(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 407 340 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
13.11.2019 Bulletin 2019/46

(21) Application number: **18182680.1**

(22) Date of filing: **06.09.2002**

(51) Int Cl.:
G09G 3/20 *(2006.01)* ***G09G 3/30*** *(2006.01)*
G09G 3/36 *(2006.01)*

(54) EL DISPLAY PANEL, METHOD OF DRIVING THE SAME, AND EL DISPLAY DEVICE

EL-ANZEIGETAFEL, VERFAHREN ZUR ANSTEUERUNG DAVON UND EL-ANZEIGEVORRICHTUNG

PANNEAU D'AFFICHAGE ÉLECTROLUMINESCENT, SON PROCÉDÉ DE COMMANDE ET DISPOSITIF D'AFFICHAGE ÉLECTROLUMINESCENT

(84) Designated Contracting States:
DE FR GB

(30) Priority: **07.09.2001 JP 2001271311**
25.09.2001 JP 2001291598
13.11.2001 JP 2001347014
10.05.2002 JP 2002136117

(43) Date of publication of application:
28.11.2018 Bulletin 2018/48

(60) Divisional application:
19200688.0

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
17172364.6 / 3 232 429
02798040.8 / 1 424 674

(73) Proprietor: **JOLED INC.**
Tokyo 101-0054 (JP)

(72) Inventors:
- **TAKAHARA, Hiroshi**
  Osaka-shi, Osaka 540-6207 (JP)
- **TSUGE, Hitoshi**
  Chiyoda-ku, Tokyo 101-0054 (JP)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

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EP-A- 1 061 499
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EP 3 407 340 B1

Description

Technical Field

[0001] The present invention relates to an EL display apparatus employing an organic or inorganic electroluminescence (EL) device and, more particularly, to an EL display apparatus capable of feeding an EL device with a desired current, a method of driving the same, and an electronic apparatus provided with such an EL display apparatus.

Background Art

[0002] In general, an active-matrix display apparatus has a multiplicity of pixels arranged in matrix and displays an image by controlling the intensity of light pixel by pixel in accordance with image signals given. When, for example, liquid crystal is used as an electro-optic substance, the transmittance of each pixel varies in accordance with the voltage applied to the pixel. The basic operation of an active-matrix image display apparatus employing an organic electroluminescence (EL) material as an electro-optic converting substance is the same as in the case where liquid crystal is used.

[0003] A liquid crystal display panel has pixels each functioning as a shutter and displays an image by turning on/off light from a back light with such a shutter, or a pixel. An organic EL display panel is a display panel of the self-luminescence type having a light-emitting device in each pixel. Such a self-luminescence type display panel has advantages over liquid crystal display panels, including higher image visibility, no need for a back light, and higher response speed.

[0004] The organic EL display panel controls the luminance of each light-emitting device (pixel) based on the amount of current. Thus, the organic EL display panel is largely different from the liquid crystal display panel in that its luminescent devices are of the current-driven type or the current-controlled type.

[0005] Like the liquid crystal display panel, the organic EL display panel can have any one of a simple-matrix configuration and an active-matrix configuration. Though the former configuration is simple in structure, it has a difficulty in realizing a large-scale and high-definition display panel. However, it is inexpensive. The latter configuration can realize a large-scale and high-definition display panel. However, it has problems of a technical difficulty in control and of a relatively high price. Presently, organic EL display panels of the active-matrix configuration are being developed intensively. Such an active-matrix EL panel controls electric current passing through the light-emitting device provided in each pixel by means of a thin film transistor (TFT) located inside the pixel.

[0006] An organic EL display panel of such an active-matrix configuration is disclosed in Japanese Patent Laid-Open Publication No. HEI 8-234683 for example. Fig. 62 shows an equivalent circuit of one pixel portion of this display panel. Pixel 216 comprises an EL device 215 as a light-emitting device, a first transistor 211a, a second transistor 211b, and a storage capacitor 219. Here, the EL device 215 is an organic electroluminescence (EL) device.

[0007] In the present description, a transistor for feeding (controlling) current to an EL device is referred to as a driving transistor, while a transistor operating as a switch like the transistor 211b in Fig. 62 referred to as a switching transistor.

[0008] EL device 215 has a rectification property in many cases and hence is called OLED (Organic Light-Emitting Diode) as the case may be. For this reason, the EL device 215 in Fig. 62 is regarded as an OLED and represented by the symbol of a diode.

[0009] In the example shown in Fig. 62, the source terminal (S) of p-channel transistor 211a is connected to Vdd (power source potential), while the cathode (negative electrode) of the EL device 215 connected to ground potential (Vk). On the other hand, the anode (positive electrode) is connected to the drain terminal (D) of the transistor 211b. The gate terminal of the p-channel transistor 211b is connected to a gate signal line 217a, the source terminal connected to a source signal line 218, and the drain terminal connected to the storage capacitor 219 and the gate terminal (G) of the transistor 211a.

