



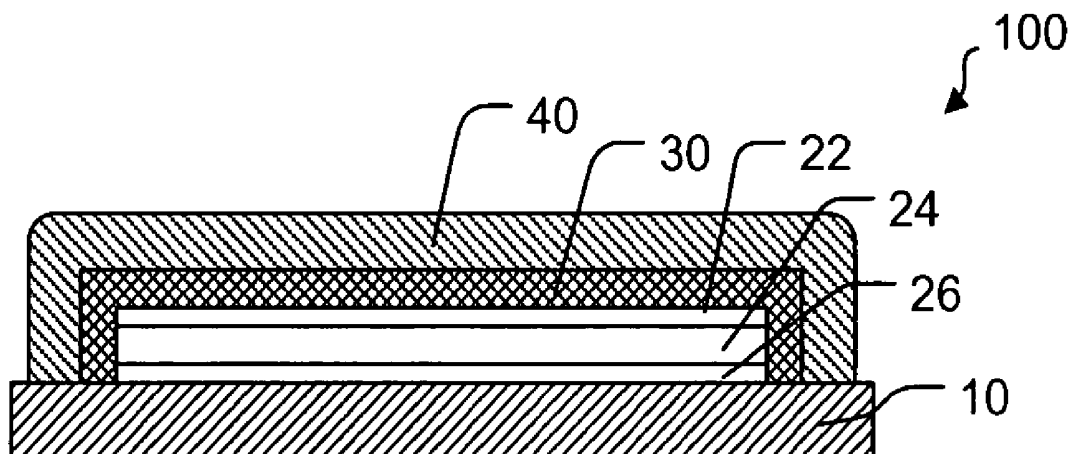
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(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2007/0164673 A1**
Hu (43) **Pub. Date: Jul. 19, 2007**(54) **ORGANIC ELECTRO-LUMINESCENT
DISPLAY DEVICE AND METHOD FOR
MAKING SAME****Publication Classification**(51) **Int. Cl.**
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MONROE, CT 06468 (US)**(73) **Assignee: AU Optronics Corporation**(21) **Appl. No.: 11/334,893**(22) **Filed: Jan. 18, 2006**(57) **ABSTRACT**

A display device having an electroluminescent display element disposed on a surface of a substrate and a scratch resistant layer disposed over or surrounding the display element. The scratch resistant layer has a hardness level of at least 2.5 on Moh's hardness scale. Additionally, a moisture and oxygen barrier is disposed between the display element and the scratch resistant layer. An adhesive material can be used to secure the scratch-resistant layer to the display device and to provide a hermetic seal to the display element. Preferably, the thickness of the scratch-resistant layer is equal to or greater than 10 μm .



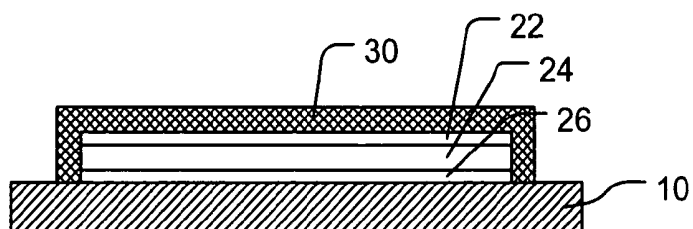


Fig. 1 (Prior Art)

