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Chen et al.

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(54) **BOTTOM AND TOP EMISSION OLED PIXEL STRUCTURE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(51) **Int. Cl.**
G09G 3/10 (2006.01)
G09G 3/32 (2006.01)

(52) **U.S. Cl.** **315/169.1**; 345/60; 345/82; 345/90; 315/169.3

(58) **Field of Classification Search** 315/169.1, 315/169.2, 169.3; 345/36, 45, 60, 68, 82, 345/90
See application file for complete search history.

(56) **References Cited**

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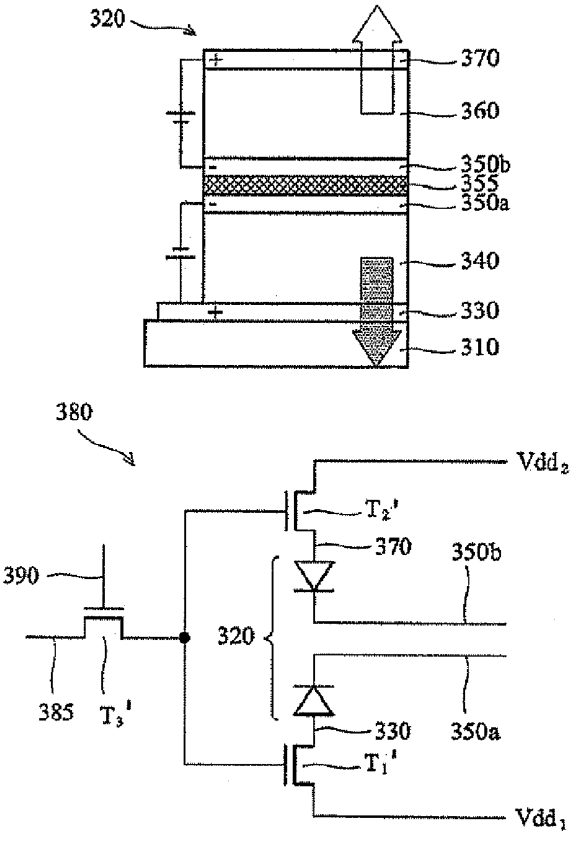
(74) *Attorney, Agent, or Firm*—Duane Morris, LLP

(57) **ABSTRACT**

A bottom and top emission OLED structure includes: first and second anodes; first and second organic light-emitting layers disposed between the first and second anodes. A first electrode may be disposed between the first and second organic light-emitting layers or first and second electrically isolated electrodes may be disposed between the first and second organic light-emitting layers.

4 Claims, 5 Drawing Sheets



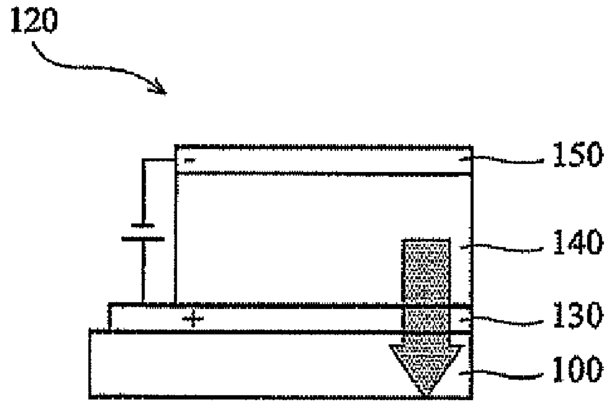


FIGURE 1A (Prior Art)

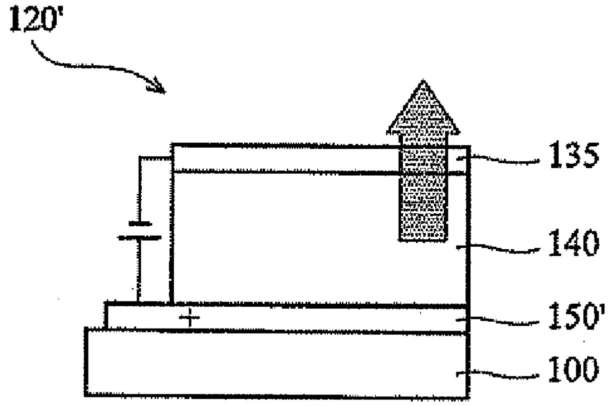


FIGURE 1B (Prior Art)

