US 20120161197A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2012/0161197 A1

Im et al.

(43) Pub. Date: Jun. 28, 2012

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

(75) Inventors: **Choong-Youl Im**, Yongin-city (KR); **Il-Jeong Lee**, Yongin-city (KR); **Do-Hyun Kwon**, Yongin-city (KR); **Ju-Won Yoon**, Yongin-city (KR); **Sung-Eun Lee**, Yongin-city (KR); **Min-Woo Woo**, Yongin-city (KR)

(73) Assignee: **SAMSUNG MOBILE DISPLAY CO., LTD.**, Yongin-city (KR)

(21) Appl. No.: **13/242,211**

(22) Filed: **Sep. 23, 2011**

(30) **Foreign Application Priority Data**

Dec. 23, 2010 (KR) 10-2010-0133711

Publication Classification

(51) **Int. Cl.**
H01L 27/15 (2006.01)
H01L 33/42 (2010.01)
B82Y 20/00 (2011.01)

(52) **U.S. Cl.** **257/100**; 438/23; 977/952; 257/E27.12; 257/E33.064

(57) **ABSTRACT**

A flexible organic light-emitting display device has a thin film encapsulation structure. The flexible organic light-emitting display device can be manufactured by a method including sequentially stacking a glass substrate, a first flexible substrate in which conductive particles are integrally dispersed, a display unit comprising a thin film transistor (TFT) layer and a light-emitting layer, and a second flexible substrate. The glass substrate can then be separated from the first flexible substrate by emitting light.

