ENCAPSULATION STRUCTURE OF DISPLAY UNIT AND METHOD OF FORMING THE SAME

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ABSTRACT
An encapsulation structure of the display unit and a method of forming the same, mainly use the thin film encapsulation structure to hermetically protect the display unit (such as OLED display unit), that is sealing the display unit by inorganic thin film layer having the characteristics of transparency as well as containing moisture-resistance and oxygen-resistance; buffering the internal and external stresses of the thin film layers and restraining the falling off of the layers caused by the bending stress when forming flexible devices. Meanwhile, the bank features formed by multilayer stack can effectively inhibit the diffusion effect of inorganic coating and the increase of the number of side water retaining walls of thin film device can improve the effect of encapsulation, and the bank structures act as a support of the metal mask during the coating process to prevent the substrate from the damage caused by the metal mask.
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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to and the benefit of U.S. Provisional Application No. 62/154,866, filed on Apr. 30, 2015, the entire content of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to the field of display devices, and more specifically, to an encapsulation structure of a display unit and the method of forming the same.

[0004] 2. Description of the Related Art

[0005] Among display devices of an electronic device, electronic devices, such as a light emitting diode (LED) or an organic light emitting diode (OLED), which is used for generating light source, are the key devices for the normal operation of a display device. However, the electronic devices mentioned above are extremely vulnerable to the erosion of moisture and oxygen in the external environment. Therefore, the electronic devices should be protected in isolation in order to ensure the normal operation of electronic devices.

[0006] At present, mainly use glass glue to fix the cover plate onto the array substrate so as to seal display electronic devices disposed on the array substrate; as shown in FIG. 1. In a traditional encapsulation structure of a display unit, the array substrate 11 is provided with the display unit 12 which is sealed by means of using glass glue 13 to fix the cover plate 14 onto the array substrate 11.

[0007] However, the mechanical strength of the encapsulating structure as shown in FIG. 1 is weak because of the characteristics of the glass glue 13 itself and the gap between the cover glass 14 and the array substrate 11. Therefore, the encapsulating structure is extremely likely to be damaged when an external force is encountered. Especially, in the service lifetime test, the encapsulating structure is extremely likely to generate the gap which cause the penetration of the destructive gas in the external environment into the sealing structure, leading to the erosion of the display unit 12 mentioned above and even the damage to the display unit 12 when encountering an external force. Therefore, the display device can not work properly.

SUMMARY OF THE INVENTION

[0008] To solve the above technical problems, the application provides a display unit encapsulating structure, comprising:

[0009] an array substrate, the surface of which is provided with a display unit;

[0010] bank structures, disposed on a surface of the array substrate and placed in periphery of the display unit;

[0011] a first film layer, disposed on the array substrate and fully covering the display unit and parts of surfaces of;

[0012] a second film layer, fully covering the first film layer and contacting a first portion of the bank structures;

[0013] a third film layer, covering the second film layer and contacting a second portion of the bank structures, wherein the second portion is independent to the first portion of the bank structures;

[0014] a fourth film layer, disposed on a portion of the third film layer; and

[0015] a fifth film layer, disposed on the array substrate to fully cover the bank structures, the third film layer and the forth film layer to form the encapsulation structure;

[0016] wherein, the fifth film layer also covers parts of exposed surfaces of the bank structures and parts of surfaces of the array substrate.

[0017] In the above display unit encapsulating structure, wherein, the array substrate further comprises a thin film transistor display circuit used to drive the display unit.

[0018] In the above encapsulation structure of the display unit, wherein, the array substrate is a low temperature polysilicon substrate.

[0019] In the above encapsulation structure of the display unit, wherein,

[0020] the display unit has a light emitting surface for light emission and a backlight surface opposite to the light emitting surface; and

[0021] the backlight surface of the display unit is adhered onto the surface of the array substrate; the first film layer covers the light emitting surface of the display unit.

[0022] In the above encapsulation structure of the display unit, wherein, the display unit is an OLED display unit.

[0023] In the above encapsulation structure of the display unit, wherein, the bank structures are stack structures with multilayer films.