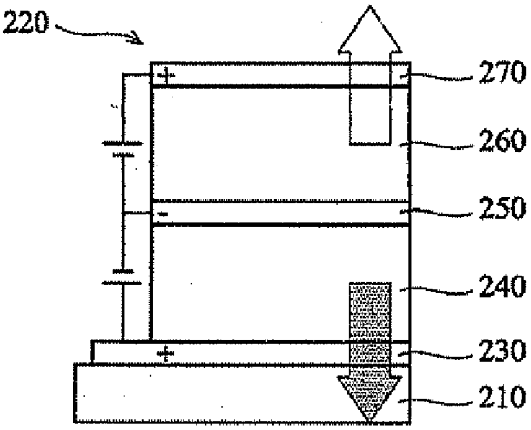


FIGURE 2A

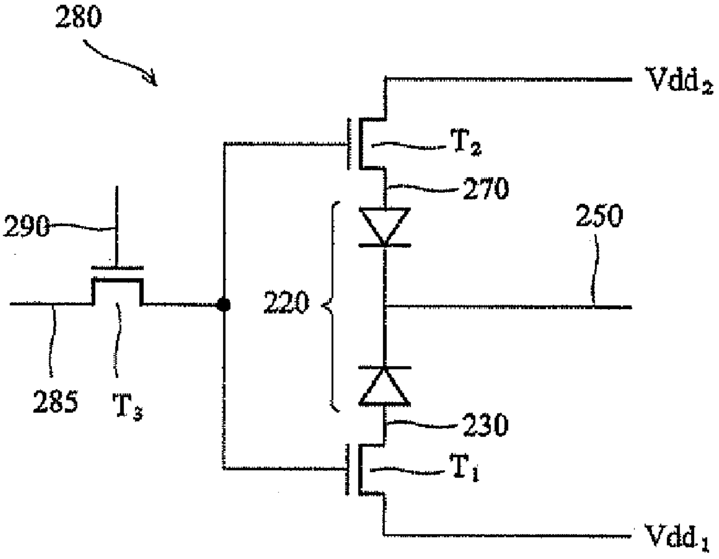


FIGURE 2B

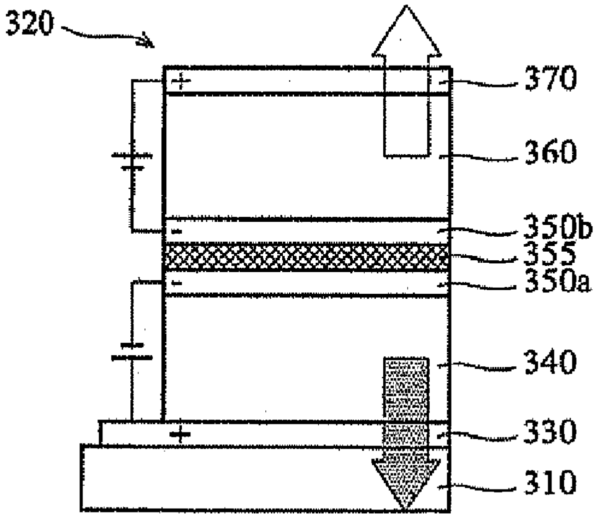


FIGURE 3A

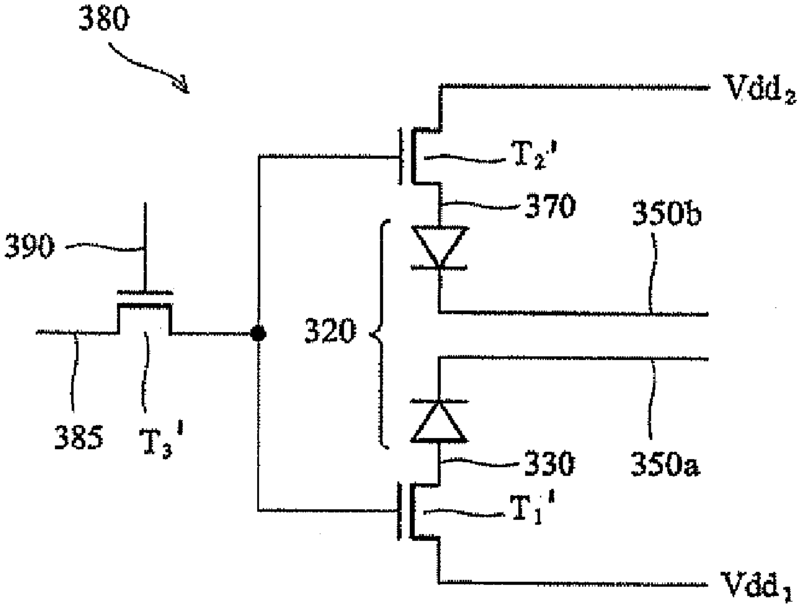


FIGURE 3B

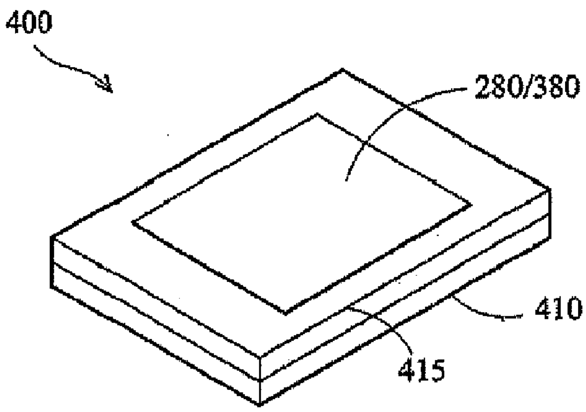


FIGURE 4A

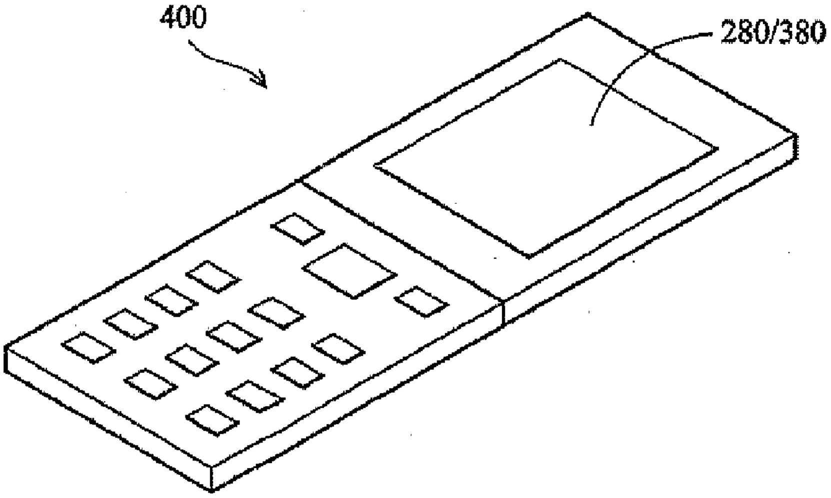


FIGURE 4B

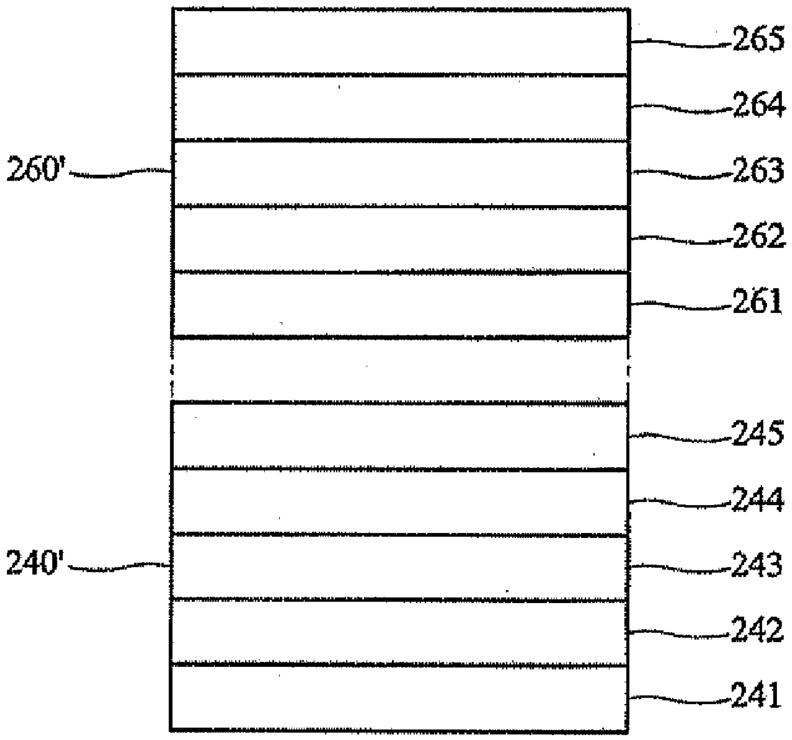


FIGURE 5

BOTTOM AND TOP EMISSION OLED PIXEL STRUCTURE

FIELD OF INVENTION

The present invention relates to light-emitting diode pixel structures for flat panel displays, and more particularly, to a light-emitting diode pixel structure that is capable of top and bottom emission, and a display structure that utilizes such a pixel structure.

BACKGROUND OF THE INVENTION

There are many types of flat panel displays that have been and are currently being developed. One popular type of flat panel display is a liquid crystal display (LCD). LCDs generally perform well, but have somewhat narrow viewing angles, relatively slow signal response times, and require background lighting. Consequently, LCDs are not at their best for high-speed image animation and consume additional energy powering the background lighting. In addition, large LCDs are difficult to produce.

Organic light emitting diode (OLED) displays have been developed to address the disadvantages of LCDs. Unlike LCDs, which modulate light generated by their background lighting systems, OLED displays emit light via an array of OLED-based pixels.