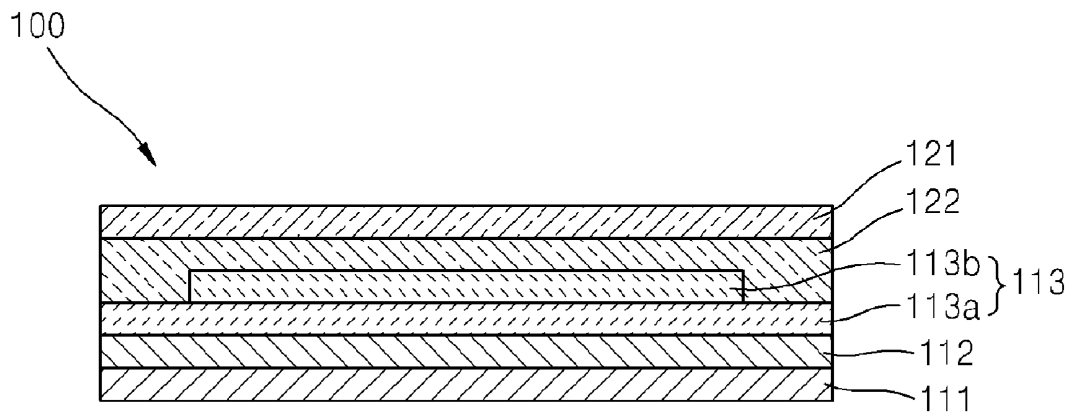


FIG. 1

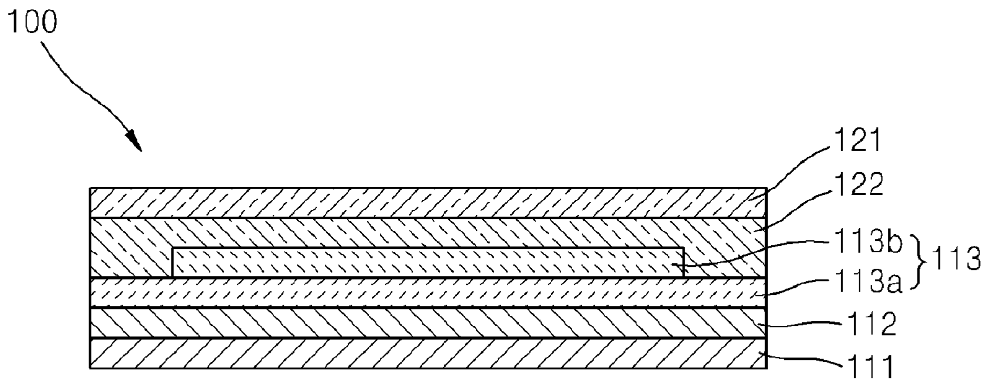


FIG. 2A

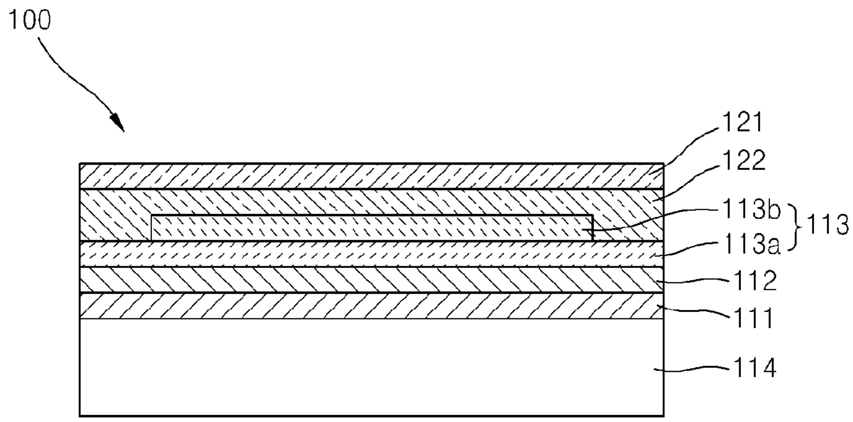

100
121
122
113b
113
113a
112
111
114

FIG. 2B

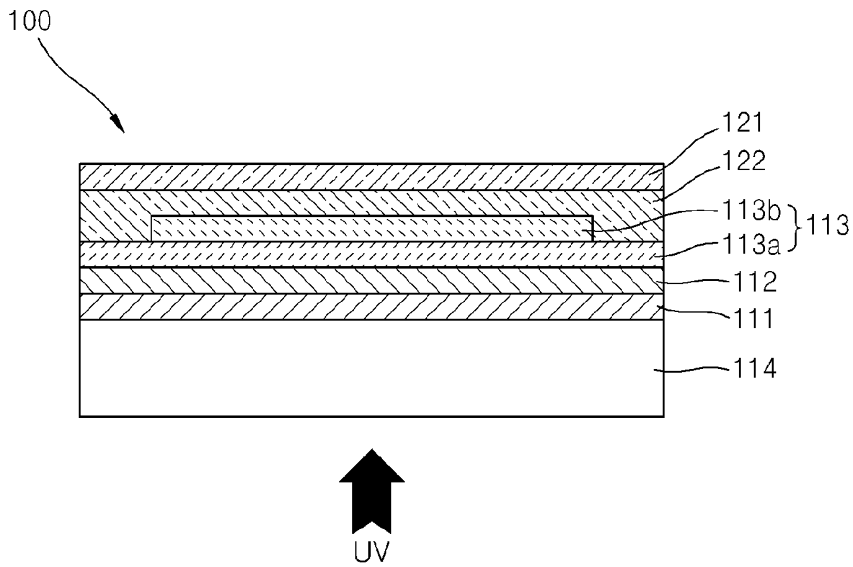

100
121
122
113b
113
113a
112
111
114
UV

FIG. 2C

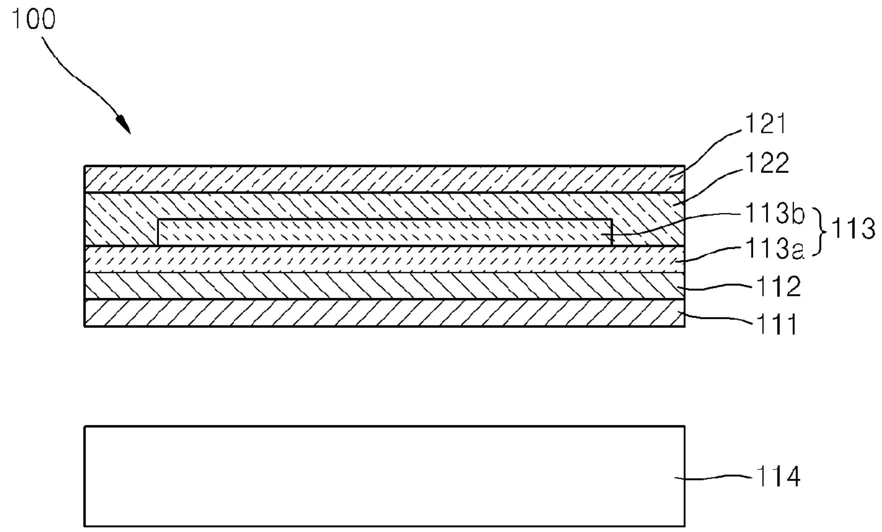
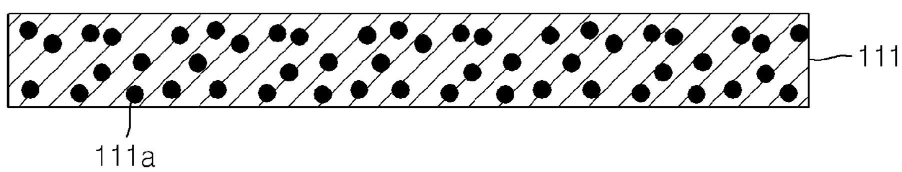


FIG. 3



FLEXIBLE ORGANIC LIGHT-EMITTING DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Patent Application No. 10-2010-0133711, filed on Dec. 23, 2010, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] The present disclosure relates to a flexible organic light-emitting display device using a thin film encapsulation structure for preventing penetration of moisture, and a method of manufacturing the flexible light-emitting display device.

[0004] 2. Description of the Related Technology

[0005] Many studies have been conducted on organic light-emitting display devices because organic light-emitting display devices may be made thin and flexible due to their driving characteristics.

[0006] A display unit of such an organic light-emitting display device may be deteriorated due to penetration of moisture in some instances. Accordingly, the organic light-emitting display device would benefit from an encapsulation structure for sealing and protecting the display unit from moisture.

[0007] Generally, an encapsulation substrate formed of a glass material is put on a glass substrate on which a display unit is formed and a sealant is used to seal the glass substrate and the encapsulation substrate together. Typically, a sealant, such as an ultraviolet (UV)-curable agent, is applied around the display unit of the glass substrate, the encapsulation substrate is put on the glass substrate to cover the glass substrate, and UV rays are emitted to cure the sealant, to achieve a sealed state.

