US 20010015620A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2001/0015620 A1

Affinito (43) Pub. Date: Aug. 23, 2001

(54) ENVIRONMENTAL BARRIER MATERIAL FOR ORGANIC LIGHT EMITTING DEVICE AND METHOD OF MAKING

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(21) Appl. No.: **09/847,233**

(22) Filed: **May 2, 2001**

Related U.S. Application Data

(62) Division of application No. 09/212,779, filed on Dec. 16, 1998.

Publication Classification

(51) **Int. Cl.**[7] **H01J 1/62**

(52) **U.S. Cl.** **313/512**; 313/506; 313/504

(57) **ABSTRACT**

The present invention is an environmental barrier for an OLED. The environmental barrier has a foundation and a cover. Both the foundation and the cover have a top of three layers of (a) a first polymer layer, (b) a ceramic layer, and (c) a second polymer layer. The foundation and/or the cover may have a at least one set of intermediate barrier each having (a) an intermediate polymer layer with (b) an intermediate ceramic layer thereon. In a preferred embodiment, the foundation has a substrate upon which at least a top is deposited. An OLED is constructed upon the top, opposite the substrate. The cover of at least a top then placed over the OLED. The placement may be by gluing or preferably by vacuum deposition. For use as a display, it is preferred that either the ceramic layer(s) in the foundation, cover or both is substantially transparent to the light emitted by the OLED. Each layer of the foundation and the cover is preferably vacuum deposited. Vacuum deposition includes monolayer spreading under vacuum, plasma deposition, flash evaporation and combinations thereof. It is further preferred that all layers are deposited and cured between rolls or rollers to avoid the defects that may be caused by abrasion over a roll or roller.