[0024] In the above encapsulation structure of the display unit, wherein, the bank structures are made of heterocyclic polymers containing imino group and benzene ring.

[0025] In the above encapsulation structure of the display unit, wherein, a thickness of the bank structures is larger than sum of thicknesses of the first film layer and second film layer.

[0026] In the above display unit encapsulating structure, wherein, the first film layer, the third film layer and the fifth film layer are all made of inorganic materials; and

[0027] the second film layer and the fourth film layer are both made of organic materials.

[0028] In the above encapsulation structure of the display unit, wherein, the first film layer is made of metal oxide or silicon nitride, both of which are transparent, moisture-resistant, and oxygen-resistant.

[0029] In the above display unit encapsulating structure, wherein, the second film layer and the fourth film layer are made of acrylic resin compound having characteristics of buffering and transparency.

[0030] In the above display unit encapsulating structure, wherein, the third film layer and the fifth film layer are made of silicon nitride.

[0031] A method of forming an encapsulation structure of a display module, comprising:

[0032] providing an array substrate with a display unit thereon;

[0033] forming bank structures on the array substrate at periphery of the display unit;

[0034] forming a first film layer on the array substrate to cover the display unit and surface of the array substrate which is located between the display unit and the bank structures for sealing the display unit;
0035] forming a second film layer on the first film layer and contacting a first portion of the bank structures;  
0036] forming a third film layer on the second film layer and contacting a second portion of the bank structures, wherein the second portion is independent to the first portion of the bank structures;  
0037] forming a fourth film layer on the third film layer, to cover parts of the third film layer; and  
0038] forming a fifth film layer on the array substrate to fully cover the bank structures, the third film layer and the forth film layer to form the encapsulation structure.  
0039] In the above method of forming an encapsulation structure of a display module, further comprising:  
0040] forming a thin film transistor display circuit in the array substrate used to drive the display unit.  
0041] In the above method of forming an encapsulation structure of a display module, wherein, the array substrate is a low temperature polycrystalline substrate.  
0042] In the above method of forming an encapsulation structure of a display module, wherein,  
0043] the display unit has a light emitting surface for light emission and a backlight surface opposite to the light emitting surface; and  
0044] the backlight surface of the display unit is adhered onto the surface of the array substrate; the first film layer is formed onto the light emitting surface of the display unit.  
0045] In the above method of forming an encapsulation structure of a display module, wherein, the display unit is an OLED display unit.  
0046] In the above method of forming an encapsulation structure of a display module, wherein, the bank structures forming step is performed by stacking multilayer thin films.  
0047] In the above method of forming an encapsulation structure of a display module, wherein, the bank structures are made of heterocyclic polymers containing imino group and benzene ring.  
0048] In the above method of forming an encapsulation structure of a display module, wherein, a thickness of the bank structures is larger than sum of thicknesses of the first film layer and second film layer.  
0049] In the above method of forming an encapsulation structure of a display module, wherein,  
0050] forming the first film layer, the third film layer and the fifth film layer by inorganic materials; and  
0051] forming the second film layer and the fourth film layer by organic materials.  
0052] In the above method of forming an encapsulation structure of a display module, wherein, the first film layer forming step is performed by atomic layer deposition with metal oxide or silicon nitride, both of which are transparent, moisture-resistant, and oxygen-resistant.  
0053] In the above method of forming an encapsulation structure of a display module, wherein, the second film layer forming step is performed by ink jet printing with acrylic resin compound which comprises flat surfaces and characteristics of buffering and transparency.  
0054] In the above method for preparing encapsulation structure of the display unit, wherein the third film layer forming step is performed by atomic layer deposition, chemical vapor deposition, or plasma enhanced chemical vapor deposition with silicon nitride.

