initiated from the organic electroluminescent layer **102***b* can directly emit out by way of passing through the transparent electrode **102***a*, the passivation layer **105** and the substrate **101**; or otherwise emit out indirectly by way of being reflected by the opaque metal layer **102***c* firstly and then

passing through the transparent electrode **102***a*, the passivation layer **105** and the substrate **101** (shown as arrow L).

**[0025]** On one hand, because the organic light emitting diode device **102** includes an opaque metal layer **102***c* serving as a mask to prevent light passing trough the display area **122** of the driving substrate **110**, such that a non-transparent area **100***a* can be defined in the display area **122**. On the other hand, since the other elements (including the transparent driving element **124** including the transparent TFT **103** and the transparent circuit layer **104**) located in the non-display area **123** are constituted of the transparent material, thus light is allowed passing through the driving substrate **110**, and a transparent area **100***b* is relatively defined in the non-display area **123**. As a result, the transparent electroluminescent display unit **100** can be substantially divided into a transparent area **100***b* and a non-transparent area **100***a* (shown in FIG. 1B).

**[0026]** In other words, although the transparent electroluminescent display unit **100** adopts the opaque metal cathode, it still retains a certain degree of light transmission. Thus, the transparent electroluminescent display unit **100** has both functions of displaying photo images and displaying the background behind the screen. Furthermore, the privacy of users can be taken account by using the opaque metal layer **102***c* serving as a mask to prevent the images from being observed from the back side of the display apparatus **10**, as well as to prevent the image contents from being double-sided spied.

**[0027]** It is noteworthy that, nevertheless the MoCr thin layer, the InSnO layer and the oxide semiconductor material has light transmittance greater than 90% which can make the transparent area **100***b* have good optical transmission property, in a preferred embodiment of the present invention, the transparent TFT **103** and the transparent circuit layer **104** are generally disposed in the transparent area **100***b*, and not overlapping the organic light emitting diode device **102**, in order to enhance the luminous efficiency of the organic light emitting diode device **102**.

**[0028]** In sum, the embodiments of the present invention are to provide a display apparatus including a driving substrate and an organic light emitting diode device. On one hand, an organic light emitting diode device having an opaque cathode metal layer is disposed in the display area of the driving substrate serving as a single-side light source. On the other hand, MoCr thin layers and InS nO layers are used to form transparent wires and the electrodes of TFTs involved in the display apparatus; and transparent oxide semiconductor material is used to form the channel of the TFTs and the transparent driving element disposed in the non-display area of the driving substrate. Since the MoCr thin layers, the InS nO layers and the oxide semiconductor material have light transmittance greater than 90%, thus the portion of the display apparatus not being covered by the opaque organic light emitting diode device may have good optical transmission property. As a result, the display apparatus can be substantially divided into a transparent area and a non-transparent area.

**[0029]** Because the displayed images are masked by the opaque cathode metal layer, thus the image contents can not be observed from the back side of the display apparatus. Therefore, the privacy of users can be taken into account simultaneously while the display apparatus performs the functions of displaying images and revealing the background behind the screen. Moreover, it is no longer necessary adopting InSnO to form the cathode metal layer. Instead, a cathode metal layer competent to be easily combined with the organic light emitting layer of the organic light emitting diode is adopted. Such that, the process for forming the display apparatus can be simplified and thus is more suitable for mass production.

**[0030]** While the invention has been described in terms of what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention needs not be limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims which are to be accorded with the broadest interpretation so as to encompass all such modifications and similar structures.

What is claimed is:

**1**. A display apparatus, including:

a driving substrate, including:

a substrate;

a display area;

a non-display area; and

a transparent driving element, disposed in the non-display area to form a transparent region; and

an organic light emitting diode device, disposed over the driving substrate and located in the display area to form a non-transparent region.

**2**. The display apparatus according to claim **1**, wherein the organic light emitting diode device includes:

a transparent electrode disposed over the substrate;

an organic electroluminescent layer disposed over the transparent electrode; and

an opaque metal layer disposed over the organic electroluminescent layer.

**3**. The display apparatus according to claim **1**, wherein the transparent driving element includes:

a first transparent thin film transistor disposed over the substrate and electrically connected to the organic light emitting diode device;

a plurality of transparent circuit layers disposed over the substrate and electrically connected to the first transparent thin film transistor; and

a second transparent TFT disposed over the substrate and electrically connected to the first transparent thin film transistor and the transparent circuit layers.

**4**. The display apparatus according to claim **3**, wherein the transparent circuit layers constitute a transparent circuit element having a transparent capacitor.

**5**. The display apparatus according to claim **4**, wherein the transparent circuit element further includes a transparent thin film transistor, a transparent capacitor, a transparent power supply line, a transparent data line, a transparent scan line, a capacitance line or arbitrary combinations of thereof.

**6**. The display apparatus according to claim **3**, wherein the driving substrate further includes:

a passivation layer, covering the transparent driving element and disposed between the organic light emitting diode device and the transparent driving element; and

a conductive wire, penetrating the passivation layer to electrically connect to the organic light emitting diode device and the first transparent thin film transistor

**7**. The display apparatus according to claim **3**, wherein each transparent circuit layer includes a chromium molybdenum (MoCr) thin layer and an indium tin oxide (InSnO) layer.

**8**. The display apparatus according to claim **3**, wherein each of the first transparent thin film transistor and the second transparent thin film transistor includes:

a transparent gate electrode disposed over the substrate;

a transparent gate insulating layer disposed over the transparent gate electrode;

a transparent source electrode disposed over the transparent gate insulating layer;

a transparent drain electrode disposed over the transparent gate insulating layer and separated from the transparent source electrode; and

a transparent channel layer disposed over the transparent insulating layer and in contact with the transparent source electrode and the transparent drain electrode.

**9**. The display apparatus according to claim **8**, wherein each of the transparent gate electrode, the transparent source electrode and the transparent drain electrode includes a chromium molybdenum thin layer and an indium tin oxide layer; and the transparent channel layer is composed of an oxide semiconductor material including indium, gallium, zinc, or arbitrary combinations of thereof.

**10**. The display apparatus according to claim **9**, wherein the oxide semiconductor material is selected from a group consisting of indium oxide (InO), gallium oxide (GaO), zinc oxide (ZnO), indium gallium zinc oxide (InGaZnO), gallium zinc oxide (GaZnO), indium gallium oxide (InGaO) and indium zinc oxide (InZnO).

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摘要(译)

一种显示装置，包括驱动基板和有机发光二极管装置。驱动基板包括显示区域，非显示区域，基板和透明驱动元件。透明驱动元件设置在非显示区域中以形成透明区域。有机发光二极管器件设置在驱动基板上方并位于显示区域中以形成非透明区域。