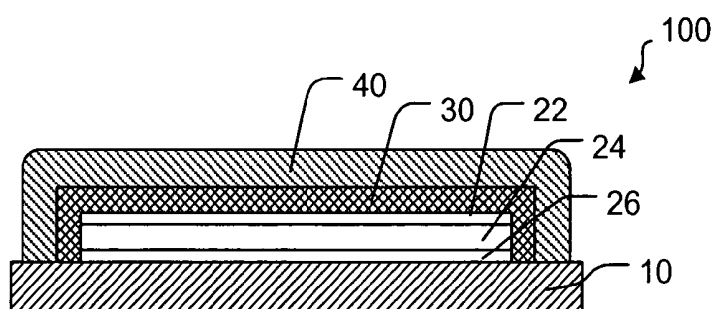


Fig. 2

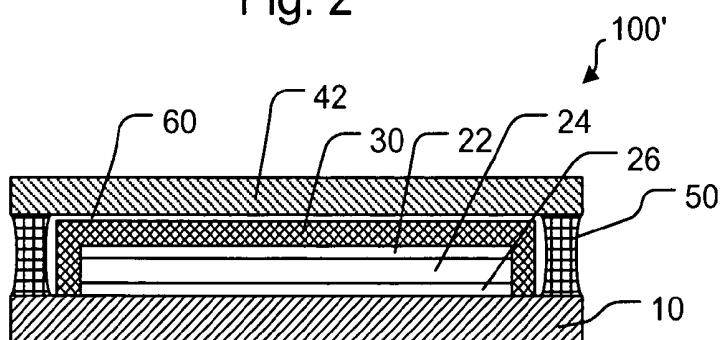


Fig. 3

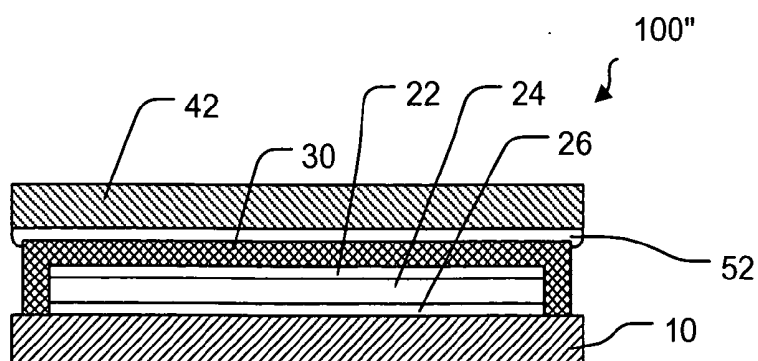


Fig. 4

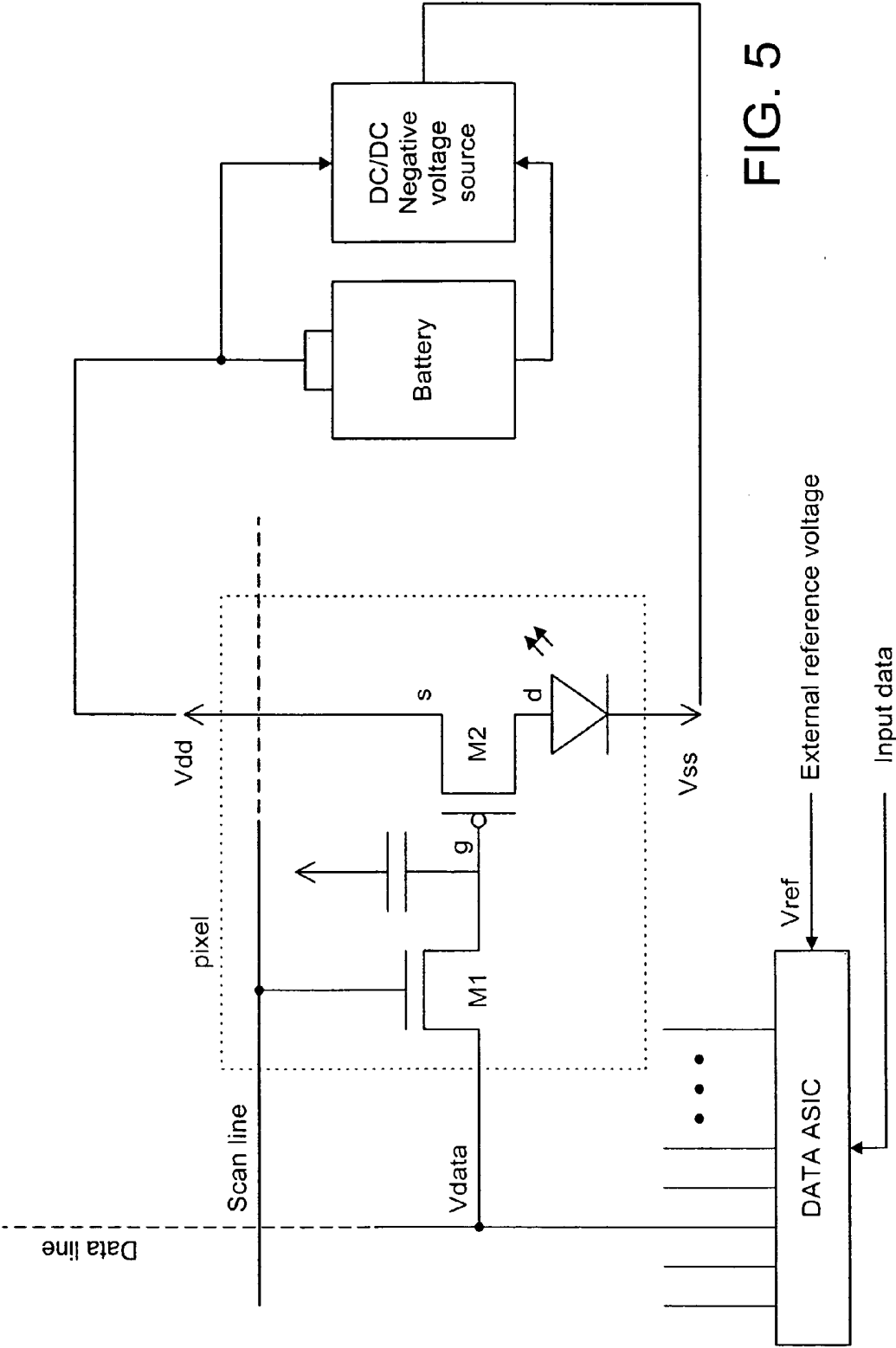


FIG. 5

ORGANIC ELECTRO-LUMINESCENT DISPLAY DEVICE AND METHOD FOR MAKING SAME

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates generally to a display device having organic light emitting diodes (OLEDs) or polymeric light emitting diodes (PLEDs) as light emitters. More specifically, the present invention relates to a method for encapsulating such display devices.

BACKGROUND OF THE INVENTION

[0002] Organic light emitting diodes (OLEDs) and polymeric light emitting diodes (PLEDs) are becoming increasingly popular for applications such as display, illumination, and backlighting. The heart of a typical organic flat panel display device is a two-dimensional pixel array disposed on a flat, transparent substrate. As shown in FIG. 1, the pixel array is typically constructed by depositing, on a substrate 10, an anode layer 26 made of a transparent conductive thin film, such as indium tin oxide (ITO), several layers of organic electro-luminescent materials 24, and a cathode layer 22. When a voltage is applied between the anode and the cathode, visible light emits from the electro-luminescent materials. Light emitted by the pixel array is transmitted through the transparent anode 26 and the substrate 10.

