US 20060216543A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2006/0216543 A1**

Li et al. (43) **Pub. Date: Sep. 28, 2006**

(54) **ORGANIC ELECTRO-LUMINESCENCE DEVICE**

(75) Inventors: **Shi-Hao Li**, Panchiao City (TW); **Chung-Yeh Iou**, Wu Chi Chen (TW)

Correspondence Address:
BRUCE H. TROXELL
SUITE 1404
5205 LEESBURG PIKE
FALLS CHURCH, VA 22041 (US)

(73) Assignee: **AU Optronics Corp.**

(21) Appl. No.: **11/315,172**

(22) Filed: **Dec. 23, 2005**

(30) **Foreign Application Priority Data**

Mar. 25, 2005 (TW)..... 94109258

Publication Classification

(51) **Int. Cl.**
H01L 51/54 (2006.01)
H05B 33/12 (2006.01)

(52) **U.S. Cl.** **428/690**; 428/917; 313/504; 313/506

(57) **ABSTRACT**

An organic electro-luminescence device includes a substrate, a hole injection layer disposed on the substrate, an organic layer disposed on the hole injection layer, a buffer layer disposed on the organic layer, and an electron injection layer forming above the buffer layer. The buffer layer is needed for protecting the organic layer while the electron injection layer is being formed. Within, the organic layer includes a light-emitting layer and an electron transporting layer disposed on the light-emitting layer. The electron transporting layer includes Cesium fluoride.

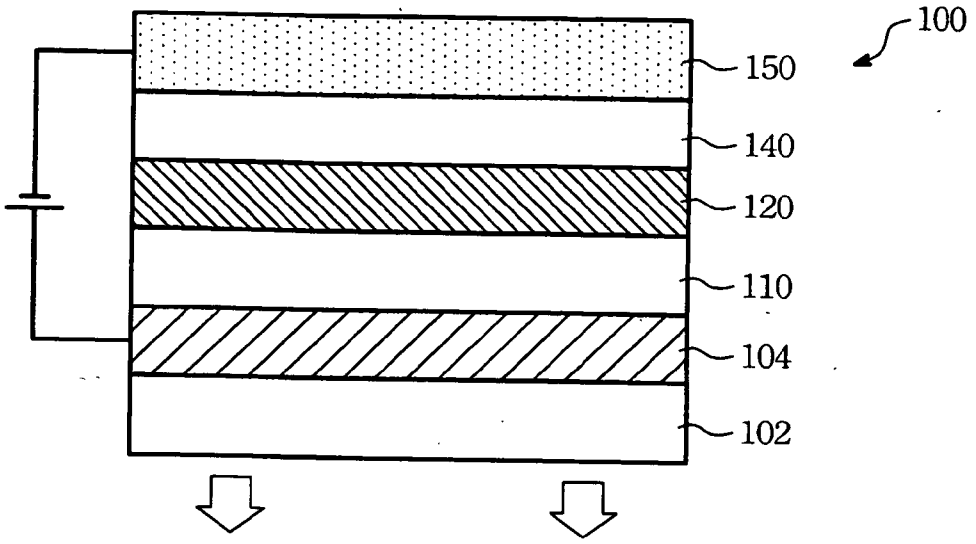

Fig. 1 (Prior Art)

