(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 February 2006 (23.02.2006)

PCT

(10) International Publication Number
WO 2006/020034 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/US2005/025173

(22) International Filing Date: 15 July 2005 (15.07.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/894,729 20 July 2004 (20.07.2004) US

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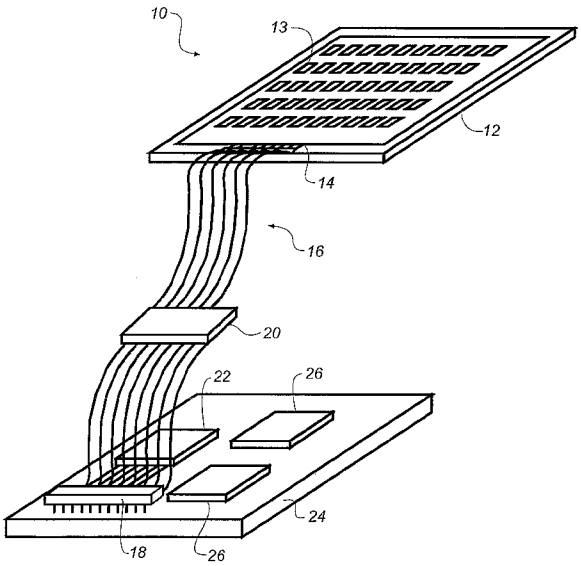
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** UNIFORMITY AND BRIGHTNESS CORRECTION IN OLED DISPLAYS



(57) **Abstract:** A system for the correction of brightness and uniformity variations in OLED displays is described, comprising: a) an OLED display including a plurality of light-emitting elements; b) a non-volatile memory having uniformity correction information for the OLED display stored therein and permanently associated with and physically attached to the OLED display; and c) a controller connected to the OLED display and to the non-volatile memory for reading the information from the non-volatile memory, receiving an input signal, correcting the input signal using the information to form a corrected input signal, and transmitting the corrected input signal to the OLED display. Also described are OLED display device units comprising an OLED display and a permanently associated non-volatile memory, and a method for the correction of brightness and uniformity variations in OLED displays.

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UNIFORMITY AND BRIGHTNESS CORRECTION IN OLED DISPLAYS

FIELD OF THE INVENTION

The present invention relates to OLED displays having a plurality of light-emitting elements and, more particularly, correcting for non-uniformities in the display.

BACKGROUND OF THE INVENTION

Organic Light Emitting Diodes (OLEDs) have been known for some years and have been recently used in commercial display devices. Such devices employ both active-matrix and passive-matrix control schemes and can employ a plurality of pixels (each comprising one or more light-emitting elements). The pixels are typically arranged in two-dimensional arrays with a row and a column address for each pixel and having a data value associated with the pixel value. However, such displays suffer from a variety of defects that limit the quality of the displays. In particular, OLED displays suffer from non-uniformities in the pixels. These non-uniformities can be attributed to both the light emitting materials in the display and, for active-matrix displays, to variability in the thin-film transistors used to drive the light emitting elements.

A variety of schemes have been proposed to correct for non-uniformities in displays by using a display controller. For example, WO2004023446 A1 entitled "Electroluminescent Display Devices " by Knapp et al published 20040318 describes an active matrix electroluminescent display device having a signal processor to control the signals sent to the electroluminescent display device to reduce the non-uniformity in the display. Typically such schemes utilize some sort of calibration step to measure the non-uniformity in a display and the information from the measurement is stored in the display controller and used to correct an input signal. The corrected input signal is then applied to the display. Referring to Fig. 3, a controller **22** controls a display **10** and includes a correction circuit **30**. An input signal **32** is corrected by the controller **30** to create a corrected input signal **34** that is provided to the display **10**.

Other examples of such correction schemes include US6081073 entitled "Matrix Display with Matched Solid-State Pixels" by Salam granted June 27, 2000, US6414661 B1 entitled "Method and apparatus for calibrating display devices and automatically compensating for loss in their efficiency over time" by Shen et al issued 20020702, US6473065 B1 entitled "Methods of improving display uniformity of organic light emitting displays by calibrating individual pixel" by Fan issued 20021029, and US20020030647 entitled "Uniform Active Matrix OLED Displays" by Hack et al published 20020314. These designs, however, require that the controller **22** having the correction information supplied within the correction circuit **30** must be permanently associated with the corresponding display. If the display **10** is calibrated at the time of manufacture, the display **10** must be sold with the controller **22** containing the calibration and any associated correction information. This is problematic because a controller is typically manufactured as part of an appliance and is not associated with a display until final assembly. Alternatively, the display may be calibrated and a controller loaded with calibration and correction information after an appliance is assembled. This is even more problematic in that the calibration must now be done by the assembler or purchaser.