0055] In the above technical schemes have the following advantages or beneficial effects:  
0056] In the encapsulation structure of the display unit and method of forming the same, applied in forming AMOLED and other related display devices, mainly use a thin film encapsulation structure to hermetically protect the display unit, such as OLED display unit, that is sealing the display unit by inorganic thin film layer which is transparent, moisture-resistant, and oxygen-resistant, buffering the internal and external stresses to the thin film layer by forming organic films outside the inorganic thin film layer and restraining the layer from falling off caused by the bending stress in the formation of flexible devices. Further, the bank structures stacked by multilayer films can effectively restrain the diffusion effect of coating on inorganic films and can increase the number of side retainting walls for resisting moisture in thin film device, and thus effectively improves the encapsulating in effect. The bank structures formed by multilayer stack can also be used to support metal masks to prevent the substrate surface pattern from being damaged during the coating process. Moreover, compared with the Frit packaging, the thin film packaging can effectively improve the mechanical strength of the whole display device.

BRIEF DESCRIPTIONS OF THE DRAWINGS

0057] The accompanying drawings, together with the specification, illustrate exemplary embodiments of the present disclosure, and, together with the description, serve to explain the principles of the present invention.  
0058] FIG. 1 shows a normal encapsulation structure of a display unit;  
0059] FIGS. 2 to 7 show flow charts of the processes of forming the encapsulation structure of the display unit in an embodiment of the present application.

DETAILED DESCRIPTION

0060] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like reference numerals refer to like elements throughout.

0061] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” or “includes” and/or “including” or “has” and/or “having” when used herein, specify the presence of stated features, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components, and/or groups thereof.

0062] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the
art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0063] As used herein, “around”, “about” or “approximately” shall generally mean within 20 percent, preferably within 10 percent, and more preferably within 5 percent of a given value or range. Numerical quantities given herein are approximate, meaning that the term “around”, “about” or “approximately” can be inferred if not expressly stated.

[0064] As used herein, the term “plurality” means a number greater than one.

[0065] Hereinafter, certain exemplary embodiments according to the present disclosure will be described with reference to the accompanying drawings.

[0066] The encapsulation structure of the display unit and method of forming the same, applied in forming AMOLED and other related display devices, mainly use a thin film encapsulation structure to hermetically protect the display unit, such as OLED display unit, that is sealing the display unit by inorganic thin film layer which is transparent, moisture-resistant, and oxygen-resistant, buffering the internal and external stresses to the thin film layer by forming organic films outside the inorganic thin film layer and restraining the layer from falling off caused by the bending stress in the formation of flexible devices. Further, the bank structures stacked by multilayer films can effectively restrain the diffusion effect of coating on inorganic films and can increase the number of side retaining walls for resisting moisture in thin film device, and thus effectively improves the encapsulating in effect. The bank structures formed by multilayer stack can also be used to support metal masks to prevent the substrate surface pattern from being damaged during the coating process. Moreover, compared with the Frit packaging, the thin film packaging can effectively improve the mechanical strength of the whole display device.

[0067] A detailed description to the present invention will be provided as follows with Figures and Embeddings.

Embodiment 1

[0068] FIGS. 2 to 7 show flow charts of the processes of forming the encapsulation structure of the display unit in an embodiment of the present application. As shown in FIGS. 2 to 5, the application provides a method of forming an encapsulation structure of a display module, comprising the following steps:

[0069] Firstly, as shown in FIG. 1, perform an array process for the display devices on the basis of a substrate (such as Low Temperature Poly Silicon-LTPS substrate) to form the array substrate 21; the above array substrate 21 can be provided with a display area and a non-display area adjacent to the display area. The array substrate 21 of the display area is mainly used for the adhesion and the formation of the display devices; moreover, a thin film transistor display circuit could be laid out on or in the array substrate 21 to drive the display unit that would be formed subsequently.

[0070] Additionally, during the array process, the bank structures 23 (which could be arranged at the periphery of the display area) are formed on the surface of the array substrate 21 in the non-display area which is adjacent to the display area, said bank structures 23 could be multilayer thin film stack structures; for example, the bank structures 23 can be raised patterns formed by exposure, development and etching during the foregoing array process, and then with a certain height; said bank structures 23 could be column, strip column or other shapes.