FIGS. **1**A and **1**B respectively illustrate conventional bottom and top emission OLED pixel structures **120**, **120'**. The bottom emission OLED pixel structure **120** shown in FIG. **1**A, is constructed on a transparent substrate **100** and includes: a bottom, transparent anode **130** disposed on the substrate **100**; an organic light-emitting layer **140** containing an organic light-emitting material disposed on the anode **130**; and a top, metal electrode **150** disposed on the organic light-emitting layer **140**. Light is emitted from the bottom of the OLED pixel structure **120** by the light-emitting layer when an electric current passes between the anode **130** and the metal electrode **150**.

The top emission OLED pixel structure **120'** shown in FIG. **1**B, is constructed on a transparent substrate **100** and includes: a bottom, metal electrode **150'** disposed on the substrate **100**; an organic light-emitting layer **140** containing an organic light-emitting material disposed on the metal electrode **150'**; and a top, transparent cathode **135** disposed on the organic light-emitting layer **140**. Light is emitted from the top of the OLED pixel structure **120'** by the light-emitting layer **140** when an electric current passes between the metal electrode **150'** and the cathode **135**.

Although conventional bottom and top emission OLED pixel structures are satisfactory for OLED display applications that only require images to be displayed on one side of the display, there are potential OLED display applications that require images to be displayed on both sides of the display. Such a two-sided OLED display would require an OLED pixel structure that emits light from the top and the bottom.

Accordingly, a need exists for an OLED pixel structure that is capable of emitting light from the top and bottom thereof.

SUMMARY OF INVENTION

A bottom and top emission OLED structure is disclosed herein. The OLED pixel structure comprises: first and second anodes; first and second organic light-emitting layers disposed between the first and second anodes. In a first embodiment, a first electrode is disposed between the first and second organic light-emitting layers. In a second embodiment, a first and second electrically isolated electrodes are disposed between the first and second organic light-emitting layers.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A shows a cross-sectional view of a conventional bottom emission OLED pixel structure.

FIG. **1**B shows a cross-sectional view of a conventional top emission OLED pixel structure.

FIG. **2**A shows a cross-sectional view of a bottom and top emission OLED pixel structure according to a first embodiment of the invention.

FIG. **2**B shows a schematic diagram of the bottom and top emission OLED pixel structure of FIG. **2**A in an active matrix display.