An alternative means for providing uniformity correction is the so-called "system-on-glass". In this alternative, processing circuitry is provided on the same substrate as the display. See for example, US20030025127 A1 entitled "Thin-Film Transistor Device and Method of Manufacturing the Same" published 20030206. Similarly, US6501230 entitled "Display with Aging Correction Circuit" by Feldman issued 20021231 describes a circuit integrated on the glass substrate of a display. However, it is difficult to manufacture high-performance or complex processing circuitry on a glass substrate using thin-film circuitry. Such an approach reduces manufacturing yields and increases the cost of display panels.

There is a need, therefore, for an improved system and method of providing uniformity correction in an OLED display that overcomes these objections.

SUMMARY OF THE INVENTION

In accordance with one embodiment, the invention is directed towards a system for the correction of brightness and uniformity variations in OLED displays, comprising:

a) an OLED display including a plurality of light-emitting elements;

b) a non-volatile memory having uniformity correction information for the OLED display stored therein and permanently associated with and physically attached to the OLED display; and

c) a controller connected to the OLED display and to the non-volatile memory for reading the information from the non-volatile memory, receiving an input signal, correcting the input signal using the information to form a corrected input signal, and transmitting the corrected input signal to the OLED display.

In accordance with further embodiments, the invention is directed towards an OLED display device comprising an OLED display and a permanently associated non-volatile memory, and a method for the correction of brightness and uniformity variations in OLED displays.

ADVANTAGES

The present invention has the advantage of providing improved uniformity, reduced manufacturing costs, and increased flexibility of use in an OLED display.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of an embodiment of the present invention;

Fig. 2 is a schematic diagram of an embodiment of the present invention;

Fig. 3 is a prior art illustration of a uniformity compensation design;

Fig. 4 is a flow graph illustrating the method of the present invention; and

Figs. 5a and 5b are photographs of an OLED device with and without uniformity correction according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to a system for the correction of brightness and uniformity variations in OLED displays, comprising an OLED display having a plurality of light-emitting elements; a non-volatile memory having uniformity correction information stored therein and permanently associated with and physically attached to the OLED display; and a controller connected to the OLED display and to the non-volatile memory for reading the information from the non-volatile memory, receiving an input signal, correcting the input signal using the information to form a corrected input signal, and transmitting the corrected input signal to the OLED display. In accordance with one embodiment, the OLED display may comprise a substrate where the plurality of light-emitting elements are formed on the substrate and are electrically connected through electrodes located on the substrate, and the non-volatile memory may be formed on a separate substrate. Alternatively, the non-volatile memory may be formed on the same substrate. Forming the non-volatile memory on a separate substrate advantageously improves yields, reduces costs, and reduces the physical size of the display. Use of a common substrate, on the other hand, reduces the number of components. The common substrate design is further advantaged over prior "system-on-glass" designs including processing circuitry provided on the same substrate as the display, in that the non-volatile memory circuitry of the present invention is smaller and less complex.

Referring to Fig. 1, an OLED display **10** having a substrate **12** and a plurality of light-emitting elements **13** electrically connected through electrodes **14** located on the substrate **12**. A non-volatile memory **20** is formed on a separate substrate having uniformity correction information stored therein and permanently associated with and physically attached to the OLED display **10**; and a controller **22** connected to the OLED display **10** and to the non-volatile memory **20** for reading the information from the non-volatile memory **20**, receiving an input signal, correcting the input signal using the information to form a corrected input signal, and transmitting the corrected input signal to the OLED display **10**. The electrodes **14** are connected to an integrated circuit comprising the non-volatile

memory device **20** through a signal cable **16** permanently affixed (e.g., by soldering) to the substrate **12**. The cable **16** is further connected through an external printed circuit board **24** to a controller **22**. The cable may be a conventional flexible wiring cable carrying one or more electrical wires for conducting signals to and from the OLED display **10**, the non-volatile memory **20**, and the controller **22**. Means for affixing and connecting the non-volatile memory **20** to the flexible wiring cable **16** are well-known in the electronics manufacturing art (e.g., adhesives) as are means to connect the flexible wiring cable **16** to the printed circuit board **24** (e.g., socket connectors) and OLED display **10** (e.g., by soldering). The printed circuit board **24** may include additional electronic components **26** as may be useful in an application.