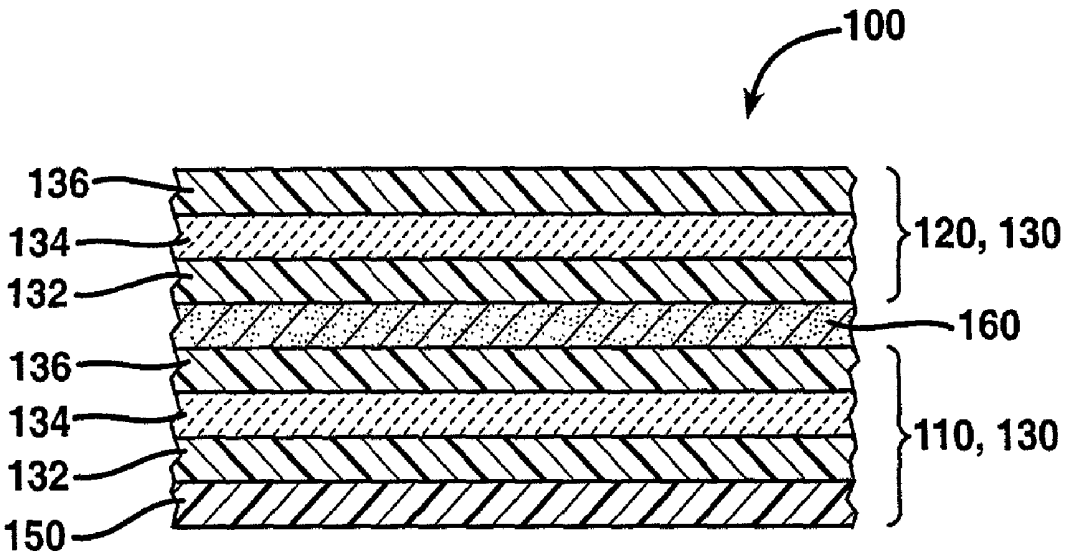

FIG. 1

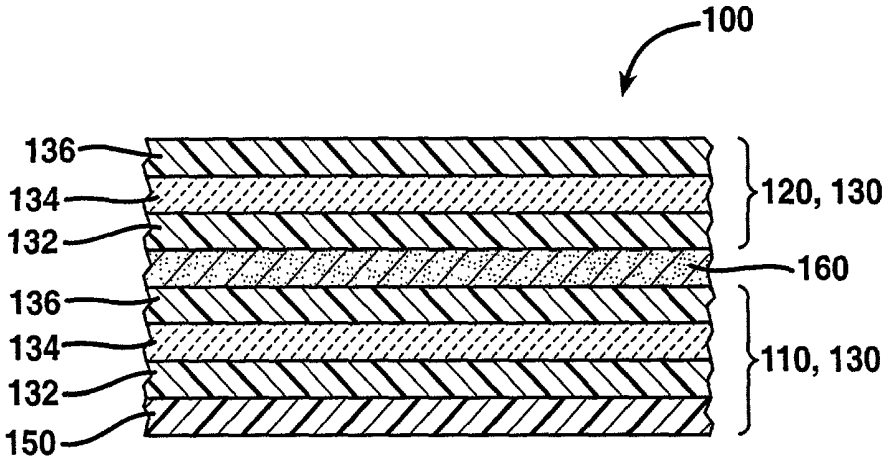
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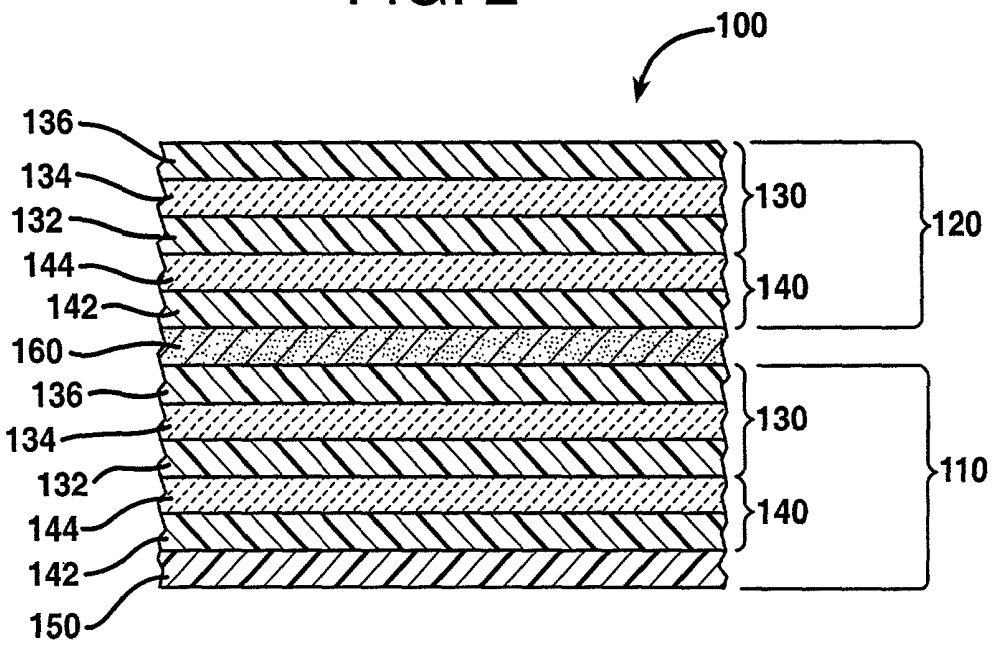
FIG. 2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ENVIRONMENTAL BARRIER MATERIAL FOR ORGANIC LIGHT EMITTING DEVICE AND METHOD OF MAKING

FIELD OF THE INVENTION

[0001] The present invention is related to environmental barrier material for organic light emitting devices (OLED), including light emitting polymer(s) (LEP). The environmental barrier prevents contact of environmental oxygen and/or water to the OLED.

BACKGROUND OF THE INVENTION

[0002] Use of Light Emitting Organic Devices (sometimes known as Light Emitting Polymer, or LEP, Devices) in flat panel displays, and other information display formats, is currently limited by the poor environmental stability of the devices (**1**). Because of this poor environmental stability, devices are currently fabricated on glass substrates and have glass covers laminated over the top as an environmental barrier. Thus, even though the active portions of the device are of a lightweight, thin film, flexible polymer construction, the finished part is heavy and rigid because of the glass sheets needed as environmental barriers to protect the device from contact by permeation of oxygen and/or water vapor.