[0010] In order to operate the pixel 216, first, the source signal line 218 is applied with an image signal indicative of luminance information with the gate signal line 217a turned into a selected state. Then, the transistor 211b becomes conducting and the storage capacitor 219 is charged or discharged, so that the gate potential of the transistor 211a becomes equal to the potential of the image signal. When the gate signal line 217a is turned into an unselected state, the transistor 211a is turned off, so that the transistor 211a is electrically disconnected from the source signal line 218. However, the gate potential of the transistor 211a is stably maintained by means of the storage capacitor 219. The current passing through the EL device 215 via the transistor 211a comes to assume a value corresponding to voltage Vgs across the gate and the source terminals of the transistor 11a, with the result that the EL device 215 keeps on emitting light at a luminance corresponding to the amount of current fed thereto through the transistor 211a.

[0011] As described above, according to the prior art configuration shown in Fig. 62, one pixel comprises one selecting transistor (switching device) and one driving transistor. Another prior art configuration is disclosed in Japanese Patent Laid-Open Publication No. HEI 11-327637 for example. This publication describes an embodiment in which a pixel comprises a current mirror circuit.

[0012] Meanwhile, the organic EL display panel is usually manufactured using a low temperature polysilicon transistor

array. Since organic EL devices emit light based on current, the organic EL display panel involves a problem that display irregularities occur if there are variations in transistor characteristics.

[0013] Further, a conventional EL display panel cannot sufficiently charge/discharge the parasitic capacitance which is present in the source signal line 18. For this reason there arises a problem that in some cases a desired current cannot be fed to pixel 16.

[0014] European patent application EP 1061 497 A1 describes an image display apparatus including current controlled light emitting elements and driving method therefor. Each pixel includes a light emitting element with a brightness value which varies depending upon an amount of current supplied thereto, a first TFT controlled by a scanning line for writing brightness information given thereto from a data line into the pixel, and second TFT for controlling the amount of current to be supplied to the OLED corresponding to the brightness information written. Writing of the brightness information into each pixel is performed by applying an electric signal corresponding to the brightness information to the data line while the scanning line is selected. The brightness information written in each pixel is held by the pixel also after the scanning line is placed into a non-selected state so that the OLED can continue lighting with a brightness value corresponding to the brightness information held by the pixel. A stopping control line compulsorily extinguishes the OLEDs of the pixels connected to the same scanning line at least in a unit of a scanning line so that the OLEDs are placed into an extinguished state from a lit state within a period of one scanning cycle after the brightness information is written into the pixels until new brightness information is written into the pixels subsequently.

[0015] JP 2001 109432 A relates to a driving device for an active matrix type tight emitting panel, capable of effectively applying a reverse bias voltage to each EL element of a light emitting panel. Accordingly, an address period and a light emitting period to each of plural capacitive light emitting elements are set repeatedly according to a synchronous timing of an input video data. A drive element corresponding to a light emitting element to be made to emit among the plural capacitive light emitting elements is specified based on the input video data in the address period, then the specified drive element is turned on in the light emitting period following the address period, a light emitting voltage polarized in the forward direction is applied to the light emitting element to be made to emit via the drive element corresponding to the light emitting period, and a bias voltage polarized opposite to the forward direction is applied to at least the light emitting element to be made to emit among the plural capacitive light emitting elements during the address period.

[0016] International application publication WO 99/38148 relates to a high resolution active matrix display system on a chip with high duty cycle for full brightness. The display includes individual driver circuits for each pixel to provide accurate, high resolution gray scale rendering and an almost 100% duty cycle. The pixel circuit drivers (Figures 6(60) and 7(70)) minimize factors known to limit gray scale resolution, such as variations in threshold voltage, voltage drops in connecting lines and from leakage currents, and large peak currents. A line driver functioning initially as a low impedance voltage driver (Figure 6(60)), then converting to a high impedance current driver (Figure 7(70)) is included.

Disclosure of Invention

[0017] The present invention has been made in view of the foregoing circumstances. It is an object of the present invention to provide an EL display apparatus which is capable of realizing satisfactory image display by sufficiently charging/discharging the parasitic capacitance present in the source signal line.

[0018] This object is solved by the present invention as defined in the appended independent claims. Embodiments of the present invention are defined by the appended dependent claims.