Referring to Fig. 2, the OLED display **10** and non-volatile memory **20** are associated and packaged as an OLED display device unit **11**. The non-volatile memory **20** may be physically affixed to a connecting cable, as shown in Fig. 1, or alternatively formed on a common substrate of the OLED display. Other means of permanently associating the non-volatile memory **20** to the OLED display may be employed, for example by affixing the memory **20** to the substrate **12** or a cover of the OLED display (not shown). The controller **22** is removably connected to the non-volatile memory **20** and includes signal and control circuitry for reading information from the non-volatile memory **20**. As understood in the electrical arts, a non-volatile memory is a memory whose stored information is not lost when power is removed from the memory. The non-volatile memory **20** may be a Read-Only Memory (ROM), such as a programmable read only memory (PROM), including one-time programmable electrically programmable read only memory (OTP EPROM), and an electrically erasable programmable read only memory (EEPROM), that can be used to both read and write non-volatile information. Signals and control for such memory devices are very well known in the electronics industry. The controller **22** also includes circuitry for accepting an input signal **32** and correcting the input signal **32** using a correction circuit **30** to form a corrected input signal **34** that is supplied to the OLED display **10**.

Referring to Fig. 4, an OLED display **10** and non-volatile memory **20** are first manufactured **108** using methods known in the OLED industry.

Because of variability in the manufacturing process, the OLED display **10** is likely to include non-uniform light-emitting elements **13**. The display is tested **110** by measuring the light output and uniformity of the display **10** and the measurements are used to calculate **112** corrections to reduce the non-uniformity of the OLED display **10**. These corrections can be stored **114** in a look-up table in the non-volatile memory **20**, and the memory can be permanently associated with and affixed to the display. A controller **22** for the OLED display **10** may be independently manufactured **116**.

The OLED display **10** and permanently associated non-volatile memory **20** may then be sold as a display device unit **11**. The purchaser may also separately purchase a controller **22**. The display **10**, memory **20**, and controller **22** are integrated into a product. In operation, the controller **22** reads **118** information from the non-volatile memory **20**. The information from the memory **20** is used to provide correction values to a correction circuit **30**. An input signal **32** is input **120** to the controller **22**. The correction circuitry **30** corrects **122** the input signal **32** using the information supplied from the non-volatile memory **20** to form a corrected input signal **34** that is transmitted **124** to the OLED display **10** and displayed **126**. Referring to Figs. 5a and 5b, e.g., an OLED display having non-uniform light-emitting elements is shown with a flat field before uniformity correction **40** (Fig. 5a) and after luminance uniformity correction is applied **42** (Fig. 5b).

The information stored in the non-volatile memory **20** may include a record of the light output from each light-emitting element of each pixel of the OLED display. It may also include brightness information for the OLED display as a whole and include an identifier for the OLED display **10** and associated memory **20** assembly. Additional information may be included in the non-volatile memory **20**, for example size, type, aging characteristics, resolution, color, pixel patterns, materials, control signal, and display type information. As is known in the art, OLED devices also tend to age and decrease their light output over time as the OLEDs are used. In a further embodiment, the non-volatile memory is a read/write memory (e.g., an EEPROM), and the controller **22** writes information back to the non-volatile memory **20**, for example a record of OLED display use.

This record of use may also be used by the controller **22** to provide aging compensation in the correction circuitry **30**. In yet another embodiment, the non-volatile memory **20** is included in an integrated circuit that also performs signal processing on the corrected input signal **34** before it is transmitted to the OLED display **10**.

Certain embodiments of the present invention have an advantage in that the OLED display **10** and associated non-volatile memory **20** are manufactured separately and with relatively improved yields. Moreover, the memory **20** is very simple and low-cost, especially in comparison to the OLED display **10**. The integration of the non-volatile memory **20** and OLED display **10** is a straightforward and low-cost manufacturing task.

The controller **22** is a relatively intelligent controller and, as is common practice, may be formed in a separate integrated circuit. Such circuits are well known and the correction circuitry incorporated into the controller may rely upon conventional integrated circuit manufacturing technologies. The OLED display and non-volatile memory unit **11** may be replaced with a different unit **11** if the first unit is no longer adequate. Hence, the present invention allows devices to be upgraded over time without regard to the characteristics of the OLED display. An intelligent controller such as that described will simply read new information from the non-volatile memory **20** and adapt the correction circuit to the new information. This adaptation may include uniformity correction, aging compensation, image rendering for alternative display resolutions, graphic rendering techniques, and many other image correction operations, for example color correction.