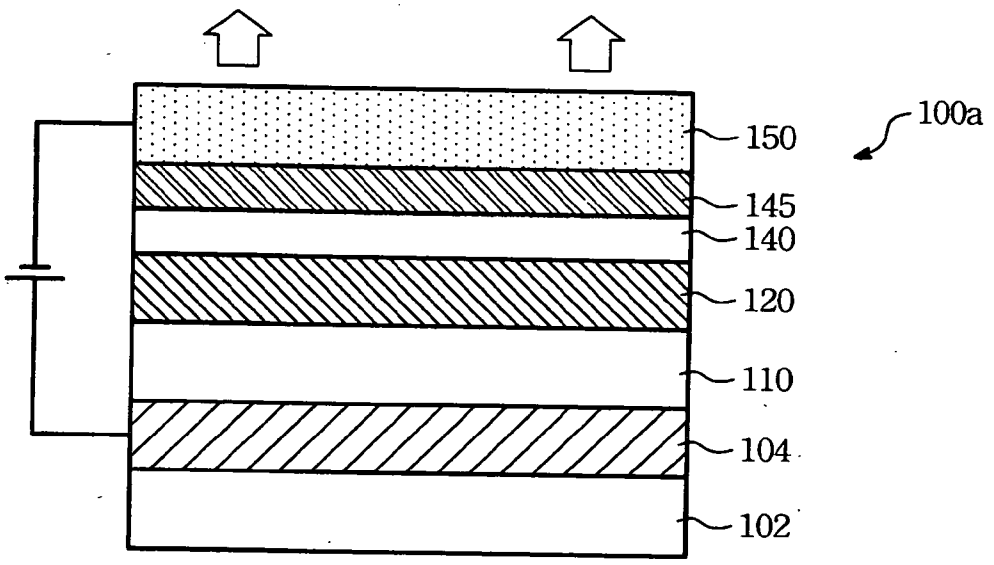

Fig. 2 (Prior Art)

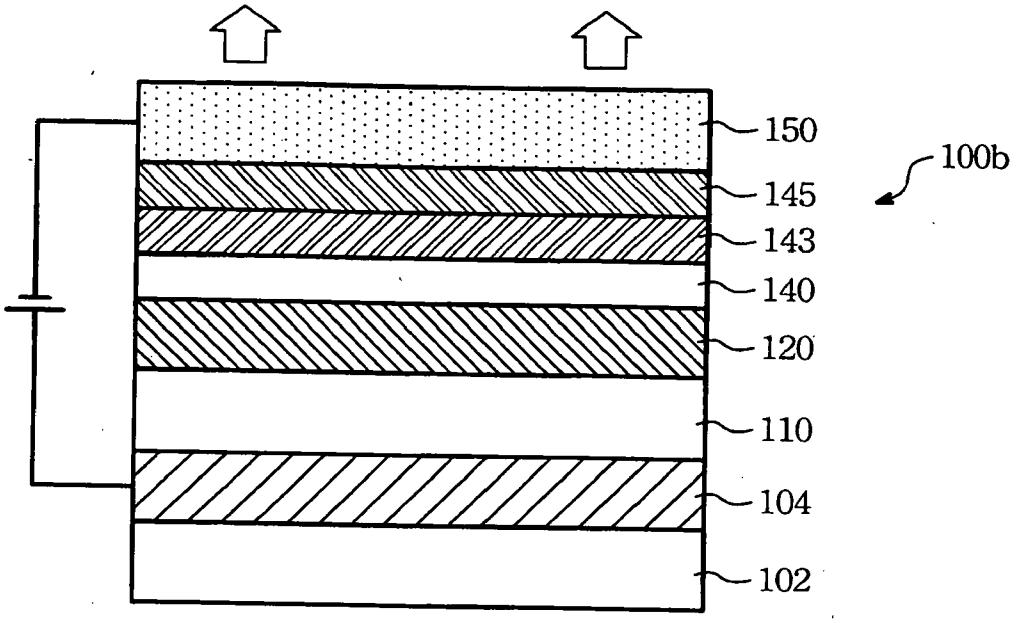

Fig. 3 (Prior Art)

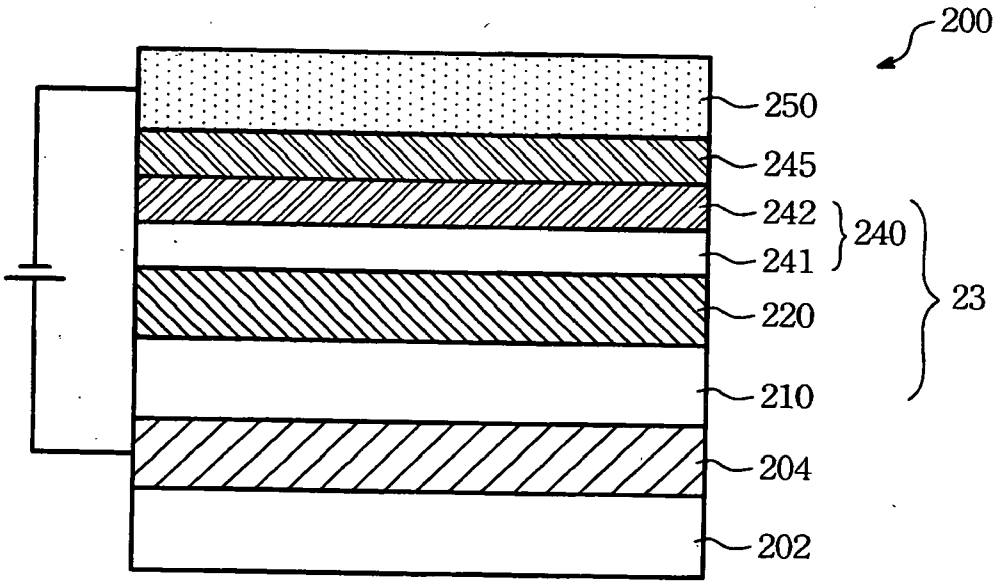

Fig. 4

ORGANIC ELECTRO-LUMINESCENCE DEVICE

BACKGROUND OF THE INVENTION

[0001] (1) Field of the Invention

[0002] The present invention relates generally to organic electro-luminescence devices (OLEDs) and particularly to a top-emission organic electro-luminescence device.