[0008] However, such encapsulation structures may not be flexible. Flexible organic light-emitting display devices are desired, which have high enough flexibility to be installed while being bent. If the glass substrate and the encapsulation substrate each formed of a hard material are used as in the conventional encapsulation structure, such requirements may not be met.

[0009] A thin film encapsulation structure using a thin film layer formed of a polymer or the like, instead of a substrate formed of a glass material, has been suggested. In such thin film encapsulation structures, appropriate thin film layers are formed on a glass substrate and on an encapsulation substrate, the thin film layers are adhered to each other, and the glass substrate and the encapsulation substrate are separated, to achieve a sealed state by using the soft thin film layers instead of the glass substrate and the encapsulation substrate.

[0010] However, in such structures, when the glass substrate and the encapsulation substrate are removed from the thin film layers in order to form the thin film encapsulation structure, static electricity greater than several kV may be produced on an interface between the glass substrate and the encapsulation substrate. The display unit in the thin film encapsulation structure may be damaged due to the static electricity thus formed.

SUMMARY OF CERTAIN INVENTIVE ASPECTS

[0011] The present disclosure provides a flexible organic light-emitting display device which has a soft thin film encapsulation structure to reduce the risk of damage to a display unit due to static electricity produced during a manufacturing process, and a method of manufacturing the flexible organic light-emitting display device.