A variety of techniques for measuring the uniformity of an OLED display are known in the art which may be employed to provide the uniformity correction information stored on the non-volatile memory in the system of the invention. US6414661 B1, e.g., describes measuring the display characteristics of all organic-light-emitting-elements of a display, and obtaining calibration parameters for each organic-light-emitting-element from the measured display characteristics of the corresponding organic-light-emitting-element. The described technique acquires information about each pixel in turn using a photo-detector.

An additional technique for measuring uniformity which may be employed to provide the uniformity correction information stored on the non-volatile memory in the system of the invention is described in copending, commonly assigned USSN 10/858,260, filed June 1, 2004. Correction circuitry **30** may be implemented in a variety of conventional ways known in the art. An additional correction circuitry technique which may be employed in the system of the present invention is described in copending, commonly assigned USSN 10/869,009, filed June 16, 2004.

PARTS LIST

10	OLED display
11	OLED display device unit
12	substrate
13	light-emitting element
14	electrode
16	cable
18	connector
20	non-volatile memory
22	controller
24	printed circuit board
26	integrated circuits
30	correction circuitry
32	input signal
34	corrected input signal
40	uncorrected OLED display
42	corrected OLED display
108	manufacture display step
110	test display step
112	calculate correction step
114	store correction step
116	manufacture controller step
118	read corrections step
120	input signal step
122	correct signal step
124	output corrected signal step
126	display corrected signal step

CLAIMS:

1. A system for the correction of brightness and uniformity variations in OLED displays, comprising:

a) an OLED display including a plurality of light-emitting elements;

b) a non-volatile memory having uniformity correction information for the OLED display stored therein and permanently associated with and physically attached to the OLED display; and

c) a controller connected to the OLED display and to the non-volatile memory for reading the information from the non-volatile memory, receiving an input signal, correcting the input signal using the information to form a corrected input signal, and transmitting the corrected input signal to the OLED display.

2. The system of claim 1 wherein the OLED display comprises a substrate and the plurality of light-emitting elements are formed on the substrate and electrically connected through electrodes located on the substrate, and the non-volatile memory is formed on a separate substrate.

3. The system of claim 2 further comprising a cable having electrical conductors located therein for transmitting the corrected input signal from the controller to the OLED display, and wherein the non-volatile memory is affixed to the cable.

4. The system of claim 3 further wherein the cable is a flexible cable.

5. The system of claim 2 wherein the non-volatile memory is affixed to the substrate or a cover of the OLED display.

6. The system of claim 1 wherein one or more of the OLED display uniformity, brightness, aging characteristics, identification, color, resolution, pixel patterns, materials, control signal, or display type information is stored in the non-volatile memory.

7. The system of claim 1 wherein the non-volatile memory is a read only memory (ROM).

8. The system of claim 1 wherein the non-volatile memory is a programmable read only memory (PROM).

9. The system of claim 1 wherein the non-volatile memory is a read/write memory and wherein the controller writes information into the non-volatile memory.

10. The system of claim 9 wherein information written into the non-volatile memory includes usage information for the OLED display.

11. The system of claim 1 wherein the controller performs one or more of uniformity correction, aging compensation, image rendering for alternative display resolutions, graphic rendering techniques, and color correction.

12. The system of claim 1 wherein the non-volatile memory is included in an integrated circuit that performs signal processing on the corrected input signal before transmitting the processed corrected input signal to the OLED display.

13. The system of claim 1 wherein the non-volatile memory is a one-time programmable electrically programmable read only memory (OTP EPROM).

14. The system of claim 1 wherein the OLED display comprises a substrate and the plurality of light-emitting elements are formed on the substrate and electrically connected through electrodes located on the substrate, and the non-volatile memory is formed on the same substrate.

15. An OLED display device, comprising:

a) an OLED display including a plurality of light-emitting elements; and

b) a non-volatile memory having uniformity correction information for the plurality of light-emitting elements of the OLED display stored therein and permanently associated with and physically attached to the OLED display.

16. The device of claim 15 wherein the OLED display comprises a substrate and the plurality of light-emitting elements are formed on the substrate and electrically connected through electrodes located on the substrate, and the non-volatile memory is formed on a separate substrate.

17. The device of claim 16 further comprising a cable having electrical conductors located therein, and wherein the non-volatile memory is affixed to the cable.

18. The device of claim 17 further wherein the cable is a flexible cable.

19. The device of claim 16 wherein the non-volatile memory is affixed to the substrate or a cover of the OLED display.

20. The device of claim 15 wherein one or more of the OLED display uniformity, brightness, aging characteristics, identification, color, resolution, pixel patterns, materials, control signal, or display type information is stored in the non-volatile memory.