[0003] It has been previously reported that the single pass, roll-to-roll, vacuum deposition of a three layer combination on a PET substrate, namely

[0004] PET SUBSTRATE/PML Polymer Smoothing Layer/Oxide Layer/PML Layer can be more than three orders of magnitude less permeable to oxygen and water vapor than a simple oxide layer on PET alone (**2,3**). This is in spite of the fact that the effect on the permeation rate of the PML layers alone, without the oxide layer, is barely measurable. It is believed that the reason for this tremendous improvement in barrier properties was due to two mechanisms:

[0005] 1) Permeation rates in the roll-to-roll coated oxide-only layers were found to be conductance limited by holes in the oxide layer that arose when the coated substrate was wound up over system idlers/rollers and onto itself in the take up roll. The oxide coating on the tops of the sharp features and debris, on the conformally oxide coated substrate, were found to fracture. These fractures were, apparently, because these rough surface features carried all of the load (since they stick up above the plane of the substrate) when the substrate is wound up after coating. In the single pass, PML/Oxide/PML process the PML smoothing layer covered all rough, sharp, and/or uneven features in the substrate topography as well as buried any foreign debris on the substrate surface. Thus, there were no high points to fracture.

[0006] 2) The PML top coat also protected the oxide layer from damage due to rough portions of the system idlers/rollers as well as from the back side of the substrate as the material was wound up.

[0007] There is, therefore, a need to encapsulate LEP devices in a flexible, transparent, environmental barrier that permits viewing while preventing ingress of oxygen and water vapor from the environment.

Background References

[0008] 1. G Gustafson, Y. Cao, G. M. Treacy, F. Klavetter, N. Colaneri, and A. J. Heeger, Nature, Vol 35, 11 Jun. 1992, pages 477-479.

[0009] 2. J. D. Affinito, M. E. Gross, C. A. Coronado, G. L. Graff, E. N. Greenwell, and P. M. Martin, Polymer-Oxide Transparent Barrier Layers Produced Using The PML Process, 39th Annual Technical Conference Proceedings of the Society of Vacuum Coaters, Vacuum Web Coating Session, 1996, pgs 392-397.

[0010] 3. J. D. Affinito, Stephan Eufinger, M. E. Gross, G. L. Graff, and P. M. Martin, PML/Oxide/PML Barrier Layer Performance Differences Arising From Use of UV or Electron Beam Polymerization of the PML Layers, Thin Solid Films, Vol 308, 1997, pg. 19-25.

SUMMARY OF THE INVENTION

[0011] The present invention is an environmental barrier for an OLED. The environmental barrier has a foundation and a cover. Either the foundation, the cover or both may have a top of three layers of (a) a first polymer layer, (b) a ceramic layer, and (c) a second polymer layer. The foundation and/or the cover may have a at least one set of intermediate barrier each having (a) an intermediate polymer layer with (b) an intermediate ceramic layer thereon. In constructing the flexible environmental barrier, the foundation is made on a substrate. An OLED is constructed upon the top, opposite the substrate. The cover of at least a top then placed over the OLED to encapsulate the OLED. The placement or encapsulation may be by gluing or laminating the cover to the foundation over the OLED or preferably by vacuum deposition of the cover layers onto the OLED. It is most preferred that the substrate, foundation and cover be flexible.

[0012] For use as a display, it is preferred that either the ceramic layer(s) in the foundation, cover or both is substantially transparent to the light emitted by the OLED.

[0013] Each layer of the foundation and the cover is preferably vacuum deposited. Vacuum deposition includes monolayer spreading under vacuum, plasma deposition, flash evaporation, sputtering, chemical vapor deposition, evaporation and combinations thereof. It is further preferred that all layers are deposited and cured between rolls or rollers to avoid the defects that may be caused by abrasion over a roll or roller.

[0014] The subject matter of the present invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. However, both the organization and method of operation, together with further advantages and objects thereof, may best be understood by reference to the following description taken in connection with accompanying drawings wherein like reference characters refer to like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] **FIG. 1***a* is a cross section of an OLED encased with flexible environmental barrier of a foundation and a cover.