[0012] According to one aspect, there is provided a flexible organic light-emitting display device including: a first flexible substrate; a display unit formed on the first flexible substrate and comprising a thin film transistor (TFT) layer and a light-emitting layer; and a second flexible substrate formed on the display unit, wherein conductive particles are integrally dispersed in the first flexible substrate.

[0013] The conductive particles may include at least one of indium tin oxide (ITO) nanoparticles and silver (Ag) nanoparticles.

[0014] The first flexible substrate may include a first polymer layer and a first barrier layer which are sequentially stacked, the second flexible substrate may include a second barrier layer and a second polymer layer which are sequentially stacked, and the conductive particles may be dispersed in the first polymer layer.

[0015] The first polymer layer may have a glass transition temperature of about 500° C. or higher.

[0016] The second polymer layer may have a glass transition temperature of about 350° C. or higher.

[0017] A thickness of each of the first polymer later and the second polymer layer may range from about 1 to about 10 μm.

[0018] Each of the first barrier layer and the second barrier layer may include a SiO/SiN multi-layered film.

[0019] A water vapor transmission rate of each of the first barrier layer and the second barrier layer may be equal to or lower than about 10^{-5} g/m^2·day.

[0020] According to another aspect, there is provided a method of manufacturing a flexible organic light-emitting display device, the method including: sequentially stacking a glass substrate, a first flexible substrate in which conductive particles are integrally dispersed, a display unit comprising a TFT layer and a light-emitting layer, and a second flexible substrate; and separating the glass substrate from the first flexible substrate by emitting light.

[0021] The conductive particles may include at least one of ITO nanoparticles and Ag nanoparticles.

[0022] The first flexible substrate may include a first polymer layer and a first barrier layer which are sequentially stacked, the second flexible substrate may include a second barrier layer and a second polymer layer which are sequentially stacked, and the conductive particles may be dispersed in the first polymer layer.

[0023] The first polymer layer may have a glass transition temperature of about 500° C. or higher.

[0024] The second polymer layer may be a transparent layer having a glass transition temperature of about 350° C. or higher.

[0025] A thickness of each of the first polymer layer and the second polymer layer may range from about 1 to about 10 μm.

[0026] Each of the first barrier layer and the second barrier layer may include a SiO/SiN multi-layered film.

[0027] A water vapor transmission rate of each of the first barrier layer and the second barrier layer may be equal to or lower than about 10^{-5} g/m^2·day.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The above and other features and advantages will become more apparent by describing in detail certain embodiments with reference to the attached drawings in which:

[0029] FIG. **1** is a cross-sectional view illustrating an embodiment of a flexible organic light-emitting display device;

[0030] FIGS. **2**A through **2**C are cross-sectional views illustrating an embodiment of a method of manufacturing the flexible organic light-emitting display device of FIG. **1**; and

[0031] FIG. **3** is a cross-sectional view illustrating a first polymer layer of the flexible organic light-emitting display device of FIG. **1**.

DETAILED DESCRIPTION OF CERTAIN INVENTIVE EMBODIMENTS

[0032] Certain embodiments will now be described more fully with reference to the accompanying drawings.

[0033] FIG. **1** is a cross-sectional view illustrating an embodiment of a flexible organic light-emitting display device **100**, which is a top-emission type device.

[0034] As shown in FIG. **1**, the flexible organic light-emitting display device **100** includes a first flexible substrate including a first polymer layer **111** and a first barrier layer **112**, a display unit **113** including a thin film transistor (TFT) layer **113***a* and a light-emitting layer **113***b*, and a second flexible substrate including a second barrier layer **122** and a second polymer layer **121**, which are sequentially stacked. In some embodiments, an encapsulation structure is configured such that the display unit **113** is sealed by the first and second flexible substrates including the first and second polymer layers **111** and **121** and the first and second barrier layers **112** and **122** instead of conventional glass substrates.