21. The device of claim 15 wherein the non-volatile memory is a read only memory (ROM).

22. The device of claim 15 wherein the non-volatile memory is a programmable read only memory (PROM).

23. The device of claim 15 wherein the non-volatile memory is a read/write memory.

24. The device of claim 23 wherein information written into the non-volatile memory includes usage information for the OLED display.

25. The device of claim 15 wherein the non-volatile memory is a one-time programmable electrically programmable read only memory (OTP EPROM).

26. The device of claim 15 wherein the OLED display comprises a substrate and the plurality of light-emitting elements are formed on the substrate and electrically connected through electrodes located on the substrate, and the non-volatile memory is formed on the same substrate.

27. A method for the correction of brightness and uniformity variations in OLED displays, comprising:

a) providing an OLED display having a plurality of light-emitting elements;

b) providing a non-volatile memory in association with the OLED display;

c) storing OLED display attribute information into the non-volatile memory;

d) permanently associating and physically attaching the non-volatile memory to the OLED display;

e) reading the OLED display attribute information from the non-volatile memory into a controller;

f) correcting an input signal using the OLED display attribute information to produce a corrected input signal; and

g) displaying the corrected input signal on the OLED display.

28. The method of claim 27 further comprising the step of writing usage information for the OLED display into the non-volatile memory.