[0016] **FIG. 1***b* is a cross section of an OLED encased with flexible environmental barrier wherein the foundation and cover include an intermediate barrier.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0017] In order to overcome the disadvantages of the environmental barrier of glass presently used for sealing OLED, including LEP, the present invention is directed toward an environmental barrier, preferably a flexible environmental barrier as shown in **FIG. 1***a* and **FIG. 1***b*. In **FIG. 1***a* the flexible environmental barrier **100** is used on both sides of an OLED **160**. The flexible environmental barrier may be a foundation **110**, a cover **120** or a combination thereof which is preferred. Either or both of the foundation **110** and/or the cover **120** may have a top **130** of three layers of (a) a first polymer layer **132**, (b) a ceramic layer **134**, and (c) a second polymer layer **136**. In **FIG. 1***b* the foundation **110** and/or the cover **120** may further have a at least one intermediate barrier **140** each having (a) an intermediate polymer layer **142** with (b) an intermediate ceramic layer **144** thereon. In operation, the foundation **110** is constructed on a substrate **150** upon which at least a top **130** is deposited. The substrate **150** may remain and be part of the foundation **110** as shown or the substrate **150** may be removed from the foundation **110**. An OLED **160** is constructed upon the top **130** of the foundation **110**, opposite the substrate **150**. The cover **120** of at least a top **130** then placed over the OLED **160**. The placement may be by gluing a previously constructed cover **120** on a cover substrate (not shown), or preferably by vacuum deposition. It is preferred that the OLED **160** be encased by at least a top **130** and an intermediate barrier **140** on both sides of the OLED **160** as shown in **FIG. 1***b*.

[0018] The cover may be placed over the OLED either by lamination or gluing of the cover to the foundation or preferably by vacuum deposition of the cover layers over the OLED and to the foundation. Again, the substrate **150** may remain with the foundation **110** as shown or be separated therefrom.

[0019] In a less preferred embodiment, only the foundation **110** or the cover **120** may be used with a rigid environmental barrier, for example glass, on the opposing side.

[0020] For use as a display, it is preferred that either the ceramic layer(s) **134**, **144** in the foundation **110**, cover **120** or both is/are substantially transparent to the light emitted by the OLED **160**.

[0021] Each layer of the foundation **110** (except the substrate **150**), and the cover **120** are preferably vacuum deposited. Vacuum deposition includes vacuum deposition of the monomer with monolayer spreading under vacuum, plasma deposition, flash evaporation, as well as vacuum deposition of the ceramic layer(s) with sputtering, chemical vapor deposition, evaporation, electron cyclotron resonance source—plasma enhanced vapor deposition (ECR-PECVD) and combinations thereof. It is preferred that the assembling of the foundation and/or cover is accomplished in a manner wherein the ceramic layer is not contacted by any equipment but only by enveloping polymer layers. This may be accomplished by depositing layers in a manner wherein a set of layers (foundation or cover) of polymer/ceramic/polymer is deposited prior to contacting or touching the layers with any layer handling equipment, for example rollers in a web coating system to avoid the defects that may be caused by abrasion over a roll or roller.

[0022] The substrate may be rigid or flexible, but is preferably a flexible substrate, especially when it remains with the foundation. The flexible substrate may be any flexible material including but not limited to polymer, for example polyethyleneterephthalate (PET), metal, paper, fabric and combinations thereof.

[0023] The first, second and/or intermediate polymer layer(s) may be acrylic, methacrylic, polyester or PET, polyethylene, polypropylene, and combinations thereof.

[0024] The first and/or second ceramic layer(s) may be any ceramic including but not limited to metal oxide, metal nitride, metal carbide, metal oxynitride, indium oxide (In_2O_3), tin oxide (SnO_2), indium tin oxide (ITO) and combinations thereof. It is preferred that at least one side (foundation or cover) is preferably a substantially transparent ceramic including but not limited to silica or silicon oxide (SiO_2), alumina or aluminum oxide (Al_2O_3), titania or titanium oxide (TiO_2), indium oxide (In_2O_3), tin oxide (SnO_2), indium tin oxide (ITO, In_20_3+SnO_2), aluminaum nitride (AIN), silicon nitride (SiN), silicon carbide (SiC), silicon oxynitride (SiON) and combinations thereof.