[0003] Because of the intrinsic properties of the materials, the pixel array of the above construction is highly susceptible to deterioration caused by oxygen and water vapor. For that reason, it has become common practice to construct a protective cover 30 on the pixel array, preferably encapsulating the pixel array. The protective cover may comprise one or more layers of inorganic or organic materials such as silicon oxides, silicon nitrides and polymers. With the protective cover properly disposed on the light-emitting materials, the display device is, to a certain extent, protected against air and moisture.

[0004] Various encapsulation structures are known in the art. For example, Graff et al (U.S. Pat. No. 6,573,652) discloses a display device encapsulated with a barrier stack comprising barrier layers and polymer layers. The barrier layers are disposed adjacent to the display device with a thickness of 100-400 Å, and the polymer layers are disposed adjacent to the barrier layers with a thickness of 1000-10,000 Å. Biebuyck et al. (U.S. Pat. No. 5,895,228), Affinito (U.S. Pat. No. 6,268,695), Terasaki et al. (U.S. Pat. No. 6,432,516) and Silvermail et al. (U.S. Pat. No. 6,597,111) also disclose similar layers of protective material disposed on top of the active layers of display devices.

[0005] The main purpose of having the protective cover encapsulating the display device, as disclosed in prior art, is to protect the environmentally sensitive display materials against moisture and oxygen in the air. The protective cover in the prior art display devices, however, is not suitable for protecting the light emitting elements in the display device from accidental physical damages, especially during the manufacturing processes.