[0035] The first polymer layer **111** can be formed of heat-resistive polyimide having a glass transition temperature of about 500° C. or higher, and it may be formed by polymerization of BPDA-biphenyl-tetracarboxylic acid dianhydride (3,3',4,4'-Biphenyl tetracarboxylic Dianhydride) and p-phenylenediamine (PDA). Since the display unit **113** is stacked on the first polymer layer **111** and exposure for patterning is performed several times, it is preferable that the first polymer **111** be formed of a material having high heat resistance in order to prevent deterioration. The first polymer layer **111** may be formed by spin coating on a glass substrate **114** (see FIG. **2**A), or may be attached as an adhesive film to the glass substrate **114**. A thickness of the first polymer layer **111** may range from about 1 to about 10 μm. The glass substrate **114** is separated from the first polymer layer **111** during a subsequent process. Since the first polymer layer **111** of the first flexible substrate is a lower substrate that replaces a conventional glass substrate, a very flexible thin film substrate having a thickness of about 1 to about 10 μm is achieved.

[0036] As shown in FIG. **3**, conductive particles **111***a* are dispersed in the first polymer layer **111**, in order to prevent static electricity from being produced on an interface between the first polymer layer **111** and the glass substrate **114** when the glass substrate **114** is separated by using laser. Due to the conductive particles **111***a*, static electricity is prevented from being accumulated around the interface, thereby preventing static electricity accumulated on the interface between the first polymer layer **111** and the glass substrate **114** from being discharged all at once, and preventing an electric shock, which may be greater than several kV, from being applied to the display unit **113**. In various embodiments, the conductive particles **111***a* may be indium tin oxide (ITO) nanoparticles, silver (Ag) nanoparticles, or the like. The conductive particles **111***a* may be dispersed in a coating solution for the spin coating, or may be dispersed in the adhesive film.

[0037] In some embodiments, the first barrier layer **112** stacked on the first polymer layer **111** having moisture resistance for preventing penetration of moisture may be, a SiO/SiN multi-layered film in which SiO and SiN are stacked as multi-layers. The first barrier layer **112** has excellent moisture resistance. A water vapor transmission rate of the first barrier layer **112** may be equal to or lower than about 10^{-5} g/m^2·day. The first barrier layer **112** may be deposited on the first polymer layer **111**.

[0038] Since the display unit **113**, and in particular, the light-emitting layer **113***b* of the display unit **113**, may be vulnerable to moisture, it is desirable to firmly seal the display unit **113** from moisture.

[0039] The second barrier layer **122** of the second flexible substrate formed on the display unit **113** may have moisture resistance for preventing penetration of moisture and may be, in some embodiments, a SiO/SiN multi-layered film in which SiO and SiN are stacked as multi-layers. A water vapor transmission rate of the second barrier layer **122** may be equal to or lower than about 10^{-5} g/m^2·day.

[0040] The second polymer layer **121** formed on the second barrier layer **122** may be formed of transparent polyimide having a glass transition temperature of about 350° C. or higher. The transparent polyimide may be a polymer composed of one or more of a dianhydride monomer, a diamine monomer, and an amide monomer.

[0041] In some embodiments, the transparent polyimide is a polymer composed of a dianhydride monomer and a diamine monomer, or a polymer composed of a dianhydride monomer and an amide monomer. In some embodiments, the dianhydride monomer may include pyromellitic dianhydride (PMDA), and 1,2,3,4-cyclobutanetetracarboxylic dianhydride (CBDA). In some embodiments, the diamine monomer may include trans-1,4-cyclohexanediamine (CHDA). In some embodiments, the amide monomer may include hexamethylphosphoramide (HMPA).