[0071] Preferably, the material of the above bank structures 23 could be the materials, of which the major components are carbon (C), nitrogen (N) and oxygen (O), such as heterocyclic polymers containing amino group and benzene ring; preferably, the material of said bank structures 23 is Polyetherimide.

[0072] Secondly, the display unit 22 (such as OLED display unit or other light emitting module) is attached in the display area of the above array substrate 21, connecting the foregoing thin film transistor display circuit, in the periphery of which the bank structures 23 are placed, and could be used to display the first and second film layers that would be formed subsequently so as to form the structure as shown in FIG. 2; there's a certain gap between the display 22 and the bank structures 23 (not contact with each other), that is to say, the surface of the array substrate 21 between the display unit 22 and the bank structures 23 is exposed.

[0073] Preferably, the above display unit 22 comprises a cathode, an anode and an organic light emitting layer arranged between the cathode and the anode, and simultaneously has a light emitting surface (the upper surface as shown in FIG. 3) for light emission and a backlight surface (the lower surface as shown in FIG. 3) opposite to the light emitting surface; said display unit 22 is adhered to the array substrate 21 at its backlight surface.

[0074] Subsequently, employ the thin film encapsulating process to form the first film layer 24, the second film layer 25, the third film layer 26, the fourth film layer 27 and the fifth film layer 28; specifically:

[0075] Employ the atomic layer deposition (Atomic Layer Deposition, ALD) process to deposit inorganic materials such as AlOx, SiNx, TiOx, so as to form an inorganic thin film layer which is transparent, moisture-resistant, and oxygen-resistant, therefore, form the above described first film layer 24. The first film layer 24 fully covers the display unit 22 and is disposed on the array substrate 21 (the first film layer 24 covers a region of the display unit 22 defined by the bank structures 23, and is not extended to the area of the display unit 22 away from the bank structures 23).

[0076] Preferably, alumina could be chose to form the inorganic thin film layer of 300~500 angstroms in thickness for the better sealing and transparent characteristics of the first film layer 24; meanwhile, the inorganic thin film layer can touch a small portion of the bank structures 23 while covering the exposed surface of the array substrate 21.

[0077] Then, spray the organic materials such as acrylic resin compound through the process like ink jet printing (IJP) to form the organic thin film layer, that is the second film layer 25, over the first film layer 24; the second film layer 25 has the effect of encapsulating the defect particles to reduce the DP issue, eliminating stress to enhance the mechanical strength of the display device, improving the smoothness of the first film layer 24 (similar to the function of the flat layer) and so on; preferably, the thickness of the second film layer 25 could be selected in the range of 15000~20000 angstroms, to make the second film layer 25
has the foresaid effect of reducing DP issues, eliminating stress, improving smoothness and so on.

[0078] It should be noted that the second film layer 25 does not contact the array substrate 21, and fully covers the first film layer and contacts a first portion the bank structures 23, more specifically, covers the surface, close to the display unit, of the bank structures 23, that is, the top surface of the bank structures 23, the surface, away from the display unit, of the bank structures 23 and part of the surface, close to the display unit, of the bank structures 23 are all exposed; that is, the height (along the vertical direction of the light emitting surface of the display unit, as shown in FIG. 5) is larger than the sum of the thickness of the first film layer 24 and the second film layer 25 (along the direction vertical to the light emitting surface of the display unit, as shown in FIG. 5).

[0079] Subsequently, deposite inorganic materials such as SiNx, AlOx, SiOx etc. through processes like chemical vapor deposition (CVD), atomic layer deposition (ALD), plasma enhanced chemical vapor deposition (PECVD) and so on to form a organic thin film layer that is the third film layer 26 which covers the surface of the second film layer 25 and, contacts a second portion of the bank structures 23, more specifically, the exposed surface of the bank structures 23, wherein the second portion is independent to the first portion of the bank structures. The second film layer 25 wraps the second film layer 25 inside the area surrounded by the bank structures 23 and the first film layer 24.

[0080] It should be noted that the third film layer 26 contacts the array substrate 21, and could cover not only the exposed surface of the second film layer 25 but also parts of the exposed surfaces of the bank structures 23.