[0003] (2) Description of the Prior Art

[0004] Organic electro-luminescence devices become popular in display technology these days. Comparing to another popular display—liquid crystal display (LCD), the organic electro-luminescence devices have the advantage of self light-emitting. Hence, backlight module is no more needed in a panel display applied OLEDs.

[0005] Please refer to **FIG. 1**, which is a cross-section view of the structure of an organic electro-luminescence device. The electro-luminescence device **100** comprises, in the sequence from bottom to top, a substrate **102**, a hole injection layer **104**, a hole transport layer **110**, a light-emitting layer **120**, an electron transporting layer **140**, and an electron injection layer **150**. Wherein the hole transport layer **110**, the light-emitting layer **120**, and the electron transporting layer **140** are made of organic materials and fabricated via organic processes.

[0006] Combination of electron and hole in the light-emitting layer **120** would release photons. In the process, electrical energy is converted to optical energy. As shown in **FIG. 1**, the generated light leaves the electro-luminescence device **100** through its bottom (the substrate **102**). So the electro-luminescence device **100** is also named as an "bottom-emission type". Wherein, the hole injection layer **104** is usually made of ITO material, which is know as a light-transparent material. The electron injection layer **150** is made of light-reflecting metal materials with low work function, for instance, Al, Ca, Mg, and Ag are well suited. The light-reflecting character of above materials forces the generated light leave the organic electro-luminescence device **100** via the substrate **102**.

[0007] However, some essential wires are disposed on the substrate **102**. As to an active-matrix organic light emitting display (AM OLED), it even needs thin film transistors (TFTs) array on the substrate **102**. Said wires or TFTs would restrict the light utilizing efficiency because of a limited aperture ratio.

[0008] Please refer to **FIG. 2**. A prior "top-emission type" organic electro-luminescence device **100*a*** is presented. Wherein, the generated light leaves the organic electro-luminescence device **100*a*** via the electron injection layer **150**. In this case, the electron injection layer **150** should be made of light transparent materials, usually ITO, which is also conductive. Because the needed wires or TFTs are made on the substrate **102**, no aperture ratio issue should be concerned in the top-emission type organic electro-luminescence device **100*a***. Comparing to the organic electro-luminescence device **100** of **FIG. 1**, the organic electro-luminescence device **100*a*** could provide a better light utilizing efficiency.

[0009] While applying conductive transparent material like ITO for the electron injection layer **150**, a major issue is that sputtering process of the ITO material would damage the organic materials (**140**) beneath. Please refer to **FIG. 2**, a buffer layer **145** made of CuPc is therefore provided by G. Parthasaraty et al. Before forming the electron injection layer **150**, the buffer **145** is formed firstly to withstand the sputtering process. However, while practical estimated, the electron injection efficiency of the organic electro-luminescence device **100*a*** is too poor to apply in commercial application. An experiment data shows that the organic electro-luminescence device **100*a*** according to G. Parthasaraty et al. has an electron injection efficiency of 3.7 mA/cm^2 with a working voltage at 6 V, mean while, the energy efficiency is less than 1 lm/W.

[0010] Please refer to **FIG. 3**. Another prior organic electro-luminescence device **100*b*** provided by Hung Liang-sun et al. is presented. Before sputtering the buffer layer **145**, a LiF/AL interface layer **143**[thickness of AL is about 10~20 A], which is a thin metal layer, is sputtered firstly. Wherein, the buffer layer **145** still comprises CuPc compound. Diffusion of Li from the LiF/AL interface layer **143** to the underneath organic materials (**140**) could lower the energy barrier of Al chelate in the electron transporting layer **140**. From this view, Hung Liang-sun et al. seems have been solved the problem of the organic electro-luminescence device **100*a*** taught by G. Parthasaraty et al.