[0019] According to comparative example useful for understanding the present invention, an EL display apparatus comprises: a plurality of gate signal lines and a plurality of source signal lines, which are arranged to intersect each other; EL devices arranged in a matrix pattern, each of the EL devices being operative to emit light at a luminance corresponding to a current fed thereto; a gate driver operative to output a gate signal to each of the gate signal lines; a source driver configured to output to each of the source signal lines a current which is higher than a current corresponding to an image signal inputted from outside; a transistor, provided for each of the EL devices, for outputting the current outputted from the source driver to the EL device; and a first switching device capable of feeding the current outputted from the source driver to the EL device by switching to bring the EL device and the transistor into and out of conduction thereacross in accordance with the gate signal fed thereto through the gate signal line, wherein the gate driver is configured to output the gate signal to the gate signal line in a manner to bring the EL device and the transistor into and out of conduction thereacross at least once in a one-frame period.

[0020] With this construction, the source driver outputs a higher current than the current corresponding to the image signal to the source signal line and, hence, even if a parasitic capacitance is present in the source signal line, the parasitic capacitance can be charged/discharged. When such a high current is fed to the EL device, the EL device emits light at a higher luminance than a luminance corresponding to the image signal. By making the duration of current feed to the EL device shorter than the one-frame period, the time period for which the EL device emits light can be shortened, with the result that image display at a luminance equivalent to the luminance corresponding to the image signal is realized.

[0021] In the EL display apparatus according to the above-described comparative example, the gate driver may be

configured to output the gate signal to the gate signal line in a manner to bring the EL device and the transistor into and out of conduction thereacross plural times periodically in the one-frame period.

[0022] With this feature, the so-called interlaced driving can be realized, which can provide for more satisfactory image display.

[0023] The EL display apparatus according to the above-described comparative example may further comprise a second switching device capable of feeding the current outputted from the source driver to the transistor by switching to bring the source driver and the transistor into and out of conduction thereacross in accordance with the gate signal fed thereto through the gate signal line, wherein the gate driver is configured to bring the source driver and the transistor into conduction thereacross to program the transistor with the current outputted from the source driver while the EL device and the transistor are out of conduction thereacross and then output the gate signal to the gate signal line in a manner to bring the EL device and the transistor into and out of conduction thereacross at least once in the one-frame period.

[0024] With this feature, display irregularities due to variations in transistor characteristics can be prevented, whereby satisfactory image display can be realized.

[0025] In the EL display apparatus according to the above-described comparative example, the gate driver and the transistor may be formed in a same process. Specifically, the gate driver and the driver [sic] may be formed using the low temperature polysilicon technology for example. The formation of these components in this manner makes it possible to narrow the frame.

[0026] In the EL display apparatus according to the above-described comparative example, the source driver may comprise a semiconductor chip.

[0027] According to a further comparative example, there is also provided an EL display apparatus comprising: a plurality of gate signal lines and a plurality of source signal lines, which are arranged to intersect each other; EL devices arranged in a matrix pattern, each of the EL devices being operative to emit light at a luminance corresponding to a current fed thereto; a gate driver operative to output a gate signal to each of the gate signal lines; a source driver operative to output to each of the source signal lines a current which is higher than a current corresponding to an image signal inputted from outside; a switching device provided for each of the EL devices and capable of feeding the EL device with a current fed through the source signal line by switching to bring the EL device and the source signal line into and out of conduction thereacross in accordance with the gate signal fed thereto through the gate signal line; a plurality of dummy devices located in a region different from a region where the EL devices are formed, the dummy devices being of substantially no use in image display; and a second switching device provided for each of the dummy devices and capable of feeding the dummy device with the current fed through the source signal line by switching to bring the dummy device and the source signal line into and out of conduction thereacross in accordance with the gate signal supplied thereto through the gate signal line, wherein the gate driver is configured to output gate signals to the gate signal line associated with the EL device and the gate signal line associated with the dummy device at substantially the same timing, whereby the EL device and the dummy device are fed with the current fed through the source signal line dividedly therebetween.

[0028] With this construction, the source driver outputs a higher current than the current corresponding to the image signal to the source signal line and, hence, even if a parasitic capacitance is present in the source signal line, the parasitic capacitance can be charged/discharged. Even when the source driver outputs the higher current than the current corresponding to the image signal to the source signal line, the EL device can be prevented from emitting light at a higher luminance than necessary because the current outputted from the source driver is divided into shares which are fed to the EL device and the dummy device, respectively.

[0029] The EL display apparatus according to the above-described comparative example may have an arrangement wherein: the gate signal line associated with the dummy device is formed to extend adjacent the gate signal line associated with EL devices in a first or final row; and the gate driver is configured to output gate signals to gate signal lines associated with a series of adjacent rows at substantially the same timing series by series sequentially, whereby plural EL devices or the pair of the EL device and the dummy device are fed with the current fed through the source signal line dividedly therebetween.

[0030] According to a further comparative example, there is also provided a method of driving an EL display apparatus having an EL device which is operative to emit light at a luminance corresponding to a current fed thereto, and a source driver operative to output a current to the EL device through a source signal line, the method comprising the steps of causing the source driver to output to the source signal line a current higher than a current corresponding to an image signal inputted from outside; and feeding the EL device with the current outputted to the source signal line for a part of a one-frame period to cause the EL device to emit light at a luminance corresponding to the current outputted to the source signal line for the part of the one-frame period.