[0081] Preferably, for the good characteristics of resistance to moisture and oxygen and obtaining the proper film thickness, aluminium oxide could be selected to form inorganic thin film which is 5000-10000 angstroms in thickness, that is the third film layer 26. The third film layer 26 is over the above bank structures 23 while covering the surface of both the second film layer 25 and the non-display area of array substrate 21.

[0082] Subsequently, form the fourth film layer 27 onto the third film layer 26 through the same process used to forming the second film layer 25, that is to spray the organic materials such as acrylic resin compound through the process like ink jet printing (IJP) to form the organic film layer, namely the fourth film layer 27, on the above third film layer. Said fourth film layer 27 also has the effect of encapsulating the defect particles to reduce the DP issue, eliminating stress to enhance the mechanical strength of the display device, improving the smoothness of the third film layer 26 (similar to the function of the flat layer) and so on, as shown in FIG. 6; preferably, the thickness of the fourth film layer 27 could be selected in the range of 15000-20000 angstroms, to make the third film layer 26 has the above effect of reducing DP issues, eliminating stress, improving smoothness and so on.

[0083] It should be noted that the fourth film layer 27 also does not contact with the array substrate 21, that is, the fourth film layer 27 disposed on a portion of the third film layer 26, and exposes the surface, close to the array substrate 21, of the third film layer 26, in order that the fifth film layer 28 to be formed later could seal the fourth film layer 27 onto the surface of the third film layer 26.

[0084] Lastly, as shown in FIG. 7, deposite inorganic materials such as SiNx, AlOx, SiOx etc. through processes like chemical vapor deposition (CVD), atomic layer deposition (ALD), plasma enhanced chemical vapor deposition (PECVD) and so on to form inorganic material such as SiNx, AlOx, and SiOx to form an inorganic thin film layer; that is the fifth film layer, covering the surface of the fourth film layer 27, the exposed surface of the third film layer 26 and the exposed surface of the bank structure 23. The fifth film layer 28 not only seals the fourth film layer 27 at the surface of the third film layer 26, but also covers parts of the surface of the bank structure 23 (non-display area) which is far away from the array substrate 21 where the display unit 22 located, so that the thin film encapsulation structure composing of the first film layer 24, the second film layer 25, the third film layer 26, the fourth film layer 27 and the fifth film layer 28 packages the foresaid bank structures 23.

[0085] It should be noted that the fifth film layer 28 contacts with the surface of the array substrate 21, and could cover not only the expose surface of both the third film layer 26 and the fourth film layer 27, but also the exposed surfaces of the bank structure 23 and part of the surface (non-display area), close to the third film layer 26, of the array substrate 21, therefore, the thin film encapsulation structure composing of the first film layer 24, the second film layer 25, the third film layer 26, the fourth film layer 27 and the fifth film layer 28 packages the foresaid bank structures 23.

[0086] Preferably, for the good characteristics of resistance to moisture and oxygen and obtaining the proper film thickness, alumina could be chose to form inorganic thin film which is 5000-10000 angstroms in thickness, that is, the fifth film layer 28.

[0087] In this embodiment, after the formation process of the above thin film encapsulation structure (namely the first film layer 24, the second film layer 25, the third film layer 26, the fourth film layer 27 and the fifth film layer 28) is done, the device structures that are used to form the cover glass of the display device could be pasted and fixed onto the foresaid thin film encapsulation structure which has already been formed, to complete the formation process of the display device.

[0088] In this embodiment, due to the characteristics, good light transmittance performance and resistance to moisture and oxygen, of the foresaid inorganic films (the first film layer 24, the third film layer 26 and the fifth film layer 28), the display device could be effectively sealed and isolated without being damaged by moisture, oxygen and the other corrosive gases from the external environment; and the organic thin film (the second film layer 25 and the fourth film layer 27) placed between the inorganic film layers could effectively buffer the external and internal stresses; meanwhile, the bank structures packaged by the thin film encapsulation structure could inhibit the diffusion of inorganic coating process while supporting the entire display device, therefore, the encapsulation structure of the display unit and the display device, which are both formed on the basis of the embodiment, have excellent sealing performance and a strong overall mechanical strength and flexibility.