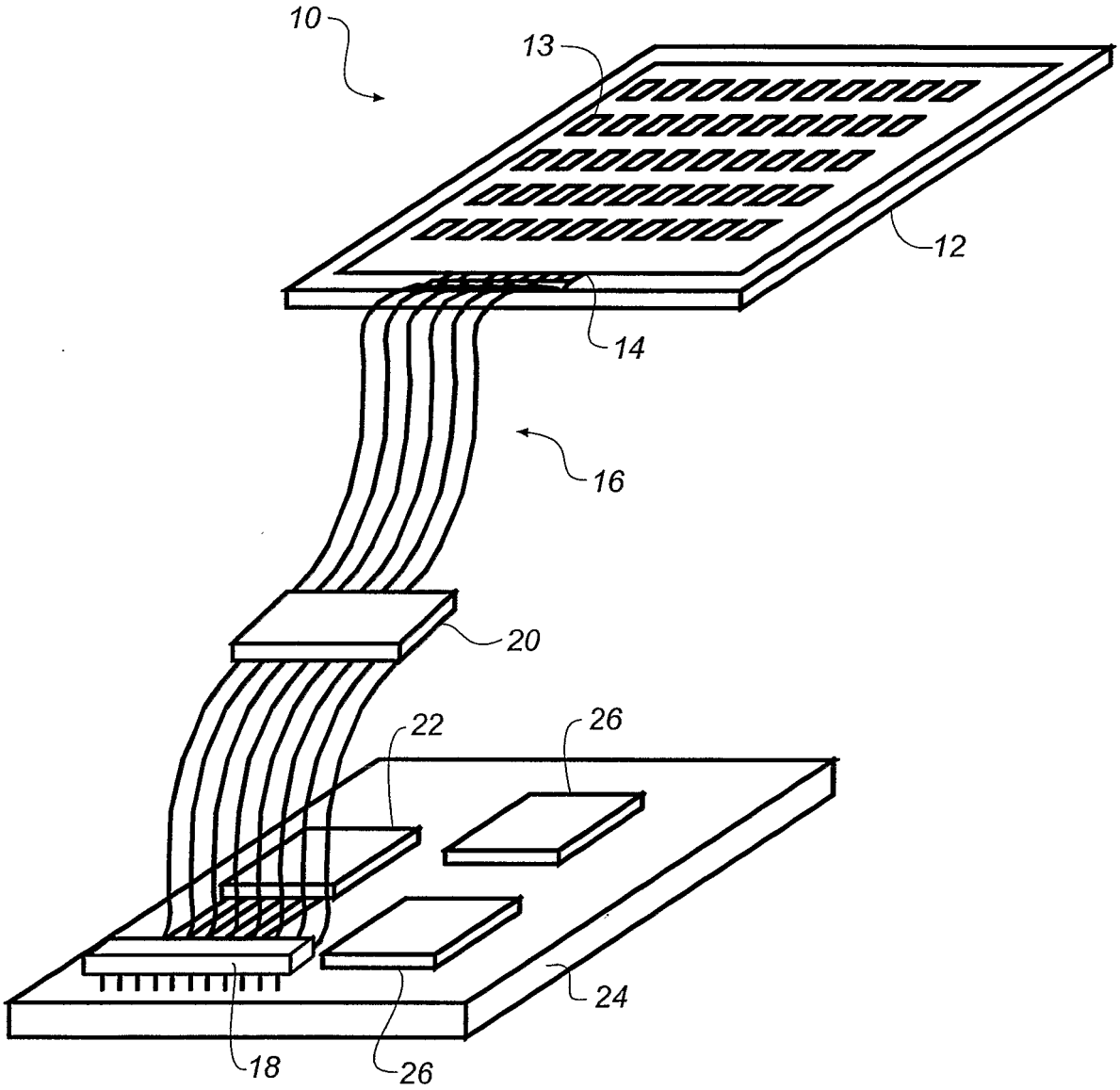

FIG. 1

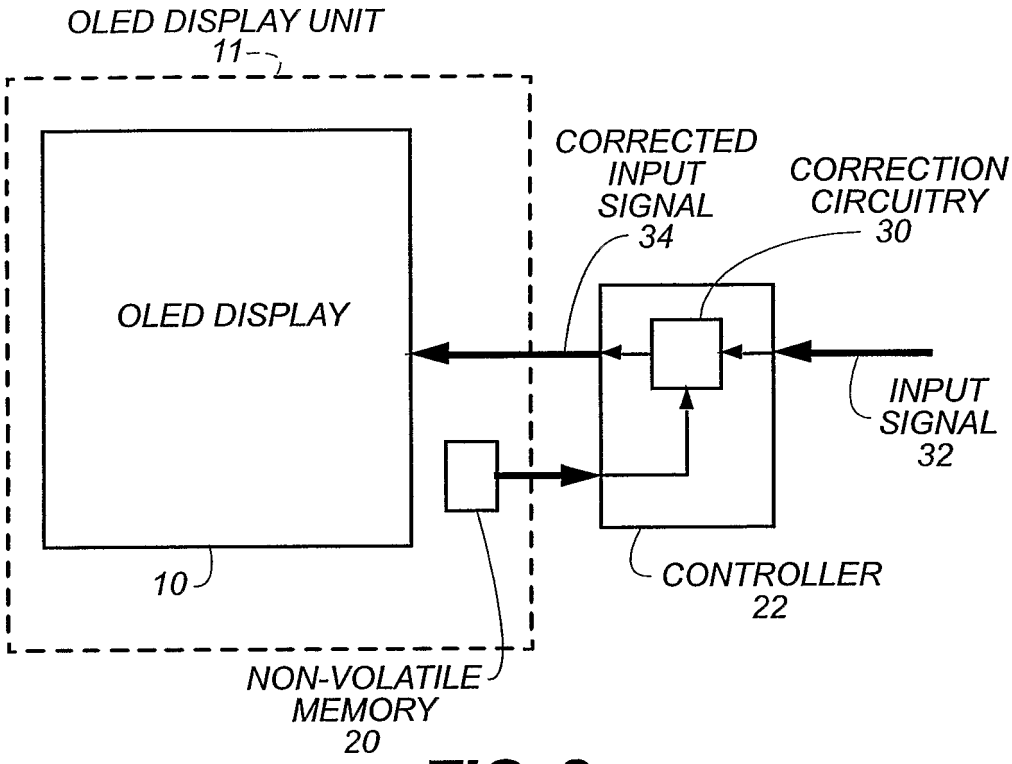

FIG. 2

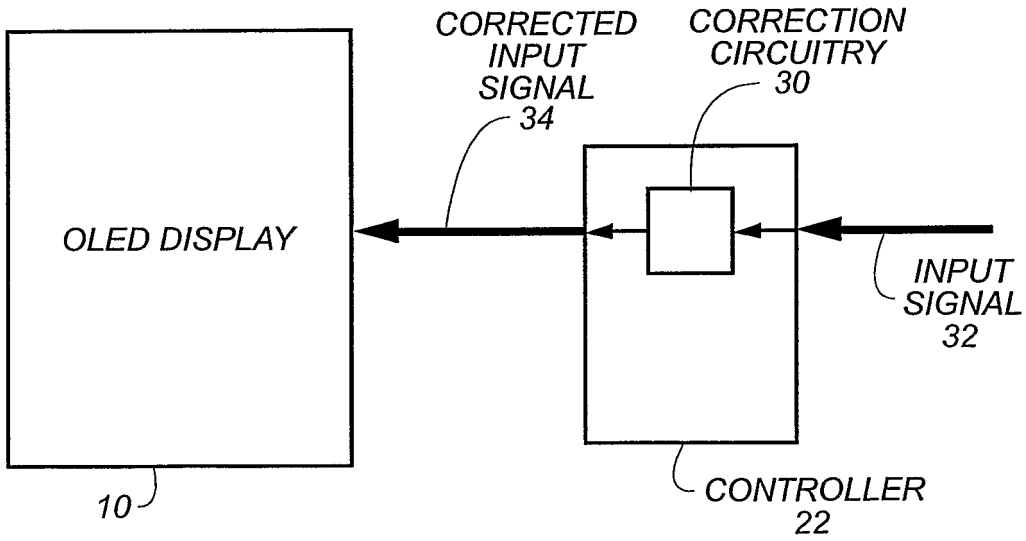

FIG. 3
(PRIOR ART)