[0042] In embodiments where the flexible organic light-emitting display device is a top-emission type, an image created by the display unit **113** may be viewed at the second polymer layer side. Accordingly, the second polymer layer **121** can be a transparent layer that transmits the image created by the display unit **113**. If the second polymer layer **121** is formed of a transparent polymer, heat resistance of the second polymer layer **121** is slightly lower than that of the first polymer layer **111** that is not formed of a transparent polymer. However, the second polymer layer **121** is not subjected to patterning when the display unit **13** is patterned. When the glass substrate **114** is separated at a later stage, since UV exposure is performed, in order to prevent any problem on the second polymer layer **121**, the second polymer layer **121** has a glass transition temperature of about 350° C. or higher. Although the second polymer layer **121** has lower heat resistance than that of the first polymer layer **111**, the second polymer layer **121** may withstand a high temperature of about 350° C.

[0043] A thickness of the second polymer layer **121** may be about 1 to about 10 μm. Since the second polymer layer **121** becomes an upper substrate that replaces a conventional glass substrate, a very flexible thin film substrate having a thickness of about 1 to about 10 μm is achieved.

[0044] In some embodiments, the flexible organic light-emitting display device **100** constructed as described above may be manufactured by the following method.

[0045] FIGS. **2**A through **2**C are cross-sectional views illustrating an embodiment of a method of manufacturing the flexible organic light-emitting display device **100** of FIG. **1**. Referring to FIG. **2**A, the glass substrate **114** is prepared, and thin film layers are formed on the glass substrate **114**.

[0046] The first flexible substrate, or the first polymer layer **111** in which the plurality of conductive particles **111***a* (see FIG. **3**A) are dispersed, and the first barrier layer **112** having moisture resistance are sequentially formed on the glass substrate **114**. Then the display unit **113**, including the TFT layer **113***a* and the light-emitting layer **113***b*, is patterned.

[0047] The second barrier layer **122** and the second polymer layer **121** of the second flexible substrate are sequentially formed on the display unit **113**.

[0048] Alternatively, the first and second polymer layers **111** and **121** may be attached as adhesive films.

[0049] Next, referring to FIG. **2**B, UV laser is emitted over an entire surface of the glass substrate **114**. The glass substrate **114** and the first polymer layer **111** are separated from each other due to a high difference in thermal expansion coefficients between the glass substrate **114** and the first polymer layer **111**.

[0050] Referring to FIG. **2**C, the glass substrate **114** is separated, and the first polymer layer **111** is left as a lower substrate. Conventionally, when laser is emitted to separate the first glass substrate **114**, static electricity accumulated on an interface between the glass substrate **114** and the first polymer layer **111** is discharged from the interface, thereby causing damage to the display unit **113**. However, in embodiments disclosed herein, since the conductive particles **111***a* dispersed in the first polymer layer **111** do not allow static electricity from being accumulated on the interface, such a damage can be avoided.

[0051] As a result, an encapsulation structure for sealing the display unit **113** is defined by the first flexible substrates including thin films, the first and second polymer layers **111** and **121** and the first and second barrier layers **112** and **122**.

[0052] Hence, since the first and second polymer layers **111** and **121** which are thin films replace a glass substrate which is hard and thick, the flexible organic light-emitting display device **100** can be soft. Also, since the first and second barrier layers **112** and **122**, which are SiO/SiN multi-layered films, have a water vapor transmission rate of equal to or lower than about 10^{-5} g/m^2·day, excellent moisture resistance may be ensured.

[0053] Furthermore, due to the conductive particles **111***a*, since static electricity is prevented from being produced when the glass substrate **114** is separated, damage to the display unit **113** due to an electric shock may be prevented.

[0054] As described above, since the flexible organic light-emitting display device and the method of manufacturing the same according to the present invention has a thin film encapsulation structure, softness of the flexible organic light-emitting display device is greatly improved. Since the flexible organic light-emitting display device and the method of manufacturing the same prevent static electricity from being produced during a manufacturing process, the risk of damage to the flexible organic light-emitting display device is greatly reduced.

[0055] While the present invention has been particularly shown and described with reference to certain embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

What is claimed is:

1. A flexible organic light-emitting display device comprising:

a first flexible substrate;

a display unit formed on the first flexible substrate and comprising a thin film transistor (TFT) layer and a light-emitting layer; and

a second flexible substrate formed on the display unit,

wherein conductive particles are integrally dispersed in the first flexible substrate.