FIG. **3**A shows a cross-sectional view of a bottom and top emission OLED pixel structure according to a second embodiment of the invention.

FIG. **3**B shows a schematic diagram of the bottom and top emission OLED pixel structure of FIG. **3**A in an active matrix display.

FIGS. **4**A and **4**B show are perspective views of a telecommunication device that utilizes the active matrix display of FIGS. **2**B or **3**B. FIG. **4**A shows the device in a flip-up position and FIG. **4**B shows the device in a flip-down position.

FIG. **5** shows a cross-sectional view of a bottom and top emission OLED pixel structure according to a third embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **2**A is a cross-sectional view of a bottom and top emission OLED pixel structure **220** according to a first embodiment of the invention. As shown in FIG. **2**A, the OLED pixel structure **220** is constructed over a transparent substrate **210** which may be a glass panel, a plastic panel or a flexible panel, for example. As further shown in FIG. **2**A, the OLED pixel structure **220** includes a transparent, bottom anode **230**, a bottom organic light-emitting layer **240**, a common metal electrode **250**, a top organic light-emitting layer **260**, and a transparent, top anode **270**. The bottom anode **230**, bottom organic light-emitting layer **240**, common metal electrode **250**, top organic light-emitting layer **260**, and top anode **270** are sequentially formed over the transparent substrate **210**.

The bottom and top anodes **230**, **270** inject electron holes into their respective bottom and top light-emitting layers **240**, **260** in an efficient manner. Thus, each of the anodes **230**, **270** preferably have a work function greater than 4.5eV. The transparent top and bottom anodes **230**, **270** may be formed from the same material or from different materials. Such materials include, without limitation, indium-tin-oxide (ITO), tin oxide, gold, silver, platinum or copper.

The bottom and top organic light-emitting layers **240**, **260** may be the single layer structure shown in FIG. **2**A, a multilayered structure as shown in FIG. **5**, or a combination thereof. FIG. **5** shows an exemplary embodiment wherein the bottom and top organic light-emitting layers **240'**, **260'** are formed by multilayered structures. The bottom organic light-emitting layer **240'** is formed by a hole injection layer **241**, a hole transporting layer **242**, an emission layer **243**, an electron transporting layer **244**, and an electron injection layer **245**. The top organic light-emitting layer **260'** is formed by an electron injection layer **261**, an electron transporting layer **262**, an emission layer **263**, a hole transporting layer **264**, and a hole injection layer **265**.

The materials used for these single or multilayered light-emitting structures **240**, **260** include, without limitation, light-emitting polymeric materials or light-emitting small organic molecules formed, for example, by spin coating. The top and bottom organic light-emitting layers **240**, **260** each produce light of a desired color according to the energy gap between the base state and the activated state of the material used for that layer.

The common metal electrode **250** is disposed between the bottom and top light-emitting layers **240**, **260** for injecting electrons into the light-emitting layers **240**, **260** in an efficient manner. The common metal electrode **250** can be a single conductive layer having a high work function such as an aluminum layer or a silver layer. Alternatively, the common electrode **250** can be a double conductive layer such as a lithium fluoride/aluminum layer, a barium/aluminum layer or a magnesium/silver layer. The common metal electrode **250** may be formed, for example, by vacuum evaporation.

In operation, light is emitted from the bottom or top (or both bottom and top) of the OLED pixel structure **220** by the structure's respective bottom and top light-emitting layers **240**, **260** when an electric current is passed between the bottom anode **230** and common metal electrode **250** and/or top anode **270** and the common metal electrode **250**.

FIG. **2**B is a schematic diagram showing the bottom and top emission OLED pixel structure **220** of FIG. **2**A in an active matrix display **280**. Although only one OLED pixel structure **220** is shown in FIG. **2**B, it should be understood that such a display would contain an array of OLED pixel structures **220**. As shown in FIG. **2**B, the bottom anode **230** of the OLED pixel structure **220** is electrically coupled to a source electrode of a first driving transistor T**1** and the top anode **270** of the OLED pixel structure **220** is electrically coupled to a source electrode of a second driving transistor T**2**. The common metal electrode **250** is electrically coupled to common voltage (Vcom). Drain electrodes of the first and second transistors T**1** and T**2** are electrically coupled to Vdd**1** and Vdd**2** bus lines respectively and gate electrodes of the first and second transistors T**1** and T**2** are electrically coupled to a drain electrode of a switching transistor T**3**. A source electrode of the switching transistor T**3** is electrically coupled to a data line **285** and a gate electrode of the switching transistor T**3** is electrically coupled to a scan line **290**. The transistors T**1**, T**2**, and T**3** forming the active matrix control components may be PMOS or NMOS. In the shown embodiment of FIG. **2**B, the transistors T**1**, T**2**, and T**3** are NMOS.