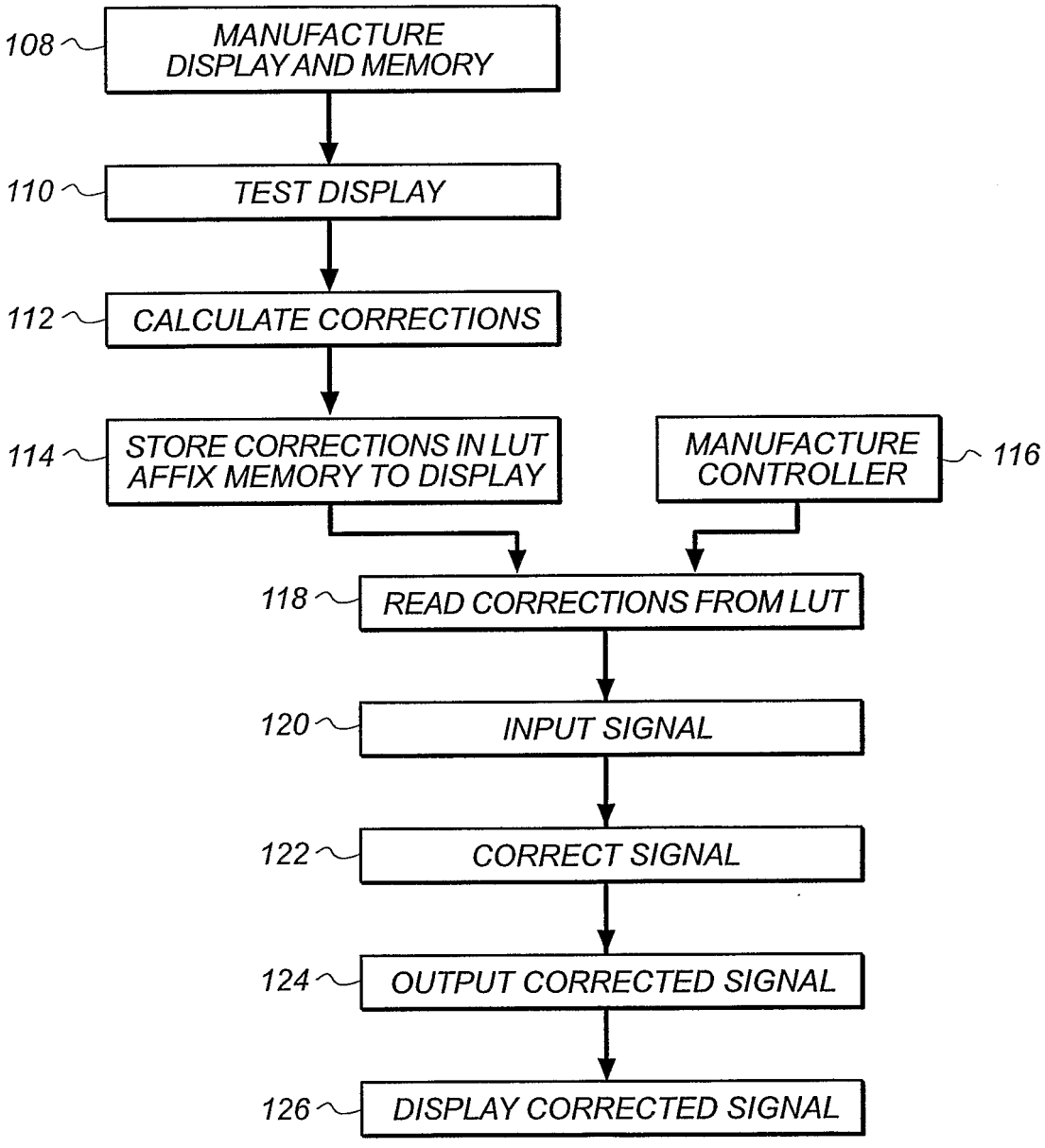
108
MANUFACTURE DISPLAY AND MEMORY
110
TEST DISPLAY
112
CALCULATE CORRECTIONS
114
STORE CORRECTIONS IN LUT AFFIX MEMORY TO DISPLAY
MANUFACTURE CONTROLLER
116
118
READ CORRECTIONS FROM LUT
120
INPUT SIGNAL
122
CORRECT SIGNAL
124
OUTPUT CORRECTED SIGNAL
126
DISPLAY CORRECTED SIGNAL