2. The flexible organic light-emitting display device of claim **1**, wherein the conductive particles comprise at least one of indium tin oxide (ITO) nanoparticles and silver (Ag) nanoparticles.

3. The flexible organic light-emitting display device of claim **1**, wherein the first flexible substrate comprises a first polymer layer and a first barrier layer which are sequentially stacked, the second flexible substrate comprises a second barrier layer and a second polymer layer which are sequentially stacked, and wherein the conductive particles are dispersed in the first polymer layer.

4. The flexible organic light-emitting display device of claim **3**, wherein the first polymer layer has a glass transition temperature of about 500° C. or higher.

5. The flexible organic light-emitting display device of claim **3**, wherein the second polymer layer has a glass transition temperature of about 350° C. or higher.

6. The flexible organic light-emitting display device of claim **3**, wherein a thickness of each of the first polymer later and the second polymer layer ranges from about 1 to about 10 μm.

7. The flexible organic light-emitting display device of claim **3**, wherein each of the first barrier layer and the second barrier layer comprises a SiO/SiN multi-layered film.

8. The flexible organic light-emitting display device of claim **7**, wherein a water vapor transmission rate of each of the first barrier layer and the second barrier layer is equal to or lower than about 10^{-5} g/m^2·day.

9. A method of manufacturing a flexible organic light-emitting display device, the method comprising:

sequentially stacking a glass substrate, a first flexible substrate in which conductive particles are integrally dispersed, a display unit comprising a TFT layer and a light-emitting layer, and a second flexible substrate; and

separating the glass substrate from the first flexible substrate by emitting light.

10. The method of claim **9**, wherein the conductive particles comprise at least one of ITO nanoparticles and Ag nanoparticles.

11. The method of claim **9**, wherein the first flexible substrate comprises a first polymer layer and a first barrier layer which are sequentially stacked, the second flexible substrate comprises a second barrier layer and a second polymer layer which are sequentially stacked, and the conductive particles are dispersed in the first polymer layer.

12. The method of claim **11**, wherein the first polymer layer has a glass transition temperature of about 500° C. or higher.

13. The method of claim **11**, wherein the second polymer layer is a transparent layer having a glass transition temperature of about 350° C. or higher.

14. The method of claim **11**, wherein a thickness of each of the first polymer layer and the second polymer layer ranges from about 1 to about 10 μm.

15. The method of claim **11**, wherein each of the first barrier layer and the second barrier layer comprises a SiO/SiN multi-layered film.

16. The method of claim **15**, wherein a water vapor transmission rate of each of the first barrier layer and the second barrier layer is equal to or lower than about 10^{-5} g/m^2·day.

* * * * *

专利名称(译)	柔性有机发光显示装置及其制造方法		
公开(公告)号	US20120161197A1	公开(公告)日	2012-06-28
申请号	US13/242211	申请日	2011-09-23
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星移动显示器有限公司.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	IM CHOONG YOUL LEE IL JEONG KWON DO HYUN YOON JU WON LEE SUNG EUN WOO MIN WOO		
发明人	IM, CHOONG-YOUL LEE, IL-JEONG KWON, DO-HYUN YOON, JU-WON LEE, SUNG-EUN WOO, MIN-WOO		
IPC分类号	H01L27/15 H01L33/42 B82Y20/00		
CPC分类号	B82Y20/00 H01L27/3244 H01L51/003 Y02E10/549 H01L51/5253 H01L2251/5338 H01L51/0097 H01L51/56 Y02P70/521		
优先权	1020100133711 2010-12-23 KR		
外部链接	Espacenet USPTO		

摘要(译)

柔性有机发光显示装置具有薄膜封装结构。柔性有机发光显示装置可以通过包括顺序堆叠玻璃基板，其中导电颗粒整体分散的第一柔性基板，包括薄膜晶体管（TFT）层和发光的显示单元的方法制造层和第二柔性基板。然后可以通过发光将玻璃基板与第一柔性基板分离。