Embodiment 2

[0089] On the basis of the above embodiment 1, as shown in FIG. 7, this embodiment provides a display unit encapsulating structure, said encapsulation structure of the display unit could be used to form various kinds of display devices (such as OLED display device), the above encapsulation structure of the display unit comprises:
an array substrate 21, could be a substrate to which an array process has been performed, may include but not limited to LTPS substrate, etc.; said array substrate 21 has a front surface (namely the top surface, as shown in FIG. 5) and a bottom surface opposite to the top surface (namely the bottom surface, as shown in FIGS. 5 and 6); the material of the substrate can be glass. A rigid substrate or a flexible substrate could also be used to form the array substrate 21. The array substrate 21, in or on which device structures, such as a driving circuit, used for driving the display unit to emit light, could be arranged.

Additionally, the array substrate 21 is configured with a display area used for arranging display device structure and a non-display area adjacent to the display area. On the front surface of the display area of the array substrate 21, a display unit (such as OLED display unit 22) has a light emitting surface (namely the top surface, as shown in FIG. 5) for light emission and a backlight surface (namely the bottom surface, as shown in FIG. 5) opposite to the light emitting surface, is provided. The backlight surface of the display unit 22 is adhered onto the front surface of the array substrate.

Preferably, the foresaid OLED display unit 22 can be an organic light emitting device (OLED) module or other kinds of light emitting modules, such as a cathode, an anode and a light emitting layer arranged between the cathode and the anode. The display unit 22 connects to the foresaid driving circuit.

Meanwhile, multilayer thin film stack bank structures 23 (such as the column bank structures), which can be disposed in the periphery of the display unit, are provided on the front surface of the above array substrate 22; additionally, said bank structures 23 could be raised patterns with a certain height, formed by exposure, development and etching during the foresaid array process. The material quality of the said bank structures 23 could be the materials, of which the major components are carbon (C), nitrogen (N) and oxygen (O), with a certain degree of hardness, such as heterocyclic polymers containing imino group and benzene ring; and the bank structure 23 could be arranged at the periphery of the display unit 22.

The first film layer 24, covers the exposed surface of both the display unit 22 and is disposed on the array substrate 21 between the display unit 22 and the bank structures 23, so that it can seal the display unit 22. The first film layer 24, the material of which can be inorganic materials like SiNₓ, AlOₓ, SiOₓ etc., is transparent, well moisture-resistant, and well oxygen-resistant. For example, the first film layer 24 can be an aluminium oxide membrane which is 300–500 angstroms in thickness, and it should have contact with the surface of the array substrate 21 (accordingly, a gap is formed between the bank structure 23 and the display unit 22, and the first film layer 24 is filled in and covered over the surface of the array substrate 21 exposed by the gap).

The second film layer 25, fully covers the first film layer and contacts a first portion of the bank structures, more specifically, the surface of the bank structures 23. Said second film layer 25 can be an organic thin films made of organic materials, such as acrylic resin compound, and it has the effect of wrapping the defect particles to reduce the DP issue, eliminating stress to enhance the mechanical strength of the display device, improving the smoothness of the first film layer 24 (similar to the function of a flat layer) and so on. However, the second film layer 25 (the thickness of it can be 15000–20000 angstroms) is blocked by the bank structure 23 and can not be in contact with the array substrate. The thickness of the bank structure 23 is larger than the sum of the thicknesses of the first film layer 24 and the second film layer 25.

The third film layer 26, covers exposed surface of the second film layer 25 and contacts a second portion of the bank structure 23, wherein the second portion is independent to the first portion of the bank structures. Together with the first film layer 24 and the second film layer 25, the third film layer, which can be inorganic material like SiNₓ, AlOₓ, SiOₓ, package the bank structure 23 onto the front surface of the array substrate.

Preferably, the third film layer can be SiN film which is 5000–10000 in thickness, for the excellent sealing property of the display device.