FIG. 4

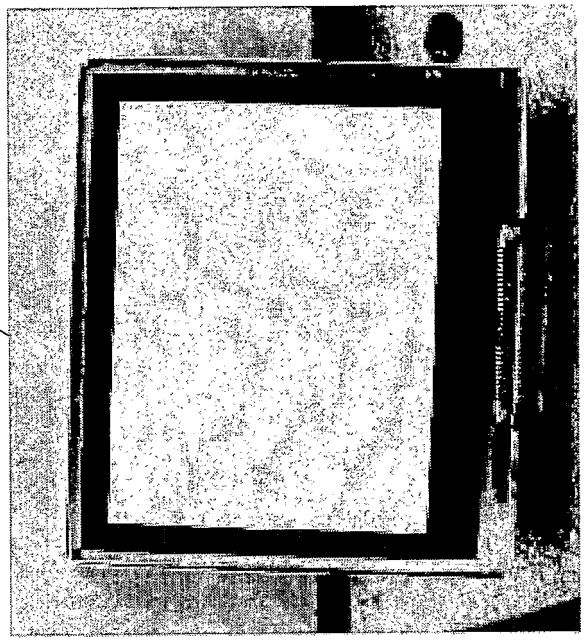

FIG. 5b

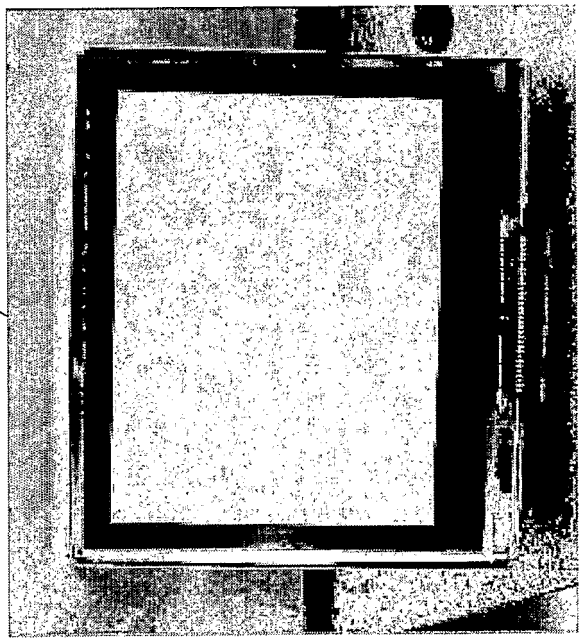

FIG. 5a

专利名称(译)	OLED显示器的均匀性和亮度校正		
公开(公告)号	EP1769486A2	公开(公告)日	2007-04-04
申请号	EP2005773182	申请日	2005-07-15
[标]申请(专利权)人(译)	伊斯曼柯达公司		
申请(专利权)人(译)	伊士曼柯达公司		
当前申请(专利权)人(译)	伊士曼柯达公司		
[标]发明人	COK RONALD STEVEN FORD JAMES HADLEY		
发明人	COK, RONALD, STEVEN FORD, JAMES, HADLEY		
IPC分类号	G09G3/32		
CPC分类号	G09G3/3216 G09G3/3225 G09G2320/0233 G09G2320/0285 G09G2320/029 G09G2320/0295 G09G2320/043 G09G2360/147		
优先权	10/894729 2004-07-20 US		
外部链接	Espacenet		

摘要(译)

描述了一种用于校正OLED显示器中的亮度和均匀性变化的系统，包括：a）包括多个发光元件的OLED显示器; b）非易失性存储器，其具有存储在其中的OLED显示器的均匀性校正信息，并且永久地与OLED显示器相关联并物理连接到OLED显示器; c）连接到OLED显示器和非易失性存储器的控制器，用于从非易失性存储器读取信息，接收输入信号，使用该信息校正输入信号以形成校正的输入信号，以及发送校正输入信号到OLED显示器。还描述了包括OLED显示器和永久关联的非易失性存储器的OLED显示装置单元，以及用于校正OLED显示器中的亮度和均匀性变化的方法。