FIG. **3**A is a cross-sectional view of a bottom and top emission OLED pixel structure **320** according to a second embodiment of the invention. As in the first embodiment, the OLED pixel structure **320** is constructed over a transparent substrate **310** which may be a glass panel, a plastic panel or a flexible panel, for example. The OLED pixel structure **320** of the second embodiment includes a transparent, bottom anode **330**, a bottom organic light-emitting layer **340**, a bottom metal electrode **350***a*, an insulation layer **355**, a top metal electrode **350***b*, a top organic light-emitting layer **360**, and a transparent, top anode **370**. The bottom anode **330**, bottom organic light-emitting layer **340**, bottom metal electrode **350***a*, insulation layer **355**, top metal electrode **350***b*, top organic light-emitting layer **360**, and top anode **370** are sequentially formed over the transparent substrate **310**.

The bottom and top anodes **330** and **370** of the second embodiment are similar to the bottom and top anodes of the first embodiment in construction and operation. The bottom and top organic light-emitting layers **340**, **360** of the second embodiment may also be similar to the bottom and top organic light-emitting layers of the embodiments shown in FIGS. **2**A or FIG. **5**, in construction and operation.

The bottom and top metal electrodes **350***a*, **350***b* inject electrons into their respective bottom and top light-emitting layers **340**, **360** in an efficient manner. The bottom and top metal electrodes **350***a*, **350***b* may each be formed as a single conductive layer having a high work function such as an aluminum layer or a silver layer or as a double conductive layer such as a lithium fluoride/aluminum layer, a barium/aluminum layer or a magnesium/silver layer. The bottom and top metal electrodes **350***a*, **350***b* may be formed, for example, by vacuum evaporation.

The insulation layer **355** is disposed between the bottom and top metal electrodes for electrically isolating the electrodes from one another. The insulation layer may be formed from one or more films of dielectric material such as SiOx or SiNx by a sputtering or CVD process.

In operation, light is emitted from the bottom or top (or both bottom and top) of the OLED pixel structure **320** by the structure's respective bottom and top light-emitting layers **340**, **360** when an electric current is passed between the bottom anode **330** and the metal electrode **350***a* and/or top anode **370** and the metal electrode **350***b*.

FIG. **3**B is a schematic diagram showing the bottom and top emission OLED pixel structure **320** of FIG. **3**A in an active matrix display **380**. Although only one OLED pixel structure **320** is shown in FIG. **3**B, it should be understood that such a display would contain an array of OLED pixel structures **320**. As shown in FIG. **3**B, the bottom anode **330** of the OLED pixel structure **320** is electrically coupled to a source electrode of a first driving transistor T**1'** and the top anode **370** of the OLED pixel structure **320** is electrically coupled to a source electrode of a second driving transistor T**2'**. The bottom and top metal electrodes **350***a*, **350***b* are each electrically coupled to Vcom. Drain electrodes of the first and second transistors T**1'** and T**2'** are electrically coupled to Vdd**1** and Vdd**2** bus lines respectively and gate electrodes of the first and second transistors T**1'** and T**2'** are electrically coupled to a drain electrode of a switching transistor T**3'**. A source electrode of the switching transistor T**3** is electrically coupled to a data line **385** and a gate electrode of the switching transistor T**3** is electrically coupled to a scan line **390**. The transistors T**1'**, T**2'**, and T**3'** forming the active matrix control components may be PMOS or NMOS. In the shown embodiment of FIG. **3**B, the transistors T**1'**, T**2'**, and T**3'** are NMOS.