[0025] The layers are preferably vacuum deposited. Vacuum deposition of polymers includes liquid monomer spreading in a vacuum, plasma deposition, flash evaporation and combinations thereof. Vacuum deposition of oxides includes chemical vapor deposition, plasma enhanced chemical vapor deposition, sputtering, electron beam evaporation, electron cyclotron resonance source—plasma enhanced chemical vapor deposition (ECR-PECVD) and combinations thereof.

[0026] Clearly the function of the foundation and cover is to prevent environmental constituents including but not limited to water, oxygen and combinations thereof from reaching the OLED. Accordingly the invention is a method for preventing water or oxygen from a source thereof reaching a device, the method having the steps of: depositing a first polymer layer between the device and the source; depositing an inorganic (ceramic) layer on the first polymer layer of the device by chemical vapor deposition, plasma enhanced chemical vapor deposition, sputtering, electron beam evaporation, electron cyclotron resonance source—plasma enhanced chemical vapor deposition (ECR-PECVD) and combinations thereof; and depositing a second polymer layer on said inorganic layer.

[0027] An electroluminescent device or OLED may have

[0028] a flexible sheet that is transparent to light of a first wavelength;

[0029] a first polymer in contact with the flexible sheet;

[0030] a first permeation barrier (ceramic or inorganic layer) in contact with the first polymer layer;

[0031] a second polymer layer in contact with the first permeation barrier;

[0032] a first electrode having a first electrode layer in contact with the flexible sheet and transparent to light of the first wavelength;

[0033] a light emitting layer of an organic material in electrical contact with the first electrode layer;

[0034] a second electrode having a second electrode layer in electrical contact with the light emitting layer, that generates light of the first wavelength when a potential difference is applied across the first and second electrodes;

[0035] a third polymer layer in contact with the second electrode layer;

[0036] a second permeation barrier of inorganic material in contact with the third polymer layer; and

[0037] a fourth polymer layer in contact with the second permeation barrier.

[0038] In this embodiment description, the combination of flexible sheet, light emitting layer, first electrode and second electrode constitute a device as recited above.

Closure

[0039] While a preferred embodiment of the present invention has been shown and described, it will be apparent to those skilled in the art that many changes and modifications may be made without departing from the invention in its broader aspects. The appended claims are therefore intended to cover all such changes and modifications as fall within the true spirit and scope of the invention.

We claim:

1. A flexible environmental barrier for an organic light emitting device, comprising:

(a) a foundation having;

(i) a top of a first polymer layer, a first ceramic layer on the first polymer layer, and a second polymer layer on the first ceramic layer; whereupon

(b) said organic light emitting device is constructed on the second polymer layer of the top; and

(c) a cover of a third polymer layer with a second ceramic layer thereon and a fourth polymer layer on said second ceramic layer, said cover deposited on said organic light emitting device, the foundation and cover encapsulating the organic light emitting device as said flexible environmental barrier.

2. The flexible environmental barrier as recited in claim 1, wherein said foundation further comprises:

at least one intermediate barrier between said substrate and said top, each intermediate barrier having (a) a polymer layer with (b) a ceramic layer thereon.

3. The flexible environmental barrier as recited in claim 1, wherein said cover further comprises:

at least one intermediate barrier between said light emitting organic device and said top, each intermediate barrier having (a) a polymer layer with (b) a ceramic layer thereon.

4. The flexible environmental barrier as recited in claim 1, wherein said first ceramic layer, said second ceramic layer or both ceramic layers is/are substantially transparent.

5. The flexible environmental barrier as recited in claim 4, wherein said first ceramic layer is selected from the group consisting of metal oxide, metal nitride, metal carbide, metal oxynitride and combinations thereof.

6. The flexible environmental barrier as recited in claim 5, wherein said metal oxide is selected from the group consisting of silica, alumina, titania, indium oxide, tin oxide, indium tin oxide and combinations thereof.

7. The flexible environmental barrier as recited in claim 5, wherein said metal nitride is selected from the group consisting of aluminum nitride, silicon nitride and combinations thereof.

8. The flexible environmental barrier as recited in claim 1, wherein said foundation includes a flexible substrate selected from the group consisting of polymer, metal, paper, fabric and combinations thereof.