[0011] However, please still refer to **FIG. 3**, Li of the LiF/AL interface layer **143** could further diffuse into the light-emitting layer **120**. This may decrease the life time of the organic electro-luminescence device. Furthermore, the light-emitting layer **120**, the electron transporting layer **140**, and the buffer layer **145** is fabricated in organic chamber, but the LiF/AL interface layer **143** is fabricated in a metal chamber. Hence the fabrication process of the organic electro-luminescence device **100*b*** comprises moving to the metal chamber after forming the light-emitting layer **120** and the electron transporting layer **140** in a organic chamber, then moving to a organic chamber, finally moving to a sputtering chamber to from the electron injection layer **150**. The complicated process (at least three times of movement between different chambers) is a disadvantage of organic electro-luminescence device **100*b***.

[0012] Therefore, how to provide a top-emission organic electro-luminescence device, which overcomes the mentioned problems—the damage of sputtering process, the low electron injection efficiency, the decreased life time of organic materials and the complicated fabrication process, is the major issue of the present invention.

SUMMARY OF THE INVENTION

[0013] It is an object of the present invention to provide an organic electro-luminescence device with high electron injection efficiency.

[0014] It is another object of the present invention to solve the prior disadvantage of decreased life time of organic materials.

[0015] It is another object of the present invention to provide a method for fabricating an organic electro-luminescence device without complicated process.

[0016] The present invention relates to an organic electro-luminescence device including a substrate, a hole injection layer disposed on the substrate, an organic layer disposed on the hole injection layer, a buffer layer disposed on the

organic layer, and an electron injection layer forming above the buffer layer. The buffer layer is needed for protecting the organic layer while the electron injection layer is being formed. Within, the organic layer at least includes a light-emitting layer, and an electron transporting layer disposed on the light-emitting layer. The electron transporting layer at least includes cesium fluoride to lower an energy barrier.

[0017] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment which is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The present invention will now be specified with reference to its preferred embodiment illustrated in the drawings, in which:

[0019] **FIG. 1** shows a cross section view of an bottom-emission type organic electro-luminescence device in accordance with a prior art;

[0020] **FIG. 2** shows a cross section view of a top-emission type organic electro-luminescence device in accordance with a prior art;

[0021] **FIG. 3** shows another cross section view of a top-emission type organic electro-luminescence device in accordance with another prior art; and

[0022] **FIG. 4** shows a cross section view of the organic electro-luminescence device of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0023] The invention aims at providing an organic electro-luminescence devices and particularly to a top-emission organic electro-luminescence device, which has high current injection efficiency, relatively loner life time, and can be fabricated with relatively simplified processes.

[0024] Please refer to **FIG. 4**, which is a cross section view of an organic electro-luminescence device of the present invention. While fabricating the organic electro-luminescence device **200**, a substrate **202** is provided first, then a hole injection layer **204** is disposed on the substrate **202**. In one embodiment, the substrate **202** is made of light transparent materials or opaque materials with light reflection character. The hole injection layer **204** is made of conductive transparent materials (for instance, ITO, IZO) via sputtering process.

[0025] Next, an organic layer **23** is disposed on the hole injection layer **204**. Wherein the organic layer **23** is an multi-layer structure. It at least comprises a light-emitting layer **220** and a electron transporting layer **240**. The electron transporting layer **240** is disposed on the light-emitting layer **220**. The electron transporting layer **240** includes Cesium fluoride. The organic layer **23** further comprises a hole transport layer **210** between the light-emitting layer **220** and the hole injection layer **204**.

[0026] The material of the light-emitting layer **220** is selected from the group of fluorescent dyes, phosphorous dyes, or chelate materials. For instance, materials selected from the group of Alq3、NPB、CuPc、C545T、DCJTB、CBP、Balq、Ir(ppy)3 are applied in separated embodiments of the present invention. The method for forming the light-emitting layer **220** is select from vacuum sputtering, plasma polymerization, vacuum evaporating, spin coating, dip coating, Langmuir-Blodgett Film tech., Sol-Gel tech., electrolytic polymerization.

[0027] Afterwards, the electron transporting layer **240** is disposed on the light-emitting layer **220**. The method of fabricating the electron transporting layer **240** comprises the following steps, in sequence: (1) disposing a metal chelate material above the light source **220** and (2) doping a CsF compound into the metal chelate material. Wherein the metal chelate material is an aluminum chelate (Alq3), and the doping process is via thermal evaporation.