[0031] In the method of driving an EL display apparatus according to the above-described comparative example, the part of the one-frame period may be divided into plural periods.

[0032] According to a further comparative example, there is also provided an EL display apparatus comprising: EL

devices arranged in a matrix pattern; a driving transistor operative to feed a current to each of the EL devices; a first switching device disposed between the EL device and the driving transistor; and a gate driver operative to on-off control the first switching device, wherein the gate driver is configured to control the first switching device in a manner to turn the first switching device off at least once within a one-frame period.

[0033] In the EL display apparatus according to the above-described comparative example, the first switching device may be controlled in a manner to turn off plural times periodically within the one-frame period.

[0034] According to a further comparative example, there is also provided an EL display apparatus comprising: a source driver circuit operative to output a programming current; EL devices arranged in a matrix pattern; a driving transistor operative to feed a current to each of the EL devices; a first switching device disposed between the EL device and the driving transistor; a second switching device forming a path for transmitting the programming current to the driving transistor; and a gate driver circuit operative to on-off control the first and second switching devices, wherein the gate driver is configured to control the first switching device in a manner to turn the first switching device on at least once and off at least once within a one-frame period.

[0035] In the EL display apparatus according to the above-described comparative example, it is possible that the gate driver and the driving transistors are formed in a same process, while the source driver comprises a semiconductor chip.

[0036] According to a further comparative example, there is also provided an EL display apparatus comprising: gate signal lines; source signal lines; a source driver operative to output a programming current; a gate driver; EL devices arranged in a matrix pattern; a driving transistor operative to feed a current to each of the EL devices; a first transistor disposed between the EL device and the driving transistor; and a second transistor forming a path for transmitting the programming current to the driving transistor, wherein: the source driver is operative to output the programming current to each of the source signal lines; the gate driver is connected to each of the gate signal lines; the second transistor has a gate terminal connected to the gate signal line, a source terminal connected to the source signal line, and a drain terminal connected to the drain terminal of the driving transistor; and the gate driver is configured to select plural ones of the gate signal lines to feed the programming current to the driving transistor of each of plural pixels and control the first transistor in a manner to turn the first transistor on at least once and off at least once within a one-frame period.

[0037] In the EL display apparatus according to the above-described comparative example, it is possible that the gate driver and the driving transistors are formed in a same process, while the source driver comprises a semiconductor chip.

[0038] According to comparative example, there is also provided an EL display apparatus comprising: a display region including I pixel rows (I is an integer not less than 2) and J pixel columns (J is an integer not less than 2); a source driver operative to apply video signals to source signal lines in the display region; a gate driver operative to apply on-voltage or off-voltage to gate signal lines in the display region; and a dummy pixel row formed in a region other than the display region, wherein the display region is formed with EL devices arranged in a matrix pattern, each of which is operative to emit light in accordance with the video signals from the source driver, while the dummy pixel row is configured such that the dummy pixel row fails to emit light or its light-emitting state is not recognized visually.

[0039] In the EL display apparatus according to the above-described comparative example, the gate driver may be configured to select plural pixel rows at a time for the pixel rows selected to be applied with the video signals from the source driver in a manner that the dummy pixel row is selected when the first pixel row or the I^{th} pixel row is selected.

[0040] According to a further comparative example, there is also provided a method of driving an EL display apparatus characterized by: feeding the EL device with a current that causes the EL device to emit light at a luminance higher than a predetermined luminance; and causing the EL device to emit light for a I/N part of a one-frame period (N is less than 1).

[0041] In the method of driving an EL display apparatus according to the above-described exemple, the 1/N part of the one-frame period may be divided into plural periods.

[0042] According to a further comparative example, there is also provided a method of driving an EL display apparatus adapted for programming of a current to pass through an EL device based on a current, characterized by: causing the EL device to emit light at a luminance higher than a predetermined luminance to provide a display in a 1/N (N>1) portion of a display region; and sequentially shifting the 1/N portion of the display region to another thereby causing the whole display region to display.

[0043] The foregoing and other objects, features and advantages of the present invention will become apparent from the following detailed description of the preferred embodiments with reference to the accompanying drawings.

Brief Description of Drawings

[0044]

Fig. 1 is a diagram illustrating a pixel configuration of an EL display panel according to the present invention.
Fig. 2 is a diagram illustrating a pixel configuration of an EL display panel according to the present invention.
Fig. 3 is an explanatory diagram illustrating an operation of an EL display panel according to the present invention.
Fig. 4 is an explanatory chart illustrating an operation of an EL display panel according to the present invention.

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