9. The flexible environmental barrier as recited in claim 1, wherein said first polymer, second polymer, third polymer, fourth polymer, or combinations thereof is selected from the group consisting of acrylic, methacrylic, polyester or polyethyleneterephthalate (PET), polyethylene, polypropylene, and combinations thereof.

10. The flexible environmental barrier as recited in claim 2, wherein said polymer is selected from the group consisting of acrylic, methacrylic, polyester or polyethyleneterephthalate (PET), polyethylene, polypropylene, and combinations thereof.

11. A method of making a flexible environmental barrier for an organic light emitting device, comprising the steps of:

(a) assembling a foundation by

(i) providing a substrate;

(ii) vacuum depositing a top by vacuum depositing a first polymer layer on the substrate, followed by vacuum depositing a first ceramic layer on the first polymer layer, then vacuum depositing a second polymer layer on the first ceramic layer;

(b) constructing said organic light emitting device on the second polymer layer;

(c) forming a cover by vacuum depositing a third polymer layer followed by vacuum depositing a second ceramic layer on the third polymer layer, then vacuum depositing a fourth polymer layer on the second ceramic layer; and

(d) encapsulating said organic light emitting device by placing said cover over said organic light emitting device thereby forming said flexible environmental barrier encapsulating said organic light emitting device.

12. The method as recited in claim 11, wherein said assembling further comprises:

placing at least one set of intermediate barrier between said substrate and said top, wherein each set is vacuum deposited by vacuum depositing (a) an intermediate polymer layer and vacuum depositing (b) an intermediate ceramic layer thereon.

13. The method as recited in claim 11, wherein said encapsulating further comprises:

placing at least one set of intermediate barrier between said light emitting organic device and said top, by vacuum depositing (a) an intermediate polymer layer and vacuum depositing (b) an intermediate ceramic layer thereon.

14. The method as recited in claim 11, wherein said first ceramic layer is substantially transparent.

15. The method as recited in claim 11, wherein said second ceramic layer is substantially transparent.

16. The method as recited in claim 11, wherein said placing is by laminating said cover over said organic light emitting device onto said foundation.

17. The method as recited in claim 11, wherein said placing is simultaneous with said forming wherein said forming is directly upon said organic light emitting polymer.

18. The method as recited in claim 11, wherein said substrate is a flexible substrate.

19. The method as recited in claim 18, wherein said flexible substrate is removed from said foundation.

20. The method as recited in claim 11, wherein said first ceramic layer is selected from the group consisting of metal oxide, metal nitride, metal carbide, metal oxynitride and combinations thereof.

21. The method as recited in claim 20, wherein said metal oxide is selected from the group consisting of silica, alumina, titania, indium oxide, tin oxide, indium tin oxide and combinations thereof.

22. The method as recited in claim 20, wherein said metal nitride is selected from the group consisting of aluminum nitride, silicon nitride and combinations thereof.

23. The method as recited in claim 11, wherein said foundation includes a flexible substrate selected from the group consisting of polymer, metal, paper, fabric and combinations thereof.

24. The method as recited in claim 11, wherein said first polymer, second polymer, third polymer, fourth polymer, or combinations thereof is selected from the group consisting of acrylic, methacrylic, polyester or polyethyleneterephthalate (PET), polyethylene, polypropylene, and combinations thereof.

25. The method as recited in claim 11, wherein said polymer is selected from the group consisting of acrylic, methacrylic, polyester or polyethyleneterephthalate (PET), polyethylene, polypropylene, and combinations thereof.

26. The method as recited in claim 11, wherein said substrate is a rigid substrate that is removed from the foundation.

27. A flexible environmental barrier for an organic light emitting device, comprising:

(a) a foundation having

(i) at least one intermediate barrier having (a) a first intermediate polymer layer with (b) a first intermediate ceramic layer thereon;

(ii) a top of a first top polymer layer on the substrate, a top ceramic layer on the first top polymer layer, and a second top polymer layer on the top ceramic layer; whereupon

(b) said organic light emitting device is constructed on the second top polymer layer of the top; and

(c) a cover having

(i) at least one intermediate barrier on said organic light emitting device, each intermediate barrier having (a) a second intermediate polymer layer with (b) a second intermediate ceramic layer thereon;

(ii) a first cover polymer layer on said at least one intermediate barrier with a second ceramic layer thereon and a second cover polymer layer on said second ceramic layer.