[0028] The doping process of CsF is an partially doping process. Only the top portion of the electron transporting layer **240** is doped with CsF. The other portion of the electron transporting layer **240** is undoped. So the electron transporting layer **240** is a double-layer structure. In **FIG. 4**, the electron transporting layer **240** comprises a first electron transporting layer **241** and a second electron transporting layer **242**. The second electron transporting layer **242** is positioned above the first electron transporting layer **241**. The second electron transporting layer **242** comprises the CsF compound and the metal chelate material. The first electron transporting layer **241** comprises the metal chelate material, for instance, the aluminum chelate.

[0029] A buffer layer **245** is disposed on the organic layer **23**. Wherein, the buffer layer **245** includes a phthalocyanine-based organic compound, for instance, phthalocyanine-Cu complex. All the above processes (from forming the organic layer **23** to the forming of the buffer layer **245**) is able to be accomplished in an organic chamber. Even the forming process of the electron transporting layer **240** is accomplished in the same organic chamber. Hence, no chamber-transferring is needed during these processes.

[0030] Lastly, the electron injection layer **250** is disposed on the buffer layer **245**. The electron injection layer **250** is made of conductive transparent materials, such as ITO or IZO, via a high energy sputtering process. One function of the buffer layer **245** is to protect the underneath layers from the damage aroused from the high energy sputtering process.

[0031] According to the above description, the present fabrication method of the organic electro-luminescence device **200** is much simpler than the mentioned prior arts. According to the teaching of Hung Liang-sun et al., three times of chamber transferring are needed after forming the light-emitting layer (organic chamber→metal chamber→organic chamber→sputtering chamber). But the processes of the present invention are able to be accomplished in the organic chamber from the forming process of the light-emitting layer **120** to the forming process of the buffer layer **245**. Only one chamber transferring is needed at the forming process of the electron injection layer **250**, which is in the sputtering chamber. Hence, the drawback of complicated process of mentioned prior arts is removed.

[0032] An experimental data via the present invention shows that the organic electro-luminescence device **200** has an electron injection efficiency of 52 mA/cm^2 with a working voltage at 6 V. Obviously, the efficiency is much better than the mentioned prior arts according to G. Parthasaraty et

al. and Hung Liang-sun et al. Mean while, the energy efficiency of the present invention is about 11.6 lm/W, which also overcomes the mentioned prior arts (1 lm/W for G. Parthasaraty et al. and 9 lm/W for Hung Liang-sun et al.).

[0033] Furthermore, the life time of the organic electro-luminescence device **200** is longer than 1500 hours with a brightness of 2000 nits. Clearly, the disadvantage of decreased life time due by diffusion of Li is improved in the present invention. The present organic electro-luminescence device has a relatively longer life time.

[0034] As can be understood by a person skilled in the art, the foregoing preferred embodiment of the present invention is illustrated of the present invention rather than limiting of the present invention. It is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims, the scope of which should be accorded the broadest interpretation so as to encompass all such modifications and similar structure.

[0035] While the present invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be without departing from the spirit and scope of the present invention.

We claim:

1. An organic electro-luminescence device comprises:

a substrate;

a hole injection layer disposed on the substrate;

an organic layer, disposed on the hole injection layer, having a light-emitting layer and an electron transporting layer disposed on the light-emitting layer, wherein the electron transporting layer comprises cesium fluoride;

a buffer layer disposed on the organic layer; and

an electron injection layer disposed on the buffer layer.

2. The organic electro-luminescence device according to claim 1, wherein the electron transporting layer comprises a metal chelate compound.

3. The organic electro-luminescence device according to claim 2, wherein the metal chelate compound comprises an aluminum chelate.

4. The organic electro-luminescence device according to claim 1, wherein the electron transporting layer comprises a first electron transporting layer and a second electron transporting layer comprising cesium fluoride.

5. The organic electro-luminescence device according to claim 4, wherein the second electron transporting layer comprises a metal chelate compound.

6. The organic electro-luminescence device according to claim 5, wherein the metal chelate compound comprises an aluminum chelate.

7. The organic electro-luminescence device according to claim 4, wherein the first electron transporting layer comprises a metal chelate compound.

8. The organic electro-luminescence device according to claim 7, wherein the metal chelate compound comprises an aluminum chelate.

9. The organic electro-luminescence device according to claim 1, wherein the buffer layer comprises a phthalocyanine-based organic compound.

10. The organic electro-luminescence device according to claim 1, wherein the buffer layer comprises copper phthalocyanine (CuPc).

11. The organic electro-luminescence device according to claim 1, wherein the organic layer further has a hole transporting layer disposed under the light-emitting layer.

* * * * *