[0006] Thus, it is advantageous and desirable to provide a method to protect a display device having a light-emitting layer from physical damages caused by the scratching by finger nails, dust particles, and metal debris, for example.

SUMMARY OF THE INVENTION

[0007] A display device, according to the present invention, has a protective structure for protecting the light

emitting elements against physical damages. The display device comprises a substrate, an electroluminescent display element disposed on the substrate, one or more layers of barrier against moisture and harmful gaseous elements, and a scratch resistant layer to protect the display element and the barrier from physical damages. The scratch resistant layer can be made of metals, high polymers, glasses and ceramics such that the hardness of the scratch resistant layer is equal to or greater than 2.5 on Moh's scale of hardness. Preferably, the thickness of the scratch resistant layer is equal to or greater than 10 µm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The above and other objects, features and advantages of the invention will become apparent upon reading the description taken in connection with accompanying drawings, in which:

[0009] FIG. 1 is a schematic cross sectional view of a typical electroluminescent display device;

[0010] FIG. 2 is a schematic cross sectional view of an exemplary electroluminescent display device with a scratch-resistant layer, according to a first embodiment of the invention;

[0011] FIG. 3 is a schematic cross sectional view of an exemplary electroluminescent display device with a scratch-resistant layer, according to a second embodiment of the invention;

[0012] FIG. 4 is a schematic cross sectional view of an exemplary electroluminescent display device with scratch-resistant layer, according to a third embodiment of the invention; and

[0013] FIG. 5 is a schematic representation of an electroluminescent display with a plurality of pixels arranged in a two-dimensional array.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The electroluminescent display device, according to the present invention, comprises a scratch resistant layer as a part of a protective structure encapsulating the active display materials of the device. A schematic representation of the electroluminescent display device is shown in FIG. 5. The material suitable for the scratch resistant layer has a hardness level of at least 2.5 on Moh's scale of hardness. The invention is further explained in the following exemplary embodiments.

First Embodiment of the Invention

[0015] The first embodiment of the invention is shown in FIG. 2. As shown, the display device 100 has a substrate 10 and an electroluminescent display element (26, 24, 22) disposed on the substrate. The display element is known in the art as described in the background section, and schematically shown in FIG. 5. Typically it comprises an anode 26 made of a transparent material, such as indium tin oxide, a plurality of active layers 24 to produce electroluminescence, and a cathode layer 22. One or more layers of thin film 30 are disposed above and surround the layered structure, forming a barrier against moisture and air. One or more layers of scratch-resistant material is disposed above and surrounding the barrier thin film layers 30 to form a pro-

protective cover **40**. Such material, when formed, must have a hardness level at least 2.5 on Moh's scale of hardness, and the thickness of scratch resistant layer is preferably greater than 10 μm so as to protect the barrier thin film layers **30** and the electroluminescent layered structure against physical damages. Since the thickness of the cover must be sufficient to ensure the hardness requirement, it may be significantly thicker than the protective thin films. The thickness of the protective cover **40** is preferably greater than 10 μm . Numerous dense and hard solid materials may be used, such as metals, glasses, ceramics, polymers and epoxy resins. Coupling of this cover to the barrier thin film layers **30** and the substrate **10** can be achieved by adhesion, chemical vapor deposition, or coating, depending on the nature of the material.

Second Embodiment of the Invention

[0016] The second embodiment of the invention is shown in FIG. 3. As shown, the display device **100'** has a sealing member **50**, such as a UV curable adhesive, disposed on the substrate **10** at the area surrounding the display element (**26**, **24**, **22**) and the barrier **30**. A plate **42** made of a suitable hardness material is laid above the barrier **30** and is connected to the substrate by the adhesive. Again, the hardness of the plate **42** must be at least 2.5 on the Moh's hardness scale. When the adhesive is cured, the display element is hermetically sealed from the atmosphere by the plate **42**, the substrate **10** and the sealing member **50**. Preferably, the plate **42** is separated from the display element by an air gap **60**.

Third Embodiment of the Invention

[0017] The third embodiment of the invention is shown in FIG. 4. As shown, the display device **100''** has a thin layer of sealing material **52**, such as a UV curable adhesive, disposed on top of the barrier **30**. A plate **42** made with a high hardness material is secured to barrier and the display element by the sealing material. When the adhesive is cured, the plate **42** and the barrier **30** form a protective structure for the display.

[0018] In the above embodiments, most metals can be used to produce the scratch-resistant layer. The preferred polymers for use to produce the scratch-resistant layer **40**, **42** include acrylic plastic, plastic steel, and epoxy resin. As for the first embodiment, the scratch resistant cover **40** can be made of platinum, titanium and ceramic in a sputtering process, for example. Other processes suitable for producing the scratch resistant cover **40** are: chemical vapor deposition of Kelvar, Lexan and lucite, for example; plasma enhanced chemical vapor deposition (PECVD) of ceramic, for example; dipping (similar to electroplating) for producing a layer of metal such as Cu, Ag; and spin-coating of polymers.

[0019] In sum, the present invention provides a display device wherein a scratch-resistant layer (**40**, **42**) is disposed in relationship to the electroluminescent display element (**26**, **24**, **22**) so as to protect the display element against physical damages such as dust particles, metal debris, and accidental scratching by finger nails. The fabrication process of the device, in general, involves the disposing of a display element on a substrate, and the disposing of the scratch-resistant layer over and/or surrounding the display element. A moisture/oxygen barrier can be provided between the scratch-resistance layer and the display element. Adhesive can be used to provide a hermetic seal for display element

and to secure the scratch-resistant layer to the display device. As shown in FIG. 5, a typical electroluminescent display device has a plurality of pixels arranged in a two-dimensional array. One of the pixels is shown in FIG. 5. The pixel comprises a switching TFT **M1** and a driving TFT **M2**. The switching TFT **M1** is controlled by the signals in a scan line and signals (V data) in a data line. These signals are provided by a Data ASIC. The source and the drain of the TFT **M2** are connected to a DC power source.

[0020] It is to be understood that the above-described arrangements are only illustrative of the principles of the present invention. Although the invention has been described and illustrated with respect to exemplary embodiments thereof, the foregoing and various other additions and omissions may be made therein without departing from the scope of the present invention, and the appended claims are intended to cover such modifications and arrangements.

What is claimed is:

1. A display device, comprising:
 - a substrate,
 - an electroluminescent display element disposed on the substrate, and
 - a scratch resistant layer disposed in relationship to the display element, wherein the scratch resistant layer is made of a material having a hardness level of at least 2.5 on Moh's hardness scale.
2. The display device of claim 1, further comprising a barrier layer disposed between the display element and the scratch resistant layer.
3. The display device of claim 2, further comprising a sealing element for securing the scratch resistant layer to the substrate.
4. The display device of claim 3, wherein the sealing element is adapted to form a hermetic seal surrounding the display element and the barrier layer.
5. The display device of claim 3, wherein the scratch resistant layer is separated from the barrier layer by a predetermined gap.
6. The display device of claim 2, further comprising a sealing element for securing the scratch resistant layer to the barrier layer.
7. The display device of claim 1, wherein the scratch resistant layer is made of a polymer disposed on the display element.
8. The display device of claim 1, wherein the scratch resistant layer comprises a metal layer.
9. The display device of claim 1, wherein the scratch resistant layer comprises a ceramic layer.
10. The display device of claim 1, wherein the scratch resistant layer has a thickness substantially equal to or greater than 10 μm .
11. A method of producing a display device, comprising the steps of:
 - disposing an electroluminescent display element on a substrate, and
 - disposing a scratch resistant layer in relationship to display element, wherein the scratch resistant layer has a hardness level at least 2.5 on Moh's hardness scale.
12. The method of claim 11, further comprising the step of:

disposing one or more layers of thin films over the display element.

13. The method of claim 11, further comprising the step of:

disposing a sealing element surrounding the display element.

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摘要(译)

一种显示装置，具有设置在基板表面上的电致发光显示元件和设置在显示元件上或周围的耐刮擦层。耐刮擦层的莫氏硬度等级的硬度水平至少为2.5。另外，在显示元件和防刮层之间设置水分和氧气阻隔层。粘合材料可用于将防刮层固定到显示装置上并为显示元件提供气密密封。优选地，耐刮擦层的厚度等于或大于10μm。