28. A method of making an environmental barrier for an organic light emitting device, comprising the steps of:

(a) constructing a foundation by

(i) vacuum depositing at least one intermediate barrier on a substrate each intermediate barrier having (a) a first intermediate polymer layer with (b) a second intermediate ceramic layer thereon onto the substrate;

(ii) vacuum depositing a top of a first top polymer layer on the substrate, a first ceramic layer on the first polymer layer, and a second top polymer layer on the first ceramic layer; whereupon

(b) constructing said organic light emitting device on the second top polymer layer of the top; and

(c) constructing a cover by

(i) vacuum depositing at least one intermediate barrier on said organic light emitting device, each intermediate barrier having (a) a second intermediate polymer layer with (b) a second intermediate ceramic layer thereon; and

(ii) vacuum depositing a first cover polymer layer on said at least one intermediate barrier with a second ceramic layer thereon and a second cover polymer layer on said second ceramic layer.

29. An environmental barrier for an OLED, comprising:

(a) a first environmental barrier; and

(b) a second environmental barrier having a first polymer layer with a ceramic layer thereon and a second polymer layer on the ceramic layer; wherein

(c) said OLED is encased between said first environmental barrier and said second environmental barrier; and

(d) either or both of said first and second environmental barrier comprises a top.

30. The environmental barrier as recited in claim 29, wherein said top comprises a first polymer layer, a first ceramic layer on the first polymer layer, and a second polymer layer on the first ceramic layer.

* * * * *

专利名称(译)	用于有机发光器件的环境阻隔材料和制造方法		
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申请号	US09/847233	申请日	2001-05-02
[标]申请(专利权)人(译)	AFFINITO约翰·D·		
申请(专利权)人(译)	AFFINITO约翰D.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	AFFINITO JOHN D		
发明人	AFFINITO, JOHN D.		
IPC分类号	H05B33/04 B32B7/02 B32B9/00 H01L51/50 H01L51/52 H01M2/08 H05B33/02 H05B33/10 H01J1/62		
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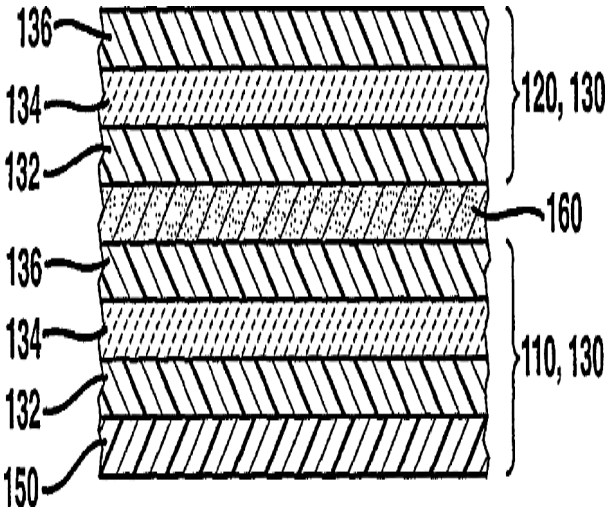
摘要(译)

本发明是OLED的环境屏障。环境屏障有基础和封面。基础和盖子都具有三层的顶部（a）第一聚合物层，（b）陶瓷层，和（c）第二聚合物层。基座和/或盖子可以具有至少一组中间屏障，每个中间屏障具有（a）中间聚合物层，其上具有（b）中间陶瓷层。在优选实施例中，基座具有基底，在基底上至少沉积顶部。在顶部构造OLED，与基板相对。然后将至少顶部的覆盖物放置在OLED上方。放置可以通过胶合或优选通过真空沉积。为了用作显示器，优选的是，基座，盖子或两者中的陶瓷层对OLED发出的光基本上是透明的。基础和盖子的每一层优选地是真空沉积的。真空沉积包括在真空下的单层铺展，等离子体沉积，闪蒸及其组合。进一步优选的是，所有层在辊或辊之间沉积和固化，以避免可能由辊或辊上的磨损引起的缺陷。