FIGS. **4**A and **4**B show a telecommunication device **400**, such as a cellular telephone, that utilizes the active matrix display **280**, **380** of FIGS. **2**B or **3**B. The device **400** includes a main body **410** having a flip-up door **415** that contains the active matrix display panel of FIGS. **2**B or **3**B. The bottom and top emission OLED pixel structures making up the active matrix display allow the display **280**, **380** to be viewed by a user from either side of the display. Accordingly, the display **280**, **380** may be viewed by the user when the door **415** is in either the flip-up (FIG. **4**A) or flip-down position (FIG. **4**B).

The displays **280**, **380** of FIGS. **2**B and **3**B may also be used in other applications where viewing from both sides is desired.

While the foregoing invention has been described with reference to the above, various modifications and changes can be made without departing from the spirit of the invention. Accordingly, all such modifications and changes are considered to be within the scope of the appended claims.

What is claimed is:

1. A display comprising:

organic light-emitting diode structures forming an array, each of the organic light-emitting diode structures comprising:

first and second anodes;

first and second organic light-emitting layers disposed between the first and the second anodes;

a common electrode disposed between the first and the second organic light-emitting layers;

a first transistor coupled to each of the organic light-emitting diode structures, the first transistor coupled to one of the first and the second anodes of the organic light-emitting diode structures;

a second transistor coupled to each of the organic light-emitting diode structures, the second transistor coupled to the other one of the first and the second anodes of the organic light-emitting diode structures; and

a third transistor coupled to the first and the second transistors, the third transistor for switching the first and second transistors,

wherein the first organic light-emitting layer is for substantially emitting light in a first direction and the second organic light-emitting layer is for substantially emitting light in a second direction opposite to the first direction.

2. The display according to claim **1**, wherein the first and the second transistors drive the organic light-emitting diode structures.

3. The display according to claim **1**, wherein light is emitted from at least one of the first and the second organic light-emitting layers when an electric current passes between one of the first and the second anodes and the first electrode.

4. A telecommunication device comprising:

a main body;

a flip-up door connected to the main body;

a display beneath the flip-up door, the display comprising:

organic light-emitting diode structures forming an array, each of the organic light-emitting diode structures comprising:

first and second anodes;

first and second organic light-emitting layers disposed between the first and the second anodes; and

a common electrode disposed between the first and second organic light-emitting layers;

a first transistor coupled to each of the organic light-emitting diode structures, the first transistor coupled to one of the first and the second anodes of the organic light-emitting diode structures;

a second transistor coupled to each of the organic light-emitting diode structures. the second transistor coupled to the other one of the first and the second anodes of the organic light-emitting diode structures; and

a third transistor coupled to the first and the second transistors, the third transistor for switching the first and second transistors,

wherein the first organic light-emitting layer is for substantially emitting light in a first direction and the second organic light-emitting layer is for substantially emitting light in a second direction opposite to the first direction.

* * * * *

专利名称(译)	底部和顶部发光OLED像素结构		
公开(公告)号	US7250728	公开(公告)日	2007-07-31
申请号	US10/829317	申请日	2004-04-21
[标]申请(专利权)人(译)	陈文KUEN KO庄重文 李施豪		
申请(专利权)人(译)	陈文堃 KO CHUNG-WEN LEE SHI-郝		
当前申请(专利权)人(译)	友达光电股份有限公司		
[标]发明人	CHEN WEN KUEN KO CHUNG WEN LEE SHI HAO		
发明人	CHEN, WEN-KUEN KO, CHUNG-WEN LEE, SHI-HAO		
IPC分类号	G09G3/10 G09G3/32 H05B33/12 G09F9/30 G09G3/00 G09G3/30 H01L27/32 H01L33/00 H01L51/50 H05B33/00 H05B33/14 H05B33/22		
CPC分类号	H01L25/048 H01L27/3267 H01L2924/0002		
其他公开文献	US20050237279A1		
外部链接	Espacenet USPTO		

摘要(译)

底部和顶部发射OLED结构包括：第一和第二阳极;第一和第二有机发光层设置在第一和第二阳极之间。第一电极可以设置在第一和第二有机发光层之间，或者第一和第二电隔离电极可以设置在第一和第二有机发光层之间。