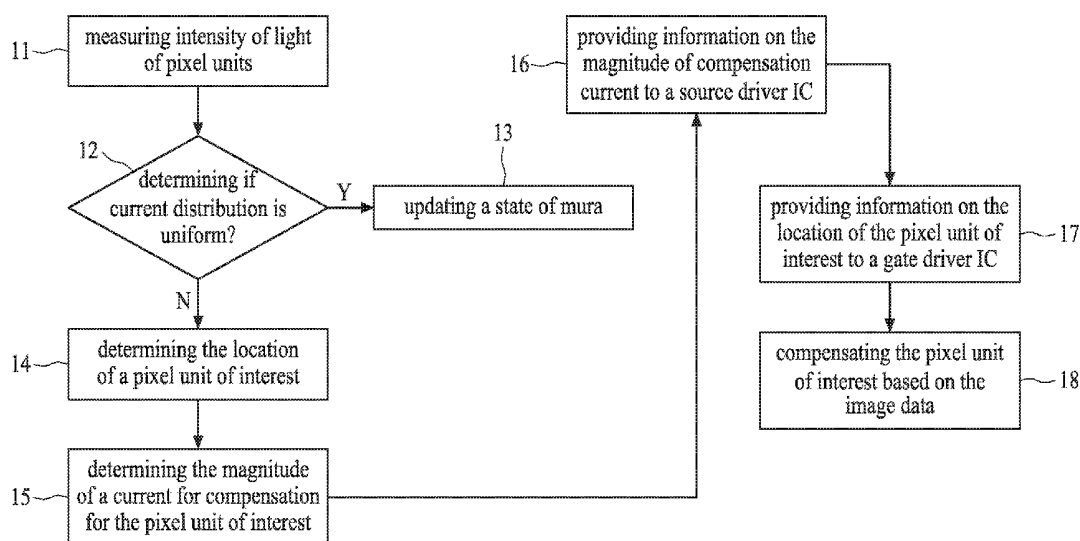




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**YAN et al.**(10) **Pub. No.: US 2018/0137812 A1**(43) **Pub. Date: May 17, 2018**(54) **METHOD AND DEVICE FOR CURRENT  
COMPENSATION FOR AN  
ELECTROLUMINESCENT DISPLAY****Publication Classification**(51) **Int. Cl.**  
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CITY (TW); **YEN-JEN LAI**,  
HSINCHU COUNTY (TW)(57) **ABSTRACT**

A method for current compensation in an electroluminescent (EL) display is provided. The method includes measuring an intensity of light of a pixel unit, identifying a pixel unit to be one that needs compensation if the measured intensity exceeds a predetermined threshold, determining the magnitude of a compensation current, and providing an image data corresponding to the magnitude of the compensation current to the identified pixel unit.

(21) Appl. No.: **15/811,337**(22) Filed: **Nov. 13, 2017****Related U.S. Application Data**(60) Provisional application No. 62/421,435, filed on Nov.  
14, 2016.

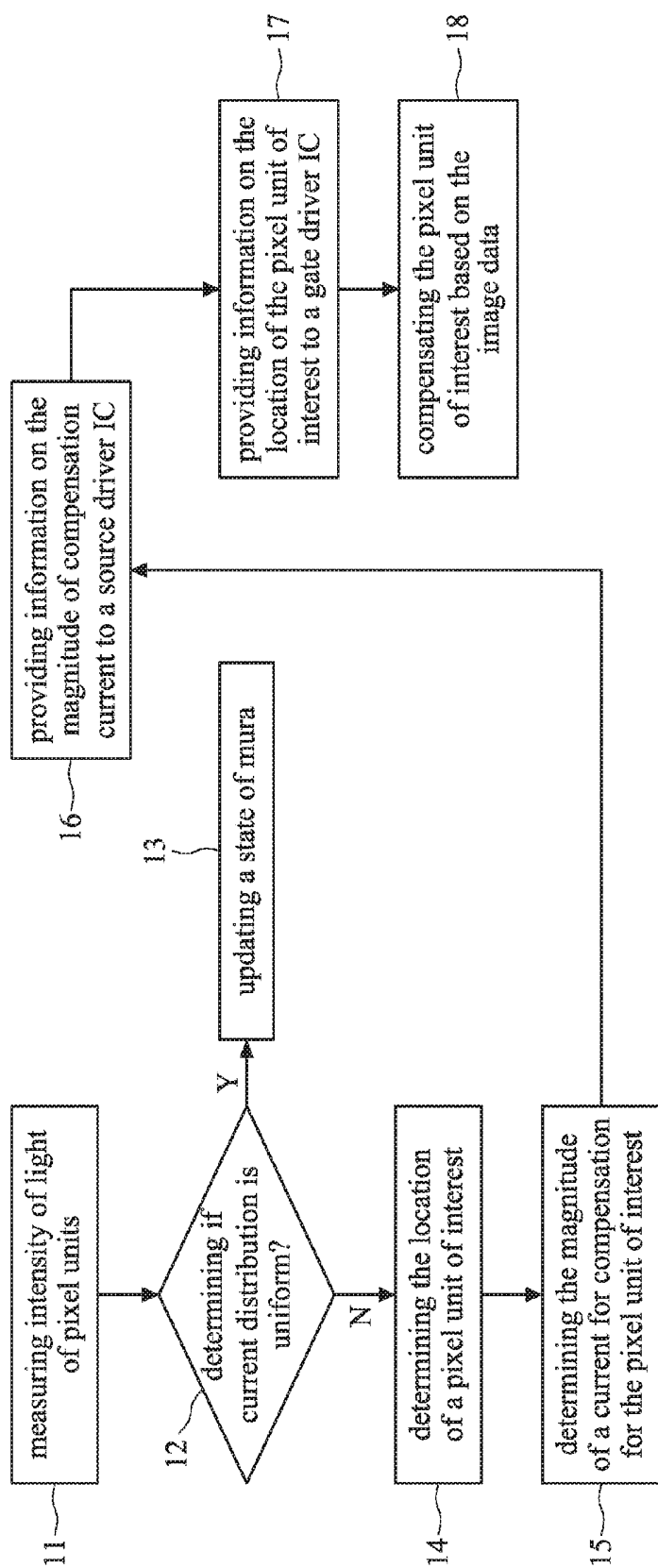


FIG. 1

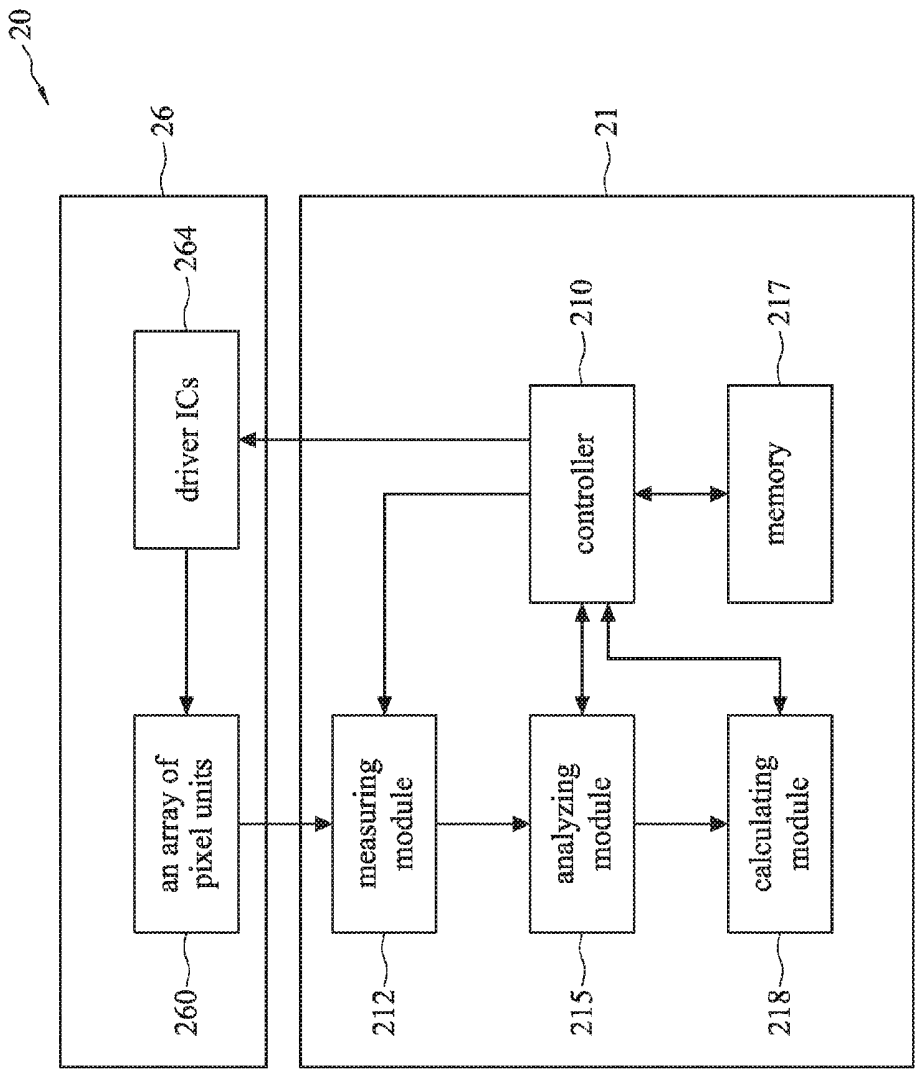


FIG. 2

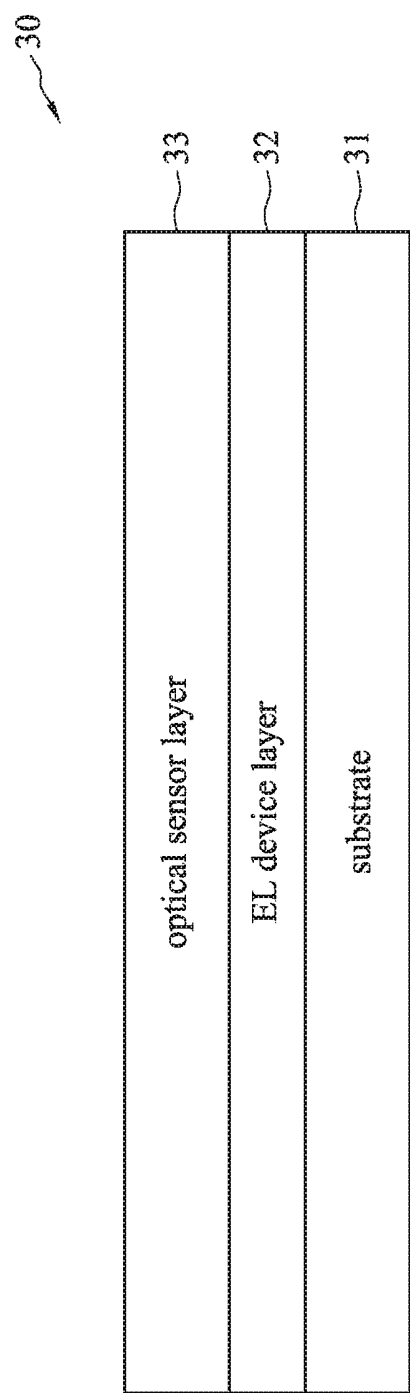


FIG. 3

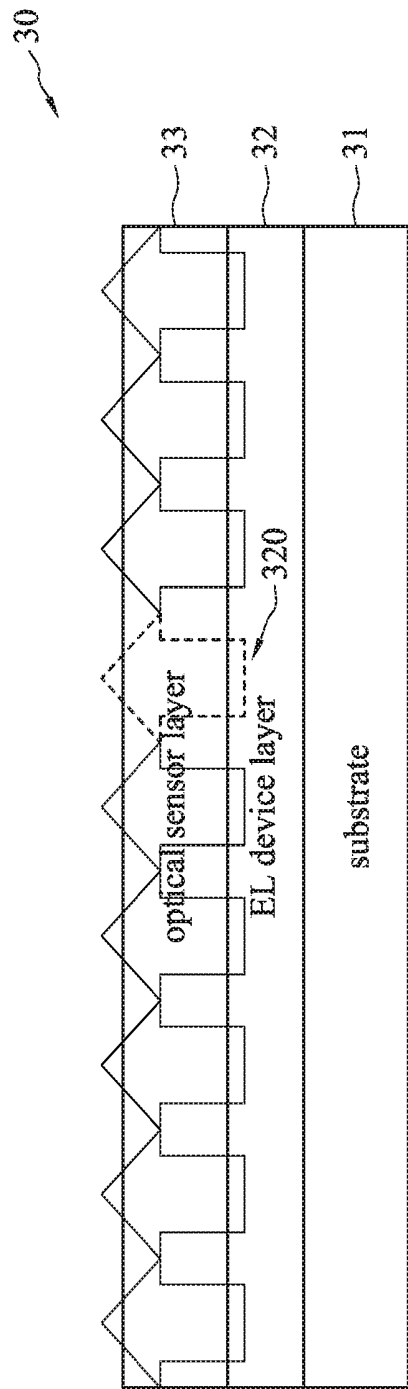


FIG. 4

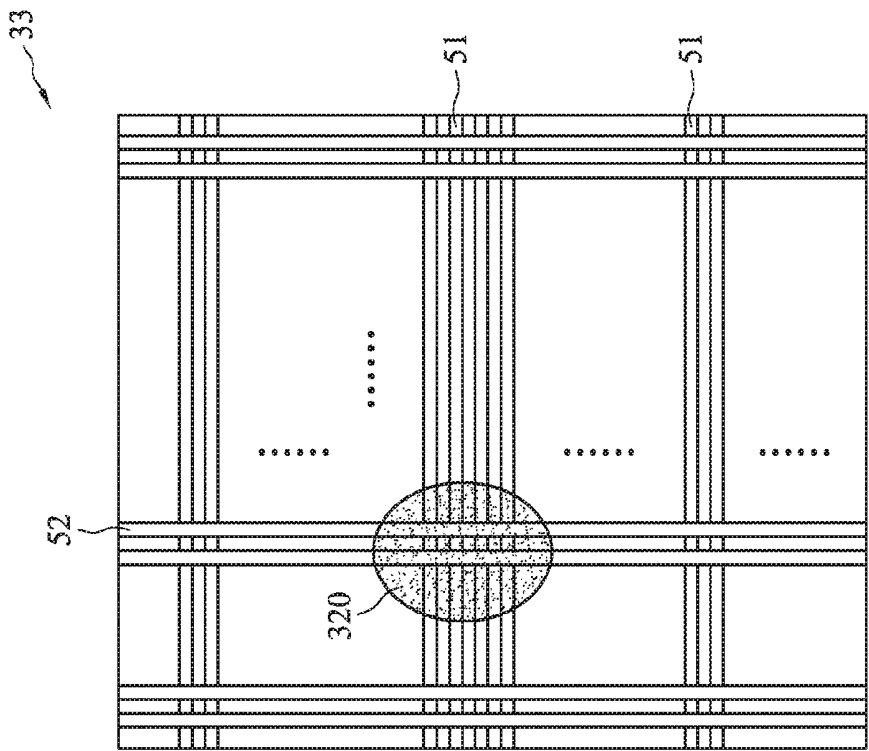


FIG. 5B

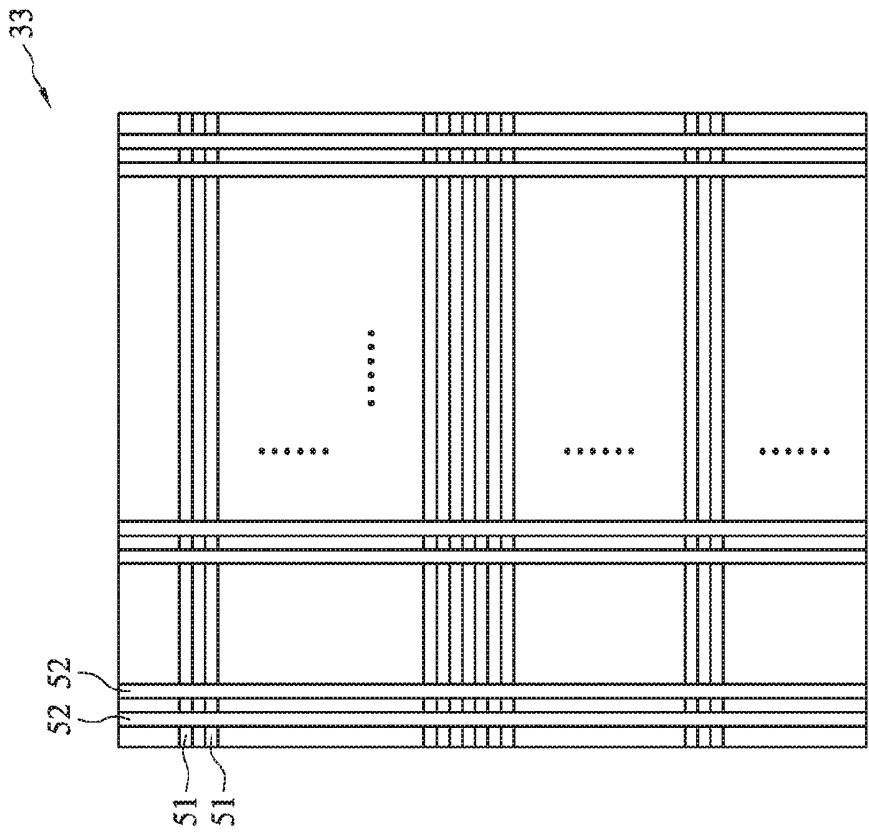


FIG. 5A

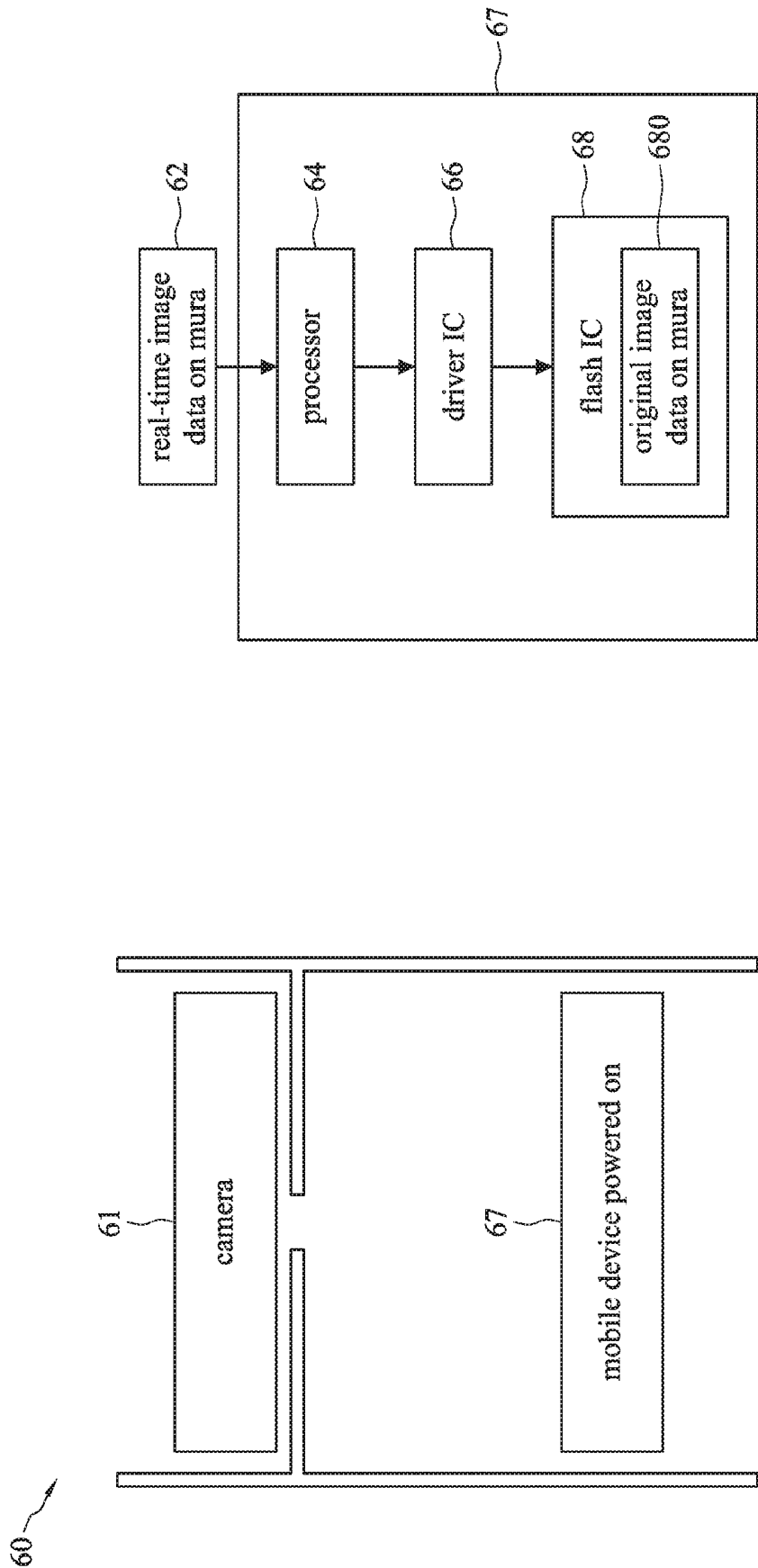


FIG. 6A

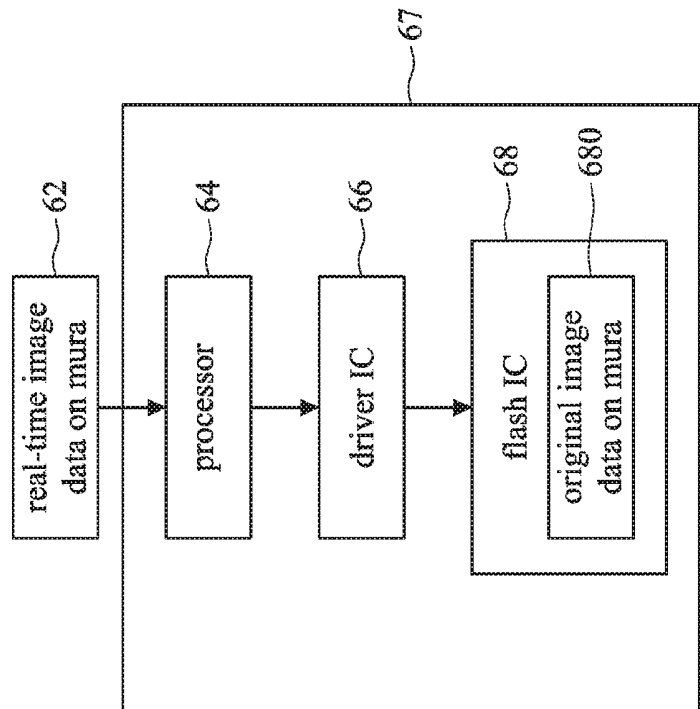


FIG. 6B

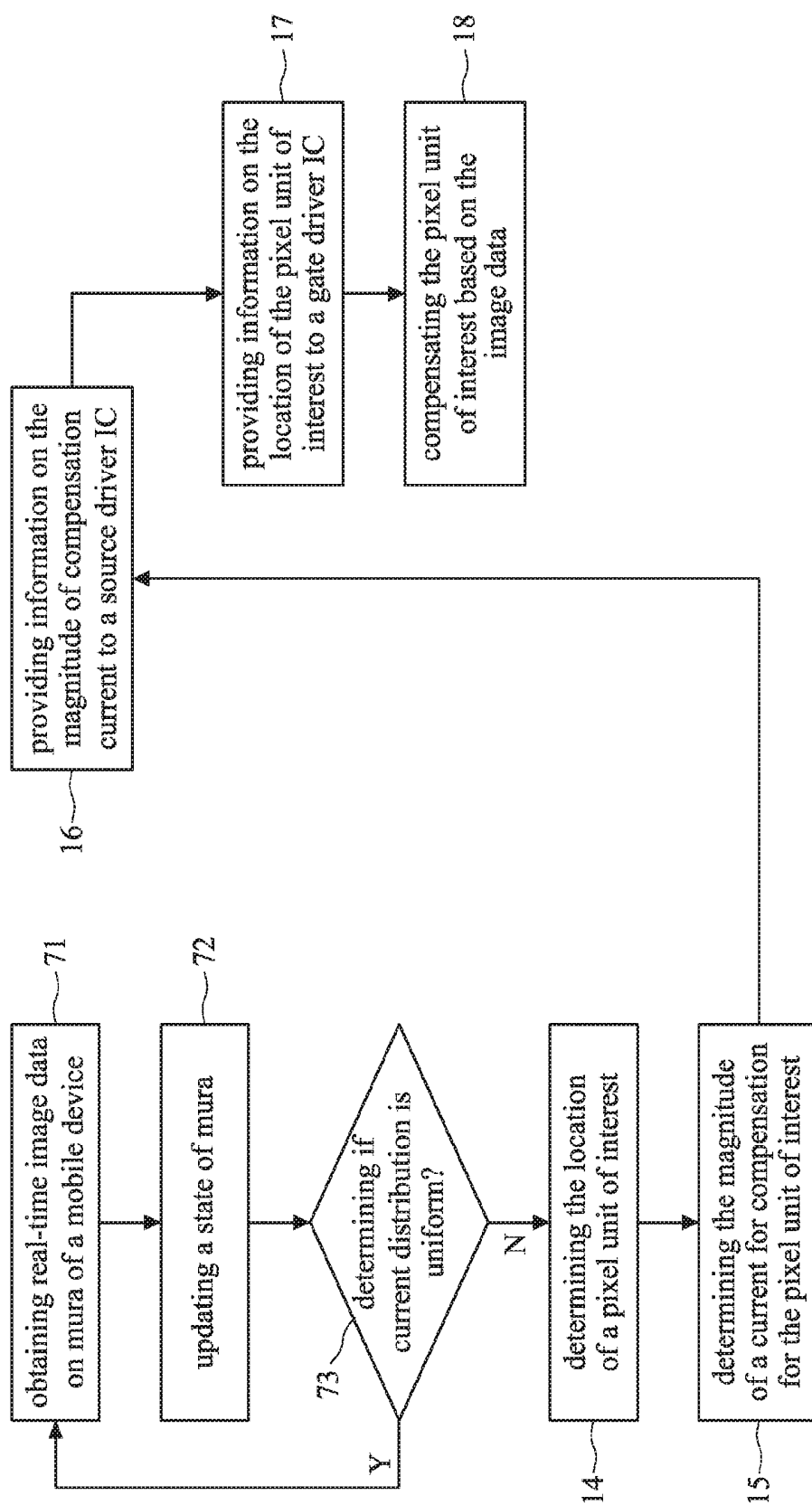


FIG. 7

# METHOD AND DEVICE FOR CURRENT COMPENSATION FOR AN ELECTROLUMINESCENT DISPLAY

## CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. provisional application Ser. No. 62/421,435, filed Nov. 14, 2016, the disclosure of which is hereby incorporated herein by reference.

## BACKGROUND

[0002] In an active matrix organic light emitting diode (AMOLED) display, each pixel unit includes a capacitor for storing data so that the pixel unit can be maintained at an illumination state. Such driving mechanism is suitable for the development of large-size, high-resolution displays. As a result, AMOLED has become increasingly important in the research and development of advanced displays such as flexible displays. For an OLED device, its luminescence is determined by the magnitude of current flowing through the OLED device, which in turn is determined by the threshold voltage  $V_{th}$  of the OLED device. For a display that comprises a plurality of the OLED devices, the magnitude of current may be different from one OLED device to another due to variation in  $V_{th}$ , resulting in a non-uniform luminescence across the pixel units. The threshold variation may result from manufacturing factors or device aging.

## SUMMARY

[0003] Embodiments of the present invention provide a method for current compensation in an electroluminescent (EL) display. The method includes measuring an intensity of light of a pixel unit, identifying a pixel unit to be one that needs compensation if the measured intensity exceeds a predetermined threshold, determining the magnitude of a compensation current, and providing an image data corresponding to the magnitude of the compensation current to the identified pixel unit.

[0004] In an embodiment, the method further includes providing an image data of a predetermined grayscale to a pixel unit under measurement before measuring an intensity of light of the pixel unit.

[0005] In another embodiment, the operation of identifying a pixel unit further includes comparing the measured intensity with the predetermined grayscale.

[0006] In yet another embodiment, the operation of determining the magnitude of a compensation current further includes calculating a difference between the measured intensity and the predetermined grayscale, and converting the difference into the magnitude of a compensation current.

[0007] In still another embodiment, the method further includes determining the location of the identified pixel unit.

[0008] In yet still another embodiment, wherein the pixel unit is driven by a gate driver integrated circuit (IC) and a source driver IC, the method further includes providing information on the location of the identified pixel unit to the gate driver IC, and providing information on the magnitude of a compensation current to the source driver IC.

[0009] Some embodiments of the present invention provide a method for current compensation. The method includes obtaining real-time image data on mura of a display of a mobile device, storing the real-time image data on mura

in a memory of the mobile device, and determining pixels that need compensation based on the real-time image data on mura.

[0010] In an embodiment, the operation of obtaining real-time image data on mura of a display of a mobile device includes taking a picture of an image displayed by the display of the mobile device.

[0011] In another embodiment, the method further includes updating in the memory an original image data on mura with the real-time image data on mura.

[0012] In yet another embodiment, the original image data on mura is stored in the memory when the mobile device is manufactured.

[0013] In still another embodiment, the original image data on mura includes a previously stored image data on mura.

[0014] In yet still another embodiment, the memory includes a flash IC.

[0015] Embodiments of the present invention also provide an electroluminescent (EL) display. The EL display includes a substrate, an EL device layer over the substrate, and an optical sensor layer over the substrate. The EL device layer includes a number of EL devices. The optical sensor layer includes first sensors arranged in a first direction and second sensors arranged in a second direction. The first sensors and the second sensors intersect one another at intersection points. The optical sensor layer is configured to identify a region of the EL device layer for compensation by detecting impedance at each intersection point from a reference point.

[0016] In an embodiment, the substrate includes one of a low temperature polysilicon (LTPS) substrate and an indium gallium zinc oxide (IGZO) substrate.

[0017] In another embodiment, the EL device includes one of an organic light emitting diode (OLED), a micro LED and a quantum dot LED (QLED).

[0018] In yet another embodiment, the optical sensor layer has a same size as the substrate.

[0019] In still another embodiment, The EL display according to claim 13, wherein the optical sensor layer 33 is made of a relatively high transparent material.

[0020] In yet still another embodiment, the EL display further includes a measuring module configured to measure an intensity of light of an EL device. In addition, the EL display includes an analyzing module configured to identify an EL device to be one that needs compensation if the measured intensity exceeds a predetermined threshold. Moreover, the EL display includes a calculating module configured to determine the magnitude of a compensation current for the identified EL device.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It is noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

[0022] FIG. 1 is a flow diagram of a method for current compensation in an electroluminescent (EL) display, in accordance with some embodiments.

[0023] FIG. 2 is a block diagram of a system comprising a device for current compensation, in accordance with some embodiments.

[0024] FIG. 3 is a cross-sectional diagram of an EL display, in accordance with some embodiments.

[0025] FIG. 4 is a schematic diagram showing function of an optical sensor layer in the EL display illustrated in FIG. 3, in accordance with some embodiments.

[0026] FIGS. 5A and 5B are diagrams showing an optical sensor layer in the EL display illustrated in FIG. 3, in accordance with some embodiments.

[0027] FIG. 6A is a schematic diagram of a system for obtaining real-time image data on mura, in accordance with some embodiments.

[0028] FIG. 6B is a schematic block diagram showing a method of updating image data on mura, in accordance with some embodiments.

[0029] FIG. 7 is a flow diagram of a method for current compensation in an electroluminescent (EL) display, in accordance with some embodiments.

#### DETAILED DESCRIPTION

[0030] The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. For example, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, such that the first and second features may not be in direct contact. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

[0031] Further, it will be understood that when an element is referred to as being “connected to” or “coupled to” another element, it may be directly connected to or coupled to the other element, or intervening elements may be present.

[0032] FIG. 1 is a flow diagram of a method for current compensation in an electroluminescent (EL) display, in accordance with some embodiments.

[0033] Referring to FIG. 1, in operation 11, intensity of light of each pixel unit in a display is measured. The display may include an electroluminescent (EL) display, for example, an active matrix organic light emitting diode (AMOLED) display. Moreover, the display may include pixel units, a gate driver integrated circuit (IC) and a source driver IC. The pixel units are arranged in, for example, an N×M matrix. The gate driver IC selects one or more rows of pixel units in the N rows of pixel units, while the source driver provides image data to selected pixel units in the M columns of pixel units. Each of the pixel units includes an EL device. The EL device may include, for example, a current-driven element that may further include an organic light emitting diode (OLED), a micro LED or a quantum dot LED (QLED).

[0034] The intensity of light of a pixel unit is a function of current that flows through the EL device of the pixel unit. Moreover, the intensity may be different from one pixel unit to another due to variation in the V<sub>th</sub> of the EL device. In an

embodiment, to measure the intensity, an image data of a predetermined grayscale is provided from the source driver IC to the pixel units.

[0035] Next, in operation 12, it is determined, based on the measured intensity of light in each pixel unit, whether current distribution across the array of pixel units is uniform. In an embodiment, if the measured intensity of a pixel unit, when compared with the predetermined grayscale, exceeds a predetermined threshold, the pixel unit is identified as one that needs current compensation.

[0036] If in operation 12 it is determined that the current distribution is uniform, then in operation 13, a state of Mura is updated.

[0037] In general, a Mura effect means a non-uniform or uneven display surface caused by an imperfect illumination of pixel units. The Mura effect may appear to be brighter or darker, less saturated, poor in contrast or from the general display presentation deviating areas, spots or pixels.

[0038] Therefore, if in operation 12 the current distribution is not uniform, then in operation 14, the location of a pixel unit that is identified in operation 12 is determined.

[0039] In operation 15, the magnitude of a compensation current for the pixel unit of interest, i.e., the pixel unit identified in operation 12, is determined. In an embodiment, an offset between the measured intensity and the predetermined grayscale is calculated to determine an amount of compensation. The amount of compensation is then converted into an image data corresponding to the magnitude of the compensation current.

[0040] In operation 16, information on the magnitude of a compensation current for the pixel unit of interest is provided to a source driver IC. In addition, in operation 17, information on the location of the pixel unit of interest is provided to a gate driver IC.

[0041] Subsequently, in operation 18, the pixel unit of interest is compensated based on the image data.

[0042] FIG. 2 is a block diagram of a system 20 comprising a device 21 for current compensation, in accordance with some embodiments.

[0043] Referring to FIG. 2, the system 20 includes a display 26 as well as the device 21. The display 26, which may be an EL display, includes an array of pixel units 260 and driver ICs 264. The device 21, configured to compensate the display 26 for non-uniform current distribution, includes a controller 210, a measuring module 212, an analyzing module 215, a calculating module 218 and a memory 217.

[0044] The measuring module 212, under the control of the controller 210, measures intensity of light of the array of pixel units 260. In operation, the controller 210 commands the driver ICs 264 to provide an image data of a predetermined grayscale to the array of pixel units 260 to facilitate measurement by the measuring module 212. A value of the predetermined grayscale may be stored in the memory 217.

[0045] In response to a measuring result, the analyzing module 215 determines whether a pixel unit needs to be compensated by, for example, comparing a measured intensity with the predetermined grayscale. If such a pixel unit is identified, the location of the identified pixel unit is stored in the memory 217.

[0046] The calculating module 218, based on a difference between the measured intensity and the predetermined grayscale, determines the amount of compensation and then converts the amount of compensation into an image data corresponding to the magnitude of a compensation current.

[0047] The controller 210, based on information on the location of the identified pixel unit and the magnitude of compensation current for the identified pixel unit, commands the driver ICs to provide the image data to the pixel units at the location.

[0048] The device 21 in some embodiment may be merged into the display 26, as will be discussed with reference to FIGS. 3 to 5 below.

[0049] FIG. 3 is a cross-sectional diagram of an EL display 30, in accordance with some embodiments.

[0050] Referring to FIG. 3, the EL display 30 includes a substrate 31, an EL device layer 32 and an optical sensor layer 33. The substrate 31 may include a low temperature polysilicon (LTPS) substrate or an indium gallium zinc oxide (IGZO) substrate. The EL device layer 32, disposed between the substrate 31 and the optical sensor layer 33, includes EL devices that may include OLEDs, micro LEDs or quantum dot LEDs (QLEDs). The optical sensor layer 33 is configured to detect if non-uniform illumination such as Mura effect occurs in the EL device layer 32 and, if any, determines a region of interest in the EL device layer 32. In an embodiment, the optical sensor 33 is integrated into a touch panel (not shown) of the EL display 30.

[0051] FIG. 4 is a schematic diagram showing function of the optical sensor layer 33 in the EL display 30 illustrated in FIG. 3, in accordance with some embodiments.

[0052] Referring to FIG. 4, a region 320 in the EL device layer 32 is detected as a region of non-uniform illumination region (shown in a dashed arrow). To detect a non-uniform illumination region, pixel units in the EL display 30 are provided with a predetermined grayscale value. Sensors in the optical sensor layer 33 detect if there is a region of interest and, if any, report the location of the region of interest and an optical difference in intensity of light to a controller. The region may be as small as a single pixel unit, or as large as the entire array of pixel units. Subsequently, a converter converts the optical difference into an image data. The controller commands driver ICs to adjust the region of interest based on the image data. The method and device for compensation are similar to or same as those described and illustrated with FIGS. 1 and 2, and therefore are not further discussed.

[0053] FIGS. 5A and 5B are diagrams showing the optical sensor layer 33 in the EL display 30 illustrated in FIG. 3, in accordance with some embodiments.

[0054] Referring to FIG. 5A, the optical sensor layer 33 includes first sensors 51 and second sensors 52. The first sensors 51 extend in a first direction, while the second sensors 52 extend in a second direction substantially orthogonal to the first direction. As a result, the first sensors 51 and the second sensors 52 intersect one another at intersection points. In an embodiment, the optical sensor layer 33 has substantially the same size as a touch panel of the EL display 30. Moreover, the optical sensor layer 33 is made of a relatively high transparent material to prevent the touch panel from optical loss. The first sensors 51 and the second sensors 52 in the optical sensor layer 33 detect the resistance at each intersection point from a reference point. The reference point may be predetermined by a user of the EL display 30. A linear relationship exists between the resistance of an intersection point and a distance between the intersection point and the reference point. However, for a non-uniform illumination region, such as the region 320 shown in FIG. 5B, no such linear relationship may exist.

Accordingly, when the EL device layer 32 emits light, a non-uniform illumination region is detected. The location of the region of interest and an image data corresponding to the amount of optical difference are sent to driver ICs for compensating the region of interest.

[0055] FIG. 5B thus illustrates a method for obtaining image data on mura by detecting non-uniform illumination regions. In other embodiments, as will be discussed with reference to FIGS. 6A and 6B, image data on mura may be obtained in real time by taking an image displayed by a display device.

[0056] FIG. 6A is a schematic diagram of a system 60 for obtaining real-time image data on mura, in accordance with some embodiments.

[0057] Referring to FIG. 6A, the system 60 includes a camera 61 and a mobile device 67. The camera 61, which may include a monocular camera, a digital camera, or a cellphone camera, is configured to obtain image data on mura of the mobile device 67. A commercially available camera may have a resolution of approximately 1.2 mega pixels or higher, which is sufficient to support the system 60. In operation, the mobile device 67 is powered on for the camera 61 to take a picture of an image displayed by the mobile device 67. The system 60 alleviates optical interference from ambient light, and facilitates adjustments in the x, y and z coordinates to ensure the quality of image data on mura.

[0058] FIG. 6B is a schematic block diagram showing a method of updating image data on mura, in accordance with some embodiments.

[0059] Referring to FIG. 6B, real-time image data on mura 62 obtained by the camera 61 is sent to the mobile device 67. In the present embodiment, a processor 64 on a main board of the mobile device 67 receives the real-time image on mura 62 and determines non-uniform illumination regions, if any, in the display of the mobile device 67. The real-time image on mura 62 is then stored via a driver IC 66 into a memory 68 such as a flash IC, and may update an original image data on mura 680 in the memory 68. In an embodiment, the original image data on mura 680 refers to one that has been stored in the memory 68 by a manufacturer when the mobile device 67 was made. In another embodiment, the original image data on mura 680 refers to a previously stored real-time image data on mura. The original image data on mura 680, in particular those stored by the manufacturer, may not reflect the current state of mura when the mobile device 67 has been used for a while. As a result, the current state of mura may be significantly different from the state originally stored. With the updated image data on mura, a more precise compensation can be made for pixels in a non-uniform illumination region.

[0060] FIG. 7 is a flow diagram of a method for current compensation in an electroluminescent (EL) display, in accordance with some embodiments.

[0061] Referring to FIG. 7, the method is similar to that illustrated in FIG. 1 except, for example, operations 71, 72 and 73. In operation 71, real-time image data on mura of a mobile device is obtained. Next, in operation 72, the real-time image data on mura is stored in a memory of the mobile device and updates an original image data on mura. Subsequently, in operation 73, it is determined if current distribution is uniform. In an embodiment, to determine if current distribution is uniform, the real-time image data on mura is compared against the original image data on mura. Based on

a comparison result, it can be determined whether the intensity of light of a pixel unit in an illumination region relative to the real-time image data on mura is changed. Accordingly, the intensity of light of the pixel unit is measured by reference to the comparison result in order to determine if current distribution is uniform.

[0062] In operation 73, if the current distribution is determined to be uniform, then the operations 71 and 72, when necessary, are repeated. If not uniform, a compensation process based on the operations 14 to 18 previously discussed with reference to FIG. 1 may be performed.

[0063] The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

What is claimed is:

1. A method for current compensation in an electroluminescent (EL) display, the method comprising:
  - measuring an intensity of light of a pixel unit;
  - identifying a pixel unit to be one that needs compensation if the measured intensity exceeds a predetermined threshold;
  - determining the magnitude of a compensation current; and
  - providing an image data corresponding to the magnitude of the compensation current to the identified pixel unit.
2. The method according to claim 1 further comprising: providing an image data of a predetermined grayscale to a pixel unit under measurement before measuring an intensity of light of the pixel unit.
3. The method according to claim 2, wherein identifying a pixel unit further comprises:
  - comparing the measured intensity with the predetermined grayscale.
4. The method according to claim 2, wherein determining the magnitude of a compensation current further comprises:
  - calculating a difference between the measured intensity and the predetermined grayscale; and
  - converting the difference into the magnitude of a compensation current.
5. The method according to claim 1 further comprising: determining the location of the identified pixel unit.
6. The method according to claim 5, wherein the pixel unit is driven by a gate driver integrated circuit (IC) and a source driver IC, further comprising:
  - providing information on the location of the identified pixel unit to the gate driver IC; and
  - providing information on the magnitude of a compensation current to the source driver IC.
7. A method for current compensation, the method comprising:

obtaining real-time image data on mura of a display of a mobile device;

storing the real-time image data on mura in a memory of the mobile device; and

determining pixels that need compensation based on the real-time image data on mura.

8. The method according to claim 7, wherein obtaining real-time image data on mura of a display of a mobile device comprises:

taking a picture of an image displayed by the display of the mobile device.

9. The method according to claim 7 further comprising: updating in the memory an original image data on mura with the real-time image data on mura.

10. The method according to claim 9, wherein the original image data on mura is stored in the memory when the mobile device is manufactured.

11. The method according to claim 9, wherein the original image data on mura includes a previously stored image data on mura.

12. The method according to claim 7, wherein the memory includes a flash IC.

13. An electroluminescent (EL) display, comprising:

a substrate;

an EL device layer over the substrate, the EL device layer including a number of EL devices; and

an optical sensor layer over the substrate, the optical sensor layer including first sensors arranged in a first direction and second sensors arranged in a second direction, the first sensors and the second sensors intersecting one another at intersection points,

wherein the optical sensor layer is configured to identify a region of the EL device layer for compensation by detecting impedance at each intersection point from a reference point.

14. The EL display according to claim 13, wherein the substrate includes one of a low temperature polysilicon (LTPS) substrate and an indium gallium zinc oxide (IGZO) substrate.

15. The EL display according to claim 13, wherein the EL device includes one of an organic light emitting diode (OLED), a micro LED and a quantum dot LED (QLED).

16. The EL display according to claim 13, wherein the optical sensor layer has a same size as the substrate.

17. The EL display according to claim 13, wherein the optical sensor layer 33 is made of a relatively high transparent material.

18. The EL display according to claim 13 further comprising a measuring module configured to measure an intensity of light of an EL device.

18. EL display according to claim 18 further comprising an analyzing module configured to identify an EL device to be one that needs compensation if the measured intensity exceeds a predetermined threshold.

20. The EL display according to claim 19 further comprising a calculating module configured to determine the magnitude of a compensation current for the identified EL device.

\* \* \* \* \*

|               |                                                                                                                                                                                                                                                                                                                                                                                               |         |            |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------|
| 专利名称(译)       | 用于电致发光显示器的电流补偿的方法和装置                                                                                                                                                                                                                                                                                                                                                                          |         |            |
| 公开(公告)号       | <a href="#">US20180137812A1</a>                                                                                                                                                                                                                                                                                                                                                               | 公开(公告)日 | 2018-05-17 |
| 申请号           | US15/811337                                                                                                                                                                                                                                                                                                                                                                                   | 申请日     | 2017-11-13 |
| 申请(专利权)人(译)   | 国际科技股份有限公司                                                                                                                                                                                                                                                                                                                                                                                    |         |            |
| 当前申请(专利权)人(译) | 国际科技股份有限公司                                                                                                                                                                                                                                                                                                                                                                                    |         |            |
| [标]发明人        | YAN YI WEI<br>YAN CHIN RUNG<br>LAI YEN JEN                                                                                                                                                                                                                                                                                                                                                    |         |            |
| 发明人           | YAN, YI WEI<br>YAN, CHIN-RUNG<br>LAI, YEN-JEN                                                                                                                                                                                                                                                                                                                                                 |         |            |
| IPC分类号        | G09G3/3208                                                                                                                                                                                                                                                                                                                                                                                    |         |            |
| CPC分类号        | G09G3/3208 G09G2320/045 G09G2320/029 G09G3/3225 G09G3/3233 G09G3/3258 G09G3/3266 G09G3/3275 G09G3/3674 G09G3/3685 G09G2300/0809 H01L27/0207 H01L27/088 H01L29/0847 G06F3/1446 G09G3/3611 G09G2300/026 G09G2300/0439 G09G2310/0278 G09G2330/02 G09G3/2092 G09G3/30 G09G2300/0819 G09G2320/0204 G09G2320/0233 H01L23/528 H01L27/3211 H01L27/3244 H01L27/3248 H01L29/41733 H01L29/78 H01L51/5036 |         |            |
| 优先权           | 62/421435 2016-11-14 US                                                                                                                                                                                                                                                                                                                                                                       |         |            |
| 外部链接          | <a href="#">Espacenet</a> <a href="#">USPTO</a>                                                                                                                                                                                                                                                                                                                                               |         |            |

#### 摘要(译)

提供了一种用于电致发光 ( EL ) 显示器中的电流补偿的方法。该方法包括测量像素单元的光强度，将像素单元识别为如果测量的强度超过预定阈值则需要补偿的像素单元，确定补偿电流的大小，并提供对应于大小的图像数据。到所识别的像素单元的补偿电流。