The fourth film layer 27, disposed on a portion of the third film layer 26, exposes the marginal area (namely the area, close to the array substrate 11, of the surface of the third film layer) of the third film layer 26.

The fifth film layer 28, covers the exposed surface of both the fourth film layer 27 and the third film layer 26, so that it can seal the fourth film layer 27 onto the surface of the third film layer 26; moreover, the fifth film layer 28 also covers the exposed surfaces of the bank structure 23 and the surface of the array substrate 21 which is close to the bank structure 23 and far away the display unit 22.

Preferably, the characteristics of the foresaid fourth film layer 27, such as the material and the structure size, can be similar to or the same as those of the second film layer 25, that is, the fourth film layer can also be organic material like acrylic resin compound. The fourth film layer 27 has the effect of wrapping the defect particles to reduce the DP issue, eliminating stress to enhance the mechanical strength of the display device, improving the smoothness of the third film layer 26 (similar to the function of a flat layer) and so on. However, the fourth film layer 27 (the thickness can be 15000–20000 angstroms) doesn’t have contact with the array substrate 21.

Similarly, the characteristics of the foresaid fifth film layer 28, such as the material quality and the structure size can be similar to or the same as those of the third film layer 26. For example, the fifth film layer 28 can be inorganic material like SiNₓ, AlOₓ, SiOₓ. The fifth film layer 28 together with the first film layer 24, the second film layer 25, the third film layer 26 and the fourth film layer 27 packages the bank structure 23 onto the front surface of the array substrate 21. The fifth film layer 28 also can be SiN film which is 5000–10000 angstroms in thickness, for the excellent sealing property of the display device.

It should be noted that the structure provided in this embodiment could be formed on the basis of the method provided in the above embodiment 1, so the technical features such as the formation process, material of the film layer and the positional relationships between the film layers can be applied to the structures of embodiment 1, and thus are omitted here for brevity.

In conclusion, the encapsulation structure of the display unit and method of forming the same provided in the embodiments of the present invention, encapsulates the display unit directly onto the substrate by means of directly using the encapsulation structure of the display unit formed through the thin film encapsulating process, meanwhile, the
encapsulation structure of the display unit has the properties of moisture-resistance, oxygen-resistance and buffering. Therefore, the encapsulation structure of the display unit can effectively buffer internal and external stresses while ensuring the sealing effectiveness of the display unit, and can avoid the films from falling off during the formation of flexible devices, and can also effectively buffer the external impact forces caused by the falling and collision of the display device structures so that the issues like the split or the broken of screens, caused by the stress concentration generated by the external impact forces, are greatly reduced, therefore, the overall structural strength of the display device is enhanced, and both the yield and the performance of the display devices are effectively improved as well. Meanwhile, the bank structures packaged by the thin film encapsulation structure could inhibit the diffusion of inorganic coating process while supporting the entire display device, therefore, the encapsulation structure of the display unit and the display device, which are both formed on the basis of the embodiments of the present invention, have excellent sealing performance and a strong overall mechanical strength and flexibility.

[0104] It will be obvious to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the invention, and therefore all changes and modifications that fall within the scope of the claims intended to be embraced by the claims.

What is claimed is:

1. An encapsulation structure, of a display unit, comprising:
   - an array substrate, the surface of which is provided with a display unit;
   - bank structures, disposed on a surface of the array substrate and placed in periphery of the display unit;
   - a first film layer, disposed on the array substrate and fully covering the display unit;
   - a second film layer, fully covering the first film layer and contacting a first portion of the bank structures;
   - a third film layer, covering the second film layer and contacting a second portion of the bank structures, wherein the second portion is independent to the first portion of the bank structures;
   - a fourth film layer, disposed on a portion of the third film layer;
   - and a fifth film layer, disposed on the array substrate to fully cover the bank structures, the third film layer and the forth film layer to form the encapsulation structure.

2. The encapsulation structure of claim 1, wherein the array substrate further comprises a thin film transistor display circuit used to drive the display unit.

3. The encapsulation structure of claim 2, wherein the array substrate is a low temperature polysilicon substrate.

4. The encapsulation structure of claim 1, wherein the display unit has a light emitting surface for light emission and a backlight surface opposite to the light emitting surface; and the backlight surface of the display unit is adhered onto the surface of the array substrate; the first film layer covers the light emitting surface of the display unit.

5. The encapsulation structure of claim 1, wherein, the display unit is an OLED display unit.

6. The encapsulation structure of claim 1, wherein, the bank structures are stack structures with multilayer films.

7. The encapsulation structure of claim 1, wherein, the bank structures are made of heterocyclic polymers containing imino group and benzene ring.

8. The encapsulation structure of claim 1, wherein, a thickness of the bank structures is larger than sum of thicknesses of the first film layer and second film layer.

9. The encapsulation structure of claim 1, wherein, the first film layer, the third film layer and the fifth film layer are all made of inorganic materials; and the second film layer and the fourth film layer are both made of organic materials.

10. The encapsulation structure of claim 9, wherein, the first film layer is made of metal oxide or silicon nitride, both of which are transparent, moisture-resistant, and oxygen-resistant.

11. The encapsulation structure of claim 9, wherein, the second film layer and the fourth film layer are made of acrylic resin compound having characteristics of buffering and transparency.

12. The encapsulation structure of claim 9, wherein, the third film layer and the fifth film layer are made of silicon nitride.

13. A method of forming an encapsulation structure of a display unit, comprising:
   - providing an array substrate with a display unit thereon;
   - forming bank structures on the array substrate at periphery of the display unit;
   - forming a first film layer on the array substrate to cover the display unit and surface of the array substrate which is located between the display unit and the bank structures for sealing the display unit;
   - forming a second film layer on the first film layer and contacting a first portion of the bank structures;
   - forming a third film layer on the second film layer and contacting a second portion of the bank structures, wherein the second portion is independent to the first portion of the bank structures;
   - forming a fourth film layer on the third film layer to cover parts of the third film layer; and
   - forming a fifth film layer on the array substrate to fully cover the bank structures, the third film layer and the forth film layer to form the encapsulation structure.

14. The method of forming the encapsulation structure of the display unit of claim 13, further comprising:
   - forming a thin film transistor display circuit in the array substrate used to drive the display unit.

15. The method of forming the encapsulation structure of the display unit of claim 14, wherein the array substrate is a low temperature polysilicon substrate.

16. The method of forming the encapsulation structure of the display unit of claim 13, wherein, the display unit has a light emitting surface for light emission and a backlight surface opposite to the light emitting surface; and the backlight surface of the display unit is adhered onto the surface of the array substrate; the first film layer is formed onto the light emitting surface of the display unit.

17. The method of forming the encapsulation structure of the display unit of claim 13, wherein, the display unit is an OLED display unit.

18. The method of forming the encapsulation structure of the display unit of claim 13, wherein, the bank structures forming step is performed by stacking multilayer thin films.
19. The method of forming the encapsulation structure of the display unit of claim 13, wherein, the bank structures are made of heterocyclic polymers containing imino group and benzene ring.

20. The method of forming the encapsulation structure of the display unit of claim 13, wherein, a thickness of the bank structures is larger than sum of thicknesses of the first film layer and second film layer.

21. The method of forming an encapsulation structure of a display unit of claim 13, wherein
forming the first film layer; the third film layer and the fifth film layer by inorganic materials; and
forming the second film layer and the fourth film layer by organic materials.

22. The method of forming an encapsulation structure of a display unit of claim 21, wherein the first film layer forming step is performed by atomic layer deposition with metal oxide or silicon nitride, both of which are transparent, moisture-resistant, and oxygen-resistant.

23. The method of forming an encapsulation structure of a display unit of claim 21, wherein the second film layer forming step is performed by ink jet printing with acrylic resin compound which comprises flat surfaces and characteristics of buffering and transparency.

24. The method of forming an encapsulation structure of a display unit of claim 21, wherein the third film layer and the fifth film layer forming steps are performed by atomic layer deposition, chemical vapor deposition, or plasma enhanced chemical vapor deposition with silicon